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DEPARTMENT OF TRANSPORTATION

Pile Driving Saximeter Application for iOS & Android Devices

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M&R

MATERIALS & RESEARCH

Background

Currently, field construction inspectors use a E-Saximeter (E-Sax) to determine the hammer fall of single action diesel hammers when driving pile during bridge construction. The hammer fall measurement is required to calculate the bearing capacity of the installed pile. Inspectors record the hammer fall data by hand and the data is entered into an in-house built record application.

Purpose of the Investigation

With new development in technology and the cost effectiveness of an iOS & Android based application, research was needed to determine the accuracy and reliability of the application.

Field Investigation (Test Methodology)

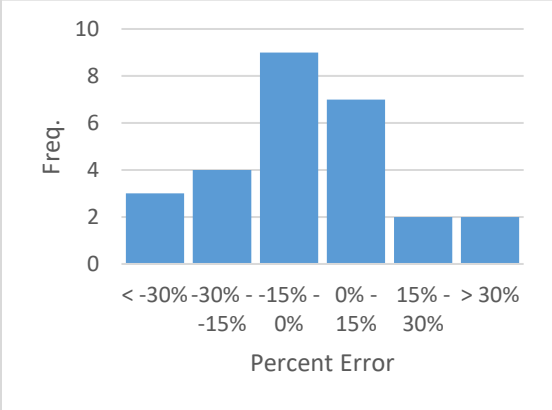
While on-site for test piles, hammer fall data was gathered using three different methods at intervals of 5' for each test pile driven. The three methods used were the saximeter application installed on an iOS system, the traditional E-Saximeter and a Pile Driving Analyzer (PDA). The data was collected on 27 projects using single acting diesel hammers of various ram weights.

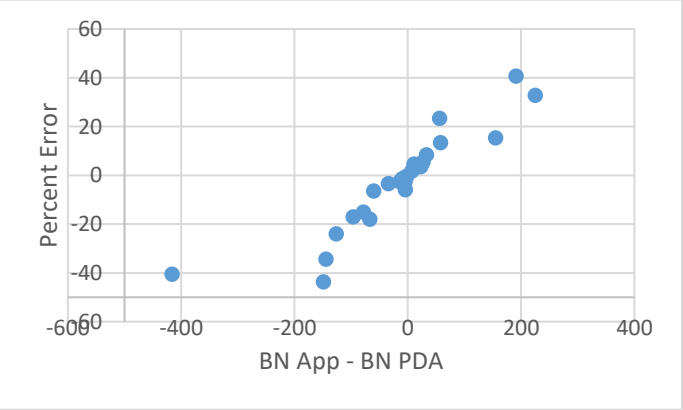
The performance evaluation criteria used in this research were the total blow count (driving log), hammer stroke and reliability. For the driving log, the saximeter application total blow count was compared to the PDA's total blow count using the saximeter application's driving report feature. The hammer stroke data was compared between the three methods using the dynamic load test data as the baseline or "true" data. Spot checks were performed throughout the driving logs to determine the reliability of the saximeter application and the E-Sax.

Results

Driving Log Blow Count

Using a performance criteria of percent error (App BN – PDA BN)/(PDA BN), the mean error in the total blows was 3.1% with a standard deviation of 13.2%.

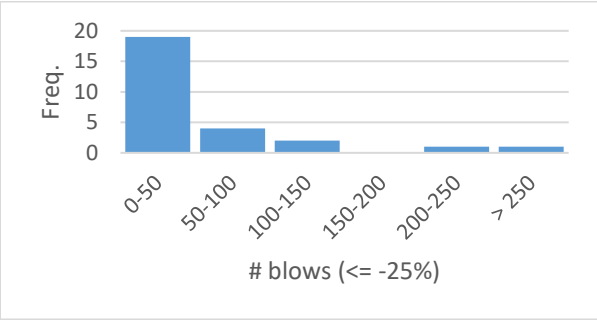


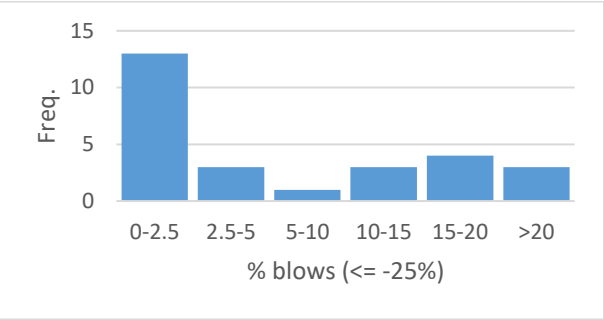


Hammer Stroke

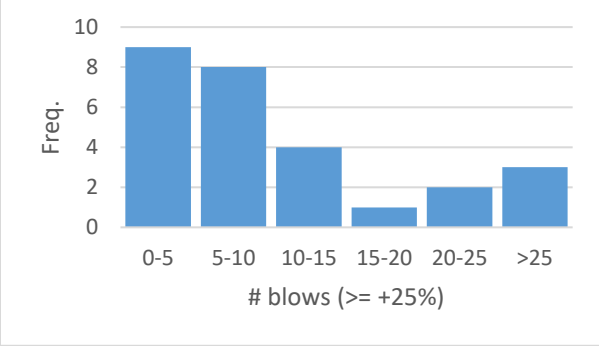
The performance criteria established for the hammer strole was +/- 25% from the range of the PDA. Typically, the E-Saximeter provided hammer strokes within 0.1-0.2' of the PDA while the saximeter application had a greater variability as shown in the graphs below.

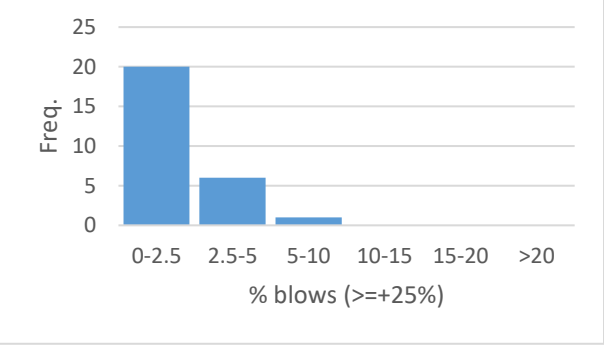
Number of blows <= -25% lower bound





Number of blows <= +25% lower bound





Final Ten Count and Spot Checks

To determine the reliability of the application, spot checks were performed throughout the driving records at random using a performance criterion of +/- 0.1' for the 10 blow average. When comparing the saximeter application to the PDA, the reliability of the application was 57.7%. In contrast, the reliability of the traditional E-Sax was shown to be 91.2%. Some example data is shown below.

Mean and Standard Deviation compared to PDA

	App-PDA		ESax-PDA	
Structure ID	μ	σ	μ	σ
S077 11247 A2 P3	0.05	0.13	0.11	0.21
S275 11475L A1 P5	0.60	1.64	0.11	0.47
S030 41903L A1 P9	1.54	3.97	0.06	0.17
S077 05394 A1 P10	0.25	0.34	0.03	0.01
S002 46136 P1 P16	2.30	2.02	0.07	0.36

Test Pile Average Hammer Fall Using Three Methods

S002 46136 P1 P16			
Penetration	App Avg	PDA Avg	Inspector Avg
35	5.96	7.04	6.87
40	1.37	6.06	6.05
45	1.37	6.8	6.15
50	4.56	6.99	7.55
55	5.77	6.8	6.77
60	7.48	7.52	7.34
65	7.67	9.1	9.08

Conclusions and Recommendations

The saximeter application for iOS & Android does have benefits such as the intuitive, simplified user interface, the ability to input and output project information to an Excel format and the small upfront cost. While the application does have these benefits, the field experience and performance evaluation were less than desirable.

The application uses a sensitivity slider to adjust the microphone and determine the hammer fall. The sensitivity setting is critical and can be greatly affected by factors such as echoing off sheet pile, noise from other construction equipment, and wind. When it comes to performance, there was a higher than expected discrepancy in logged blows compared to the PDA. The hammer fall data was unreliable, which is especially important during critical driving periods such as the last 10 blows and restrikes of the pile. The frequency of observed erroneous values was also concerning. The E-Saximeter reliability was shown to be significantly higher.

The Geotechnical Section will monitor the iOS & Android store for updates to the saximeter applications. If updates are found in the future, the application will be reevaluated. At this time, the Department will continue to use the E-Saximeter for all driven pile monitoring.