# Quarterly Progress Report

| TPF-5(039) | Falling Weight Deflectometer (FWD) Calibration Center and Operational Improvements |
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| Principal Investigator: | Agency: |
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| Reporting Period: | January 1, 2005 through March 31, 2005 |
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| Project Status: (Tasks 1-5) | | |
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| | Work completed through end of period: | 13.3% |
| | Project funds expended: | 12.7% |
| | Expected completion date: | September 8, 2006 |

## *Project summary*

The objective of this project is to update the equipment and procedures for calibration of Falling Weight Deflectometers (a device for measuring pavement deflection response due to a pulse load) incorporating selected technological developments that have occurred since the current calibration protocol was released in March 1994. The research must demonstrate that the new procedures achieve a quality of calibration that is at least as good as the current procedures, while making all necessary updates to the FWD calibration hardware and software. The details of the project are described in FHWA's Statement of Work which is posted at the TPF-5(039) Web site

The contract for Transportation Pooled-Fund Study TPF-5(039), "Falling Weight Deflectometer (FWD) Calibration Center and Operational Improvements," was awarded to Cornell University on September 9, 2004. The Cornell Local Roads Program (i.e., "Cornell") got underway with the project on October 1, 2004, as was projected in the proposal. The expected completion date for tasks 1-5 is September 8, 2006. An optional Task 6 may continue the project for up to three years, through September 8, 2009

## *Activity during the reporting period*

Among the activities during the reporting period were the following.

- Met with the Contracting Officer's Technical Representative (COTR), Eric Weaver, during the Annual Transportation Research Board Meeting in January to discuss the project. The discussion focused mainly on the possible use of accelerometers in FWD calibration. Plans were begun for a meeting of the project Technical Advisory Committee to be held in late April.
- Met with Gary Sanati, Foundation Mechanics, Inc., Ed Trujillo and Eric Prieve, Colorado DOT, at the Colorado FWD Calibration Center to review the applicability of the SHRP FWD Calibration Protocol with the JILS FWD. The meeting took place in Denver on March 16-18. A truck-mounted JILS FWD owned by Colorado DOT was used for the calibration.
- We obtained a set of specifications for the KUAB FWD from ERI, Inc.
- Continued efforts to establish a subcontract agreement with Applied Research Associates. Inc.. At the end of the reporting period both parties were in agreement, but the formal paperwork had not yet been exchanged.
- Created an FWD calibration center in our laboratory at Cornell. This required casting a concrete inertial block, and fabricating an aluminum beam, sensor holder and LVDT holder. After assembly, testing showed that the floor in the lab was too stiff to meet the deflection requirements. An area of the floor was delineated for replacement and a new test pad was designed. At the end of the reporting period a contract was let to build the test pad.
- Began work on installing and testing the FWDREFCL software to be used in the SHRP Calibration Protocol. Some problems were encountered and will be discussed.
- Continued a dialog with the FWD manufacturers seeking their input for improvements in the protocol and discussing specific ideas for changes.
- Continued a review of available products for data acquisition. Prepared an internal report on the products. In mid-March the Keithley-Metrabyte company announced a new family of USB-compatible data acquisition boards, and we are taking a close look at them.

## *Problems encountered during the reporting period*

One problem was the relatively small deflection in the floor in our lab. In Fall 2003 we relocated from the lab where the SHRP Protocol was originally developed. The concrete floor in our new lab is several inches thicker than it was in the old lab. The floor deflections in the new lab are about 200-300 microns (8-12 mils). Test specifications call for a 400-600 micron (16-24 mil) deflection.

To overcome this problem we have designed a new test pad to replace the existing floor. A 9 foot by 9 foot area of the floor will be removed and a 5 inch thick concrete pad will be built. The design should provide a deflection close to 500 microns (20 mils).

A second problem came when the FWDREFCL software was installed in our data acquisition computer in the lab. Several generations of new computers have been purchased since the FWDREFCL software was last used in 1995. We found that the software features that use DMA (direct memory access) would not work in the current computer. All other aspects of the software did work. Investigation of the problem uncovered a message from the company that makes the DAS-16 board, disclosing a possible incompatibility with the chip set in the Dell computer.

To overcome the problem we purchased a mid-1990's Gateway 486 computer. At the end of the reporting period we were setting it up as a DOS computer. We expect that the FWDREFCL program will run, but that has not yet been tested.

## *Work completed by Task*

Our strategy is to work simultaneously on Task 2 and 3. We feel that both the hardware upgrades and the software upgrades interact, and thus it is more efficient to work on the two tasks together.

Task 1. Communication, Coordination and Reference Resources

**Subtask 1a is complete.** All existing protocols, software and drawings of the currently used equipment are in hand.

**Subtask 1b will continue throughout the project.** This subtask provides for a dialog with the FWD manufacturers and the calibration center operators. We feel this dialog should continue for the duration of the project.

Specifications for all four brands of FWDs have finally been obtained. We plan to prepare a brief synopsis, noting the similarities and differences in the four brands. This report will be completed during the next quarter.

We met with Gary Sanati in Denver and reviewed the calibration of a JILS FWD. This was not entirely successful. The calibration factors were unreasonably large. While it was a possibility that the problem was in the calibration center equipment, nevertheless the center calibrated a Dynatest FWD successfully, without any complications, three days later.

The discussions with Gary Sanati were quite fruitful. We identified several small changes needed in the JTEST field program that runs the FWD during the calibration procedure. Mr. Sanati has indicated that he has made the changes and he will make the revised program available to the JILS owners.

Task 2. Modify Calibration Process

In order to compare any changed processes and procedures to the SHRP/FHWA FWD Calibration Protocol, it is necessary to build a complete SHRP calibration center. At the end of the reporting period this effort was nearly completed. This work will be finished early in the next quarter.

**Subtask 2a is continuing.** Efforts during this reporting period mainly involved assessing through a literature review and manufacturers' specifications whether an accelerometer could be substituted for the LVDT as a reference calibration device. A brief internal report on this topic has been written. This work will continue during the next quarter.

**Subtask 2b is continuing.** Efforts during this reporting period assessed the viability of using an accelerometer to trigger the data acquisition system. While this appears to be quite feasible, an alternative strategy would be to use the buffering capability of the data acquisition card to detect that the incoming data signal is changing. The latter approach would not require any added hardware. Many data acquisition card manufacturers offer buffering capabilities, but one manufacturer uses computer memory for this purpose. This could accommodate a substantially larger number of readings, which is attractive. We expect to make a selection of the card early in the next quarter.

**Subtask 2c is continuing.** Efforts during this reporting period assessed the viability of using an accelerometer to detect beam movement. The movement (and attendant acceleration) is quite small, and this may not be feasible. This work will continue during the next quarter.

Task 3. Hardware and Software Upgrades and/or Development

**Subtask 3a is continuing.** The effort during this reporting period mainly involved gathering information on the various types of data acquisition boards that will meet our specifications. A brief internal report on this topic has been written. This work will continue during the next quarter.

**No effort was made on Subtask 3b during this reporting period.** Effort on this task is not scheduled to begin until late summer 2005.

Task 4. Calibration System Testing, Installation and Operator Materials/Training

**No effort was made on Subtask 4a, 4b, or 4c during this reporting period.** Effort on these tasks is not scheduled to begin until late fall 2005.

Task 5. Presentation and Reporting

**Plans were begun for a meeting of the Technical Advisory Committee.** The meeting will be hosted by the New York State Department of Transportation at their headquarters facility in Albany, New York. Meeting dates will be April 27-28.

Task 6. Miscellaneous Support for TPF-5(039)

This task is not included in the current contract. Effort on this task is not anticipated before fall 2006. It will require separate task orders.

## *Work planned during the coming quarter*

Administratively, we expect to complete the establishment of a subcontract with Applied Research Associates. Inc.

Under Task 1 we will continue to seek input from the FWD manufacturer and calibration center operators concerning needed calibration protocol modifications. We will prepare a brief synopsis of our findings from a review of the FWD specifications.

Under Task 2 we will finish the installation of a concrete test pad for performing SHRP/FHWA FWD Calibration. We will also get the FWDREFCL software running on a DOS computer. We will continue our evaluation of various types of accelerometers for use in geophone calibration, triggering and beam movement detection. We anticipate purchasing one or more accelerometers and doing some experimental studies as soon as the new concrete test pad has cured and is ready for use. If it appears that accelerometers can be used, then we will build an accelerometer calibrator.

We also plan to begin to develop several new sensor holder designs that can be used to conduct reference and relative calibration on all geophones simultaneously.

Under Task 3 we expect to finalize our selection of a new data acquisition board and to purchase a unit. We plan to give particular attention to a new board that runs on the USB bus. We will hire a computer programmer who will begin the task of converting the existing FWDREFCL software to work with the new data acquisition board. We may also need to purchase a computer that will have a PCI bus and chip set suitable for running the new board.

Task 4 – No activities planned.

Under Task 5 we will meet with the Technical Advisory Committee in Albany on April 27-28.

Task 6 – Not included in the current contract.

Table 1. Work Schedule and Completed Work

**WORK COMPLETED**

| Task | 2004 Oct | 2004 Nov | 2004 Dec | 2005 Jan | 2005 Feb | 2005 Mar | 2005 Apr | 2005 May | 2005 Jun | 2005 Jul | 2005 Aug | 2005 Sep | 2005 Oct | 2005 Nov | 2005 Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Communication, Coordination and Reference Resources | | | | | | | | | | | | | | | |
| 2 Modify Calibration Processes | | | | TASK 2 | | | | | | | | | | | |
| 3 Hardware and Software Upgrades | | | | | | | | TASK 3 | | | | | | | |
| 4 Testing, Installation, and Training | | | | | | | | | | | | | TASK 4 | | |
| 5 Presentation and Reporting | | | | | | | | | | | | | | | |
| 6 Miscellaneous Support | | | | | | | | | | | | | | | |

| Task | 2006 Jan | 2006 Feb | 2006 Mar | 2006 Apr | 2006 May | 2006 Jun | 2006 Jul | 2006 Aug | 2006 Sep | 2007 FY | 2008 FY | 2009 FY | Percent of Task Completed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Communication, Coordination and Reference Resources | | | | | | | | | | | | | 70 |
| 2 Modify Calibration Processes | | | | | | | | | | | | | 30 |
| 3 Hardware and Software Upgrades | | | | | | | | | | | | | 15 |
| 4 Testing, Installation, and Training | TASK 4 | | | | | | | | | | | | 0 |
| 5 Presentation and Reporting | | TASK 5 | | | Draft Report | TASK 5 | | | Final Report | | | | 0 |
| 6 Miscellaneous Support (not in this contract) | | | | | | | | | | TASK 6 | | | Not in contract |