

Quarterly Progress Report

TPF-5(039)	Falling Weight Deflectometer (FWD) Calibration Center and Operational Improvements	
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Reporting Period:	September 9, 2004 through December 31, 2004	
Project Status:	Work completed through end of period:	9.2%
	Project funds expended:	0.6%
	Expected completion date:	September 8, 2006

Overview

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](#)

Activity during the reporting period

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.

On Friday, September 24, a teleconference was held to discuss:

- Task overview and approach
- Communications Reference Guide
- TAC Selection and Participant feedback

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- FWDUG presentation
- Next PFS meeting

An internal memorandum summarizing the major points of discussion during the teleconference was prepared and distributed via e-mail on September 29, 2004.

The Cornell Local Roads Program (i.e., "Cornell") got underway with the project on October 1, 2004, as was projected in the proposal. During the reporting period the major emphasis was given to *Task 1, Communication, Coordination and Reference Resources*.

Among the activities during the reporting period were the following.

- Participate in the Falling Weight Deflectometer Users Group meeting, October 2-5, in West Lafayette, Indiana. A meeting of the FWD Calibration Center Operators was held on October 3, and during our presentation we began a dialog with the FWD manufacturers and the calibration centers. Further information concerning the discussions at that meeting is provided below under [Work Completed, Task 1](#).
- Participate in the UK/Ireland FWD Users Group Meeting, November 23, in Nottingham, England. We gave a 30-minute presentation on the pooled-fund project during the one-day conference.
- Meet with UK Highway Authority (HA) and Transport Research Laboratory (TRL) representatives in London, England, November 22. The trip to England afforded the opportunity to discuss the procedures that are currently used in the United Kingdom for calibrating FWDs. The HA specifies the procedure and TRL conducts the calibrations on an annual basis. They use a "round-robin" method that compares one machine to another. They do not use a reference calibration procedure, but they expressed interest in adopting the method that we use in the United States.
- Began investigation of using an accelerometer to replace the LVDT that is currently used to measure pavement deformation during FWD calibration. The first step involves a thorough literature review and evaluation of available products and costs. A draft white paper on the use of accelerometers was completed during the reporting period.
- Began the development of a device that can be used to calibrate accelerometers versus known displacements in a cyclic loading system over a range of ground frequencies. Effort to date has involved the design of several alternative devices.
- Discussed staffing with the Applied Research Associates, Inc. to identify suitable individuals who have experience with accelerometers and data acquisition boards.
- Began work on setting up a formal subcontract agreement with Applied Research Associates, Inc.. The Cornell University Office of Sponsored Programs will handle the contractual negotiations on behalf of the Local Roads Program.
- Assembled a complete set of fabrication drawings for the equipment used in the 1994 FHWA/SHRP FWD Calibration Protocol.
- Gathered a complete set of source code files for the existing software, including FWDREFCL and REFLCCAL. These programs are used for FWD calibration and reference load cell calibration, respectively.

- Began work on setting up an FWD calibration station according to the March 1994 protocol in the Cornell Local Roads Program laboratory. Several years ago we made a long-term loan of some of our FWD calibration equipment to a research agency in New Hampshire. Regrettably they disposed of the equipment. We still have the Schaevitz LVDT, Vishay signal conditioner, Metrabyte DAS-16 data acquisition board, and the custom reference load cell. We need to replace the inertial concrete block, the aluminum beam, and the various small metal parts that hold the LVDT and the sensor under test. At the end of the reporting period the metal parts were being fabricated by a local machine shop and the pour of the concrete block was completed. Removal of the forms is scheduled for the first week in January.
- Solicited a complete set of manufacturer's specifications from the Dynatest, JILS, Carl Bro and KUAB firms. At the end of the reporting period a satisfactory response had been received from everyone except the KUAB firm.
- Began a thorough review of available products for data acquisition. Our initial goal is to identify those boards that have at least eight channels of 16-bit a/d input, two channels of d/a output, and can be programmed in C++, Visual Basic, or LabView. After the initial review is completed we plan to seek advice from Applied Research Associates. Inc. before finalizing the board selection.

Problems encountered during the reporting period

Cornell University was uncommonly slow about issuing a project account number. We finally received an account number on October 29. Until that point, no expenditures could be made, and this also delayed the initiation of the subcontract agreement with Applied Research Associates. Inc. As of the end of the reporting period, the Cornell staff salaries were not yet posted on the account. During the coming quarter we expect to get the staff appointments completed, the accounts up to date, and a subcontract agreement with Applied Research Associates. Inc. in place.

Based on our findings so far, it appears doubtful that an accelerometer can be substituted for the LVDT in the calibration procedure. Among several barriers to the use of an accelerometer are the temperature sensitivity and the range of displacements that are involved. The most promising accelerometers that have been investigated so far are the MEMS devices. We are hopeful that we will uncover a suitable device of this type. It does appear at this time that the accelerometer will need to be calibrated on the day of use against known displacement. For this reason we began the development of a suitable accelerometer calibration device after first reviewing the commercially available calibration devices.

Work completed by Task

Nearly all of the effort in this reporting period involved Task 1. The reader is referred to the [Statement of Work](#) at the TPF-5(039) Web site for a detailed description of the activities under each individual task and subtask.

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 is underway. Contact has been made with all four manufacturers, and a contact person for the project has been named by all four companies. Manufacturer's literature and specifications have been obtained from three of the four FWD producers. The fourth set of literature has been promised. A comparative synopsis of the literature will be provided to the COTR as soon as the fourth literature set is obtained.

Contact has been made with each of the four FHWA-sponsored calibration centers, as well as the Indiana DOT and Dynatest calibration centers.

Plans have been made with Gary Sanati, owner of the JILS company, to meet with him during the calibration of a JILS FWD. We plan to go over in detail the modifications of the calibration procedure that are needed in order to calibrate the JILS machine. We will also discuss the needed changes in the JILS field program needed to accommodate the calibration procedure. The meeting will be scheduled when the next JILS machine is calibrated, most likely in February or early March at the Colorado calibration center.

An agreement has been reached with the Carl Bro FWD company to provide the use of the Carl Bro FWD that is currently located in Austin, Texas when it is needed during the development and proving of the new FWD calibration test procedures.

A meeting with the Calibration Center Operators was held on Sunday, October 3, from 1:00 – 4:00 PM in West Lafayette, Indiana, in conjunction with the FWD Users Group Meeting. Representatives of the Minnesota, Pennsylvania, Colorado and Texas calibration centers were present. Manufacturer representatives from Dynatest, Carl Bro and KUAB were also present. The JILS firm was not represented. During the discussion of the TPF-5 (039) project the following suggestions were offered.

- Be aware of export issues surrounding the purchase of accelerometers and related devices.
- The sensor bar arrangement needs to be adjusted so that it will work with all types of FWDs.
- Consider using a shaker table rather than the FWD to provide a load pulse for the geophones. (We explained that a basic tenant of the SHRP protocol is to use a ground wave, rather than a single frequency wave, in the geophone calibration. The objective is to simulate as closely as possible during calibration the use of the FWD in the field.)
- We need to overcome a problem of detecting when the KUAB FWD mass is released. This problem was confirmed by several calibration center operators.
- There is a need to speed up the calibration process. This was advocated by one calibration center, while others expressed a feeling that the current 4-hour cycle was adequate. Concern was expressed by one center operator that we must not become so

worried about speed that we lose a basic understanding of what is going on in the calibration process.

- Several of the FWD manufacturers noted it is likely that a growing proportion of FWD sales will be truck- and van-mounted systems. One center mentioned that they have successfully calibrated a truck-mounted system using the current calibration protocol.

These suggestions will be considered as we redevelop the testing protocol under Tasks 2 and 3.

Task 2. Modify Calibration Process

A first step under Task 2 was to replace the missing equipment needed to be able to perform the current SHRP/FHWA FWD Calibration Protocol. This capability is necessary in order to be able to compare the newly developed procedures to the old, standard procedures. At the end of the reporting period this effort was nearly completed. This work will be finished during the next quarter.

Subtask 2a is underway. 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. This work will continue during the next quarter.

Subtask 2b is underway. 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. This work will continue during the next quarter.

Subtask 2c is underway. Efforts during this reporting period assessed the viability of using an accelerometer to detect beam movement. This work will continue during the next quarter.

Task 3. Hardware and Software Upgrades and/or Development

Subtask 3a is underway. The effort during this reporting period mainly involved gathering information on the various types of data acquisition boards that will meet our specifications. 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

No effort was made on this task during this reporting period. Effort on this task is not scheduled to begin until early 2006.

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 start-up details involving staff appointments to the project and establishment of a subcontract with Applied Research Associates, Inc.

Under Task 1 we expect to complete a white paper on applications of accelerometers to FWD calibration. We expect to finish the gathering of manufacturers' specifications for FWDs and then prepare a comparative summary of the major brands of FWDs. We also expect to witness the calibration of a JILS FWD and seek input from the manufacturer concerning needed calibration protocol modifications.

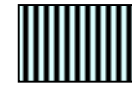
Under Task 2 we expect to get the equipment for performing SHRP/FHWA FWD Calibration procedures up and running, working with the FWDREFCL software. We will continue our evaluation of various types of accelerometers for use in geophone calibration, triggering and beam movement detection. We anticipate purchasing one or more accelerometers and doing some experimental studies. If it appears that accelerometers can be used, then we will build an accelerometer calibrator.

Under Task 3 we expect to finalize our selection of a new data acquisition board and to purchase a unit. 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 suitable for running the new board.

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Table 1. Work Schedule and Completed Work

WORK COMPLETED



Task	2004			2005												
	Month	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
1 Communication, Coordination and Reference Resources			TASK 1													
2 Modify Calibration Processes						TASK 2										
3 Hardware and Software Upgrades																
4 Testing, Installation, and Training																TASK 4
5 Presentation and Reporting																
6 Miscellaneous Support																

Task	2006									2007	2008	2009	Percent of Task Completed	
	Month	January	February	March	April	May	June	July	August	September	FY	FY		FY
1 Communication, Coordination and Reference Resources														55
2 Modify Calibration Processes														12
3 Hardware and Software Upgrades														10
4 Testing, Installation, and Training														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

Effort and Expense to Date

