Set-Up

Increase in pile capacity over time

- Dissipation of porewater pressures
- Remolding of soil
- Aging
End-of-Initial Drive (423 kips)

Typically,

\[ \text{Factored resistance} = \varphi_{\text{dyn}} \times \text{driven resistance} \]

for \( \varphi_{\text{dyn}} = 0.8 \) (static testing, PDA),

Factored resistance = \textbf{338 kips (average)}
Set-Up

End-of-Initial Drive (423 kips)

At 40-50 days (1397 kips)

EOID  Set-Up
At 40-50 days (1397 kips)

For $\varphi_{\text{dyn}} = 0.6$ to 0.7 (range)

Factored resist = 838 to 978 kips (average)
Gamechanger!

Use of set-up can:

• Increase factored resistance (reduce number of piles and cap size)
• Reduce pile length
• Optimize pile size
• Reduce driving equipment size
So... what’s the catch?

No reliable method of accurate prediction using exploration methods

Need to conduct on-site pile test program
Test Pile Program

- 24 piles - 18” dia, 0.5” wall closed-ended
- Installed with ICE D46-V2 hammer
- 3 static load tests with internal strain gages
- Short-term and long-term restrikes
- All piles restruck with drop hammer
- Done in conjunction with structural design
- 23 of 24 piles used as production piles
Design-Phase Pile Installation

3200 feet

- 5 piles
- 5 piles
- 5 piles
End-of-Initial-Drive (EOID) Capacities

- **Depth (ft):** 160, 140, 159, 173, 179, 140, 150, 124, 122, 116, 110, 90
- **Kips:** 423 average

The chart shows the end-of-initial-drive capacities for different depths, with an average of 423 kips.
EOID & Restrike Capacities

Avg. Restrike: 1397 kips
Avg. EOID: 423 kips
Set-Up Calculation

Restrike Shaft Resistance

End-of-Drive Shaft Resistance

Set-Up Distribution
Design

\[ \text{Factored\_resistance}_z = \varphi_{\text{dyn}} \times EOID_z + \varphi_{\text{set-up}} \times \sum_0^z (\text{setup}) \]

As per AASHTO / ODOT
\[ \varphi = 0.8 \]

As per agreement with ODOT OGE
\[ \varphi = 0.55 - 0.60 \]

\[ EOID_z = \frac{\text{Factored\_resistance}_z - \varphi_{\text{set-up}} \times \sum_0^z (\text{setup})}{\varphi_{\text{dyn}}} \]
Design

- Long-Term Factored Resistance
- Factored Set-Up
- Factored CASE (EOID) Resistance

Pile Toe Elevation, feet vs. Factored Resistance, kips
Total factored resistance (per pile) = 725 kips

Req’d EOID Resistance

Factored Set-Up
Depth-Variable Penetration Resistance Criteria

<table>
<thead>
<tr>
<th>Pile Toe Depth, feet</th>
<th>Average Hammer Stroke, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>from to</td>
<td>9.0 9.5 10.0 10.5 11.0</td>
</tr>
<tr>
<td>102 105</td>
<td>82 62 48 39 33</td>
</tr>
<tr>
<td>105 108</td>
<td>43 35 29 25 22</td>
</tr>
<tr>
<td>108</td>
<td>-- 25 21 18 16 15</td>
</tr>
</tbody>
</table>

Req’d EOID Resistance
Savings

- Total footage (West abut, Piers 1-11) per plan = 63,925 lineal feet (12.1 miles)
- Estimated footage without set-up component = 173,100 lineal feet (32.8 miles)
- Estimated savings due to set-up = 109,175 lineal feet (20.7 miles)
- Pile cap savings = 7,050 cubic yards (2.2 Olympic-sized swimming pools)
- …..and don’t forget schedule savings…!
Nuances

• Need experienced testing firm

• Need uniform approach to CAPWAP analyses

• Calibrate CAPWAP analyses to static test pile strain gage data

• Pay attention to splice and overall driven lengths

• Short-term restrikes lead to greater assurance of valid set-up profiles
Keys to Success

Buy in from entire team (owner, contractor, IQF, structural)

Get a really good PDA testing firm

Keep geotechnical engineer involved throughout

  Identify problems
  Maintain contact with field staff, inspectors, etc.
  Accountability
  Geotech “a seat at the table”

Communication, Communication, Communication
I-480 Valley View Bridge

Measurement and Use of Set-Up in Pile Design