Controlling the Installation of Driven Piles

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Ontario

Outline

- Background
- MTO Hiley Formula
- High Strain Dynamic Testing (PDA)
- Research Study
- Proposed Policy Changes

Background

- Driven piles support a significant number of MTO bridges
- This trend is likely to continue with future structures
- Ensuring that the piles have sufficient resistance is critical to maintaining both:
  - Public Safety
  - Long term performance / maintenance
- The MTO Hiley Dynamic Formula has been the main tool to control the installation of driven piles

The MTO Hiley Formula

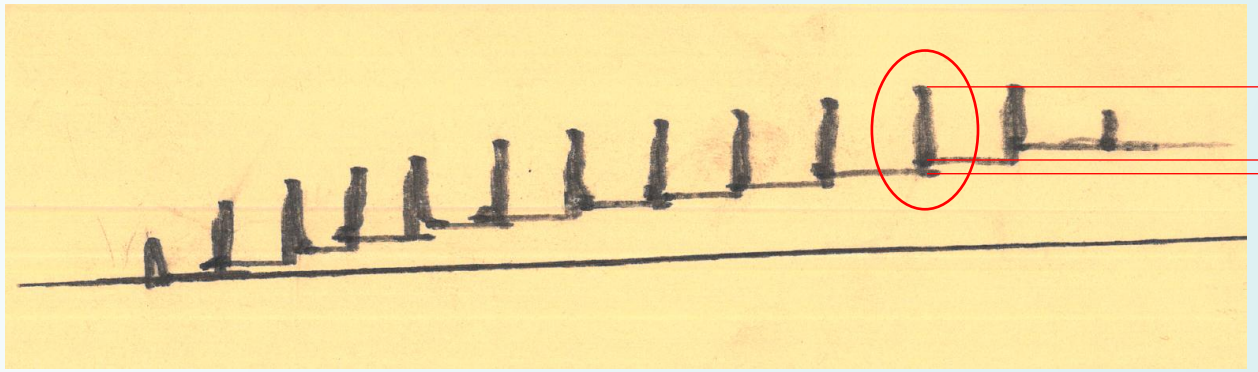
- Hiley formula first published in 1925
- Simple and low cost method
- Based on simplifying assumptions (may not apply to field conditions)
- Requires hand drawn lines on the pile itself (inconsistent)
- Hiley Formula does not account for pile geometry, such as area and length (inappropriate method)
- Provides estimate of total resistance only (limited results)

The MTO Hiley Formula

$$R(kN) = \frac{n\, e_f\, E}{S + {}^{C}/_{2}}$$

Assumed values for hammer energy and efficiency – these can change from pile to pile or even blow to blow

Measured from a hand drawn plot



The MTO Hiley Formula

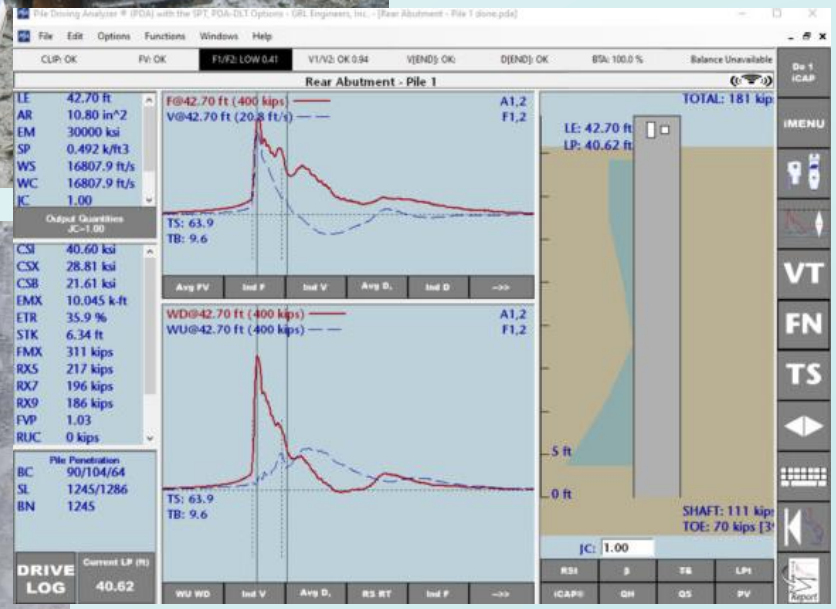
- Results are inconsistent between sites and even individual piles on the same site
- The accuracy has been challenged on MTO projects
- Pile driving industry has been shifting away from dynamic formula due to liability issues from inconsistent / inaccurate results

High Strain Dynamic Pile Testing (PDA)

- High strain dynamic testing has become standard in the industry and in other jurisdictions
- Advancement in technology have allowed for modernization of testing and analysis methods (including high speed sensors and real time data processing)
- Provides important additional information, including:
  - Shaft / Toe resistance distribution
  - Pile integrity
  - Stresses during driving
  - Transferred energy / Hammer performance

High Strain Dynamic Pile Testing (PDA)

- Simple to perform
- Strain transducers and accelerometers are attached to the pile
- Data from the sensors are computer recorded during pile driving
- Preliminary results available immediately



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Benefits of PDA Testing

- No simplifying assumptions inherent in the process
- Consistent, repeatable results
- More relevant information provided from testing
- Safety … does not require someone to be standing beside the pile during driving

Research Program

- MTO and EXP Services Inc. undertook a comprehensive study involving:
  - 299 piles
  - 34 sites
  - Tests spanning 40 years (1979 – 2022)
- Compared pile capacity results from PDA testing and MTO Hiley Formula based on accuracy, consistency, reproducibility, and efficiency
- PDA and Hiley results were compared to static load test results (the “gold standard” for pile testing) and empirical analysis methods.

Research Program

Primary findings of the study:

"*the **MTO Hiley Formula cannot be generally relied upon** to predict a pile's ultimate capacity with a reasonable degree of accuracy and repeatability; quantitative agreement, where it occurs, is primarily coincidental.*" [emphasis added]

"*an approach using the easy to perform wave equation analysis coupled with **dynamic monitoring with the PDA** and CAPWAP treatment of the data is indicated as **the best way forward to control pilling installation***" [emphasis added]

Proposed Policy

- PDA will become the default method for controlling the installation of driven piles
- Minimum 10% of piles shall be subjected to PDA testing
- Use of the MTO Hiley Formula will only be allowed on an exception basis with approval from MTO Foundations Section.
- Recommendations to be included in FIDRs:
  - PDA testing details (e.g. time between EOID and RSTR, if required)
  - Rationale for using MTO Hiley Formula
- PDA testing to be performed by the CA / FES (unchanged from current practice)

Thank You