

Request for Research Funding for FY 2024-2025

Project Number (Research Center Use Only): GEO-25-01

Requesting Office	Geotechnical	Priority	1 of 3
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Proposed Title Measuring Rebound During Pile Driving using Ultra-High Speed/Resolution Photogrammetry

Justification The limiting rebound value for accepting driven piles, meaning the amount of upward movement experienced by the pile after each hammer blow, is ¼-inch. Rebound is the result of elastic response of the combined pile-soil system, and the ¼-inch limit was implemented to prevent pile acceptance in conditions where the upward movement is prevalent enough to potentially generate separation between the pile tip and the supporting soils, and to prevent a misapplication of the driving criteria. Historically, this has been a difficult parameter to measure in the field. Ultra-high speed, high-resolution photogrammetry methods have shown promising applications for structural health monitoring that can be applied to monitor the exposed portion of the pile during initial drive and restrike, and supplement the widely used dynamic testing methods. Previous research efforts by the Department addressing pile rebound have used camera-based measurements, however, the data collection was coarse in temporal resolution (60 Hz) versus the proposed effort which would provide a resolution of 60 kHz. Advanced noncontact sensing methods imply that direct access to the piles will not be necessary. The proposed methods can avoid obstructions for construction equipment, disruption of construction operations, and can provide safe-distance accurate monitoring of pile installations. The proposed research has the potential to improve accuracy in the measurements of pile penetration in terms of displacement, velocity and strain during the installation of driven deep foundations. The project will address those issues using physical model tests and direct measurements collected during field testing in upcoming FDOT projects.

Impact The proposed work will result in the development of novel noncontact monitoring methods for pile installation, which may result in improvements to the current methods used to measure displacement, velocity and strain. If successful, the proposed approach would improve worker safety, and could result in a new method of measuring key parameters used in the estimation of static pile capacity. Compared to conventional camera-based techniques, the proposed method using ultra-high-speed, ultra-high-resolution photogrammetry will yield more accurate measurements of displacements and velocities by removing the ground vibration effects.

Affected Offices/Districts Structures Design and Construction.

Existing Work

Examples of work on similar topics:

- Bloomquist and McVay, Measurement of Stress Waves in EDC Piles (2008) BD545, RPWO # 86
- McVay et al., Embedded Data Collector (EDC) Evaluation Phase II (2013) BDK75 977-24
- Cosentino et al., Quantifying Pile Rebound with Deflection Measuring Systems Best Suited for Florida Soils (2020) BD28 977-07
- Lee, S. N., et al. (2002). Visual measurement of pile penetration and rebound movement using a high-speed line-scan camera. IEEE International Conference on Robotics and Automation, Vol. 4, pp. 4307-4312.

Keywords Used In Existing Work Search (Cannot leave blank) Pile rebound, displacement measurement, noncontact measurements, pile-driving monitoring, photogrammetry.

Related Contracts (Give contract numbers)

BD545, RPWO #87: Analysis of Embedded Data Collector (EDC).
 BED26 977-07: Quantifying Pile Rebound with Deflection Measuring Systems Best Suited for Florida Soils.
 BDV24 TWO 977-33: Prediction Model of Vibration-Induced Settlement due to Pile Driving.

Funding Request	Estimated cost: \$270,000	Anticipated Duration	24 months
Project Manager	Rodrigo Herrera	Contracting Method	Direct contract with the University of Central Florida. Drs. Patrick Sun and Luis G. Arboleda-Monsalve.
Equipment	\$25,000	Cameras and associated equipment.	
Urgency	2	Successful results from this effort would result in increased worker safety during pile installation.	
Implementability	2	Research results effort would likely result in updates to the Specifications for Roadway and Bridge Construction,	

Project Benefits (Succinct, complete explanation)

The benefits of developing noncontact methods of high accuracy and high temporal resolution is that pile acceptance will be based on accurate measurements of pile rebound. In addition, ultra-high-speed high-resolution photogrammetric sensing methods have the potential to measure pile velocity and strain, which could lead to new ways of estimating pile capacity during installation.

Project Benefits (Select all that apply and explain)	Quantifiable Benefits (units, dollars, etc...if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits
<input type="radio"/> Materials Enhancement	N/A	
<input type="radio"/> Financial Impact	Beneficial	On projects where rebound is an issue, the monitoring efforts would be expedited using the new technology.
<input type="radio"/> Time Savings	Beneficial	If the proposed methods are successful, less time will be needed when instrumenting sensors on piles and potential construction delays will be avoided when sensors are damaged during pile installations.
<input type="radio"/> Lives Saved/Injuries Prevented	Beneficial	The effort will allow for better informed decisions when accepting or rejecting piles.
<input type="radio"/> Other (Explain)	Advancement of the state-of-practice	This project will provide a novel and accurate noncontact method that is currently unavailable to practitioners for monitoring pile installations.

*Comments should explain and support urgency, financial benefit, and implementability scores