



Effect of Pile-Driving Induced Vibrations on Nearby  
Structures and Other Assets

ORBP # OR10-046

**The request for proposal has been revised**

1/24/2011

The end date for the project has been changed to March 30,  
2013.



## **GENERAL INFORMATION**

Any questions relative to the Research Problem Statement must be submitted by e-mail to: [mdot-research@michigan.gov](mailto:mdot-research@michigan.gov). Questions must be received by **February 18, 2011 at 5:00 p.m. EST**. All questions and answers will be placed on the MDOT RFP Web site as soon as possible after receipt of the questions and at least three (3) days prior to the due date listed above. The names of organizations submitting questions will not be disclosed.

The prime contractor must be a Michigan university. An organization located outside of Michigan may be included in the research team, but cannot be the primary contractor. A consultant located in Michigan may be included in the research team, but cannot be the primary contractor. MDOT is an equal opportunity employer and MDOT DBE firms are encouraged to participate as a subcontractor. The participating DBE firm, as currently certified by MDOT's Office of Equal Opportunity, shall be listed in the Proposal.

### **MDOT AND ORBP FORMS REQUIRED AS PART OF PROPOSAL SUBMISSION:**

- 5100D – Request for Proposal Cover Sheet
- 5100G – Certification of Key Personnel
- 5100I – Conflict of Interest Statement
- ORBP Research Proposal Budget Form Worksheet
- ORBP Schedule of Research Activities Form
- ORBP Deliverables Table
- ORBP Implementation Project Recommendation Form

**OFFICE OF RESEARCH & BEST PRACTICES  
MDOT RESEARCH PROGRAM  
2010 PROBLEM STATEMENT**

**PROBLEM TITLE**

Effect of Pile-Driving Induced Vibrations on Nearby Structures and Other Assets

ORBP NO.  
OR10-046

STRATEGIC PRIORITY NO.

CRITICAL ISSUE CODE  
7-Infrastructure

MDOT PROJECT CATEGORY

**PROBLEM TO ADDRESS**

**BRIEFLY DESCRIBE THE PROBLEM TO BE ADDRESSED AND WHY IT IS AN ISSUE FOR MDOT**

With the increased emphasis on mobility during construction, more MDOT bridges are being demolished and replaced part-width using a staged construction approach. In this construction scenario, part of the existing structure is demolished while traffic is maintained on the remaining portion. After part width demolition, the first portion of the new structure is constructed adjacent. Quite often, the existing structure is supported on spread footings and the new structure includes driving piles for foundation support. Pile-driving is performed typically by use of impact or vibratory hammers. This process induces vibrations into the ground which can be transmitted to nearby structures and underground utilities and threaten their integrity and serviceability. More specifically, these vibrations can cause ground settlements and deformations that may lead to differential settlements of foundations, deformations or cracking of underground utilities. Settlement of existing spread footings has been observed at some locations.

Vibration effects realized from pile driving depend on many factors including the soil profile, the size of the pile hammer, the pile impedance, pile batter, distance from the pile, etc. Currently MDOT has no guidance document with which to identify potentially troublesome soil profiles. Research is necessary to develop guidance documents for geotechnical site assessment as related to vibration analysis. Furthermore, a review of MDOT's existing pile design and construction criteria is proposed with respect to the pile/ hammer combinations typically used by Michigan contractors.

MDOT and consultant designers lack research based geotechnical screening criteria for prediction of settlement from construction equipment common on MDOT projects.

**RESEARCH OBJECTIVES AND TASKS**

**LIST THE RESEARCH OBJECTIVE(S) TO BE ACCOMPLISHED**

1. Provide screening criteria to identify sites where the magnitude of shakedown settlement could be damaging to existing bridge structures. A site class approach similar to that found in existing codes is envisioned.
2. Determine vibration characteristics of construction equipment commonly used by MDOT contractors and perform field tests as needed to calibrate analytical models, such as vibration monitoring and soil attenuation measurements.
- 3.
- 4.

**LIST THE MAJOR TASKS TO ACCOMPLISH THE RESEARCH OBJECTIVES:**

**ESTIMATED PERSON HOURS**

- |  |     |
|--|-----|
| 1. Conduct comprehensive literature search.  | 400 |
| 2. Determine vibration characteristics of construction equipment commonly used by MDOT contractors.  | 100 |
| 3. Develop geotechnical screening criteria for identification of sites susceptible to shakedown settlement.  | 200 |
| 4. For various site classes and construction operations, provide recommended radial distance between vibration source and spread footings, existing pavements, and utilities. Construction operations include demolition, sheet pile earth retention and pile driving. | 200 |
| 5. Provide report summarizing results.   | 200 |

**ESTIMATED COST AND TIMELINE**

ESTIMATE THE COST OF THIS RESEARCH STUDY (Please provide a cost range [min. and max.] associated with the person hours by task above)  
Tier II (\$100,000 - \$250,000)

PROVIDE A PROPOSED TIMELINE FOR THE PROJECT (At minimum, the expected duration of the project)  
10/1/2011 to 3/30/2013

REQUIRED COMPLETION DATE (At minimum, the date by which results are needed to be applicable)  
3/30/2013

**BUDGET INFORMATION**

(For each FY, list suggested minimum and maximum budgets as targets. Indirect Cost Rate is for ORBP use only.)

TOTAL BUDGET (BY FY)	FY1	FY2	FY3	FY4	INDIRECT COST RATE
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**DELIVERABLES**

WHAT DELIVERABLES SHOULD BE RECEIVED AT THE END OF THIS PROJECT? (e.g., usable technical product, design method, techniques, training, workshops, report, manual of practice, policy, procedure, specification, standard, software, hardware, equipment, training tools, etc.)

- 1) A report that summarizes the information collected from the literature review and provides guidelines for determining the acceptable vibration levels for various types of structures.
- 2) A report that summarizes the results of the investigation (field testing data and numerical analyses results) and provides design charts for assessing

the impact of pile-driving induced vibrations to neighboring structures and underground utilities. These charts will be developed for a range of soil conditions and a range of equipment used for pile-driving. Data will also be provided in electronic format in CDs.

3) A spreadsheet (in electronic format) that will produce charts relating pile-driving induced vibrations by means of particle peak velocity to distance from vibration source given the site conditions and the type of equipment.

4) Conduct a training event for appropriate MDOT engineers. Training event to include procedure to determine site class and determination of recommended radial distance for various construction operations.

**MDOT INVOLVEMENT (What will MDOT provide for this project and when)**

MDOT will provide access to some of MDOTs pile-driving sites to perform part of the field testing program. Project sites selected for research must be determined. Data collection on active construction projects will require mobilization to site with very little lead time. Researchers must coordinate with contractors as necessary to minimize impact on contractor's operations. Furthermore, researchers must use appropriate personal protective equipment, which at a minimum includes hard hat, safety boots, safety glasses, and ear plugs, meeting MDOT specifications.

MDOT will provide documents describing the currently employed practice with regard to pile driving induced ground vibrations.

The results of the research investigation will be communicated to interested MDOT personnel during the study to allow for feedback that will be of most interest to MDOT.

MDOT will provide access to any historical monitoring data for vibrations and settlement on past MDOT projects. Raw data on vibration events recorded on past construction projects, along with the monitoring logs, will be provided via CD and/or the MDOT FTP site. The data may be loosely correlated to specific construction activities by the monitoring log description and time/date stamp. The research team will need to purchase the instancel blastware software for data analysis.

**URGENCY, PAYOFF POTENTIAL AND IMPLEMENTATION**

**HOW URGENT IS THIS RESEARCH? IS IT IMPORTANT THAT IT BE DONE SOON? IF SO, WHY?**

Research is urgent and site classification criteria is needed by FY 2013. This research will result in more economical and safe designs by understanding the influence of the various factors related to shakedown settlement.

**DESCRIBE HOW THE PROPOSED RESULTS OF THIS PROJECT CAN BE IMPLEMENTED AT MDOT**

The screening criteria developed will be incorporated into the Bridge Design Manual and/or Bridge Design Guides.

**DESCRIBE HOW MDOT WILL BENEFIT FROM THE IMPLEMENTATION OF THIS PROJECT AND WHO THE BENEFICIARIES WILL BE. INCLUDE A DISCUSSION OF HOW MDOT DIVISIONS, OTHER THAN THAT OF THE PROBLEM SUBMITTER, WILL BENEFIT AND HOW.**

The results and final products of this research investigation will provide MDOT with more efficient and reliable tools to evaluate the impact of pile-driving induced vibrations to adjacent structures and underground utilities. The design criteria developed will be specific to soil conditions commonly encountered in the state of Michigan, however the developed framework and review will be beneficial to a wide range of applications on a national level. Consultants and MDOT bridge designers will benefit from research based guidance.

**POTENTIAL OBSTACLES**

**WHAT RISKS OR OBSTACLES MAY MAKE CARRYING OUT THIS PROJECT DIFFICULT? WHAT STRATEGIES WILL YOU USE TO OVERCOME THEM?**

Difficulty in collection of research data on active construction projects. Projects with potential research sites must have coordination clauses added to the contract documents. Researchers must be prepared to mobilize quickly.

Difficulty in measuring vibration response of soil underground. May need to use some type of down-hole vibration measurement or modeling.

**POSSIBLE INVESTIGATOR(S)**

**DESIRED QUALIFICATIONS IN AN INVESTIGATOR**

Investigators experienced in the field of soil dynamics with experience in pile-driving operations. In addition, the research team must possess professional experience in application of statistical theory.