

**Standard Practice for
Calibrating the Load Cell and Deflection Sensors
for a Falling Weight Deflectometer**

AASHTO Designation: PP7-95^{1,2}

1. Scope

1.1 This practice covers the reference calibration of the load cell and the deflection sensors and the relative calibration of the deflection sensors of a falling weight deflectometer (FWD). It is used to establish calibration factors for correcting FWD measurements.

1.2 This procedure is not applicable to the calibration of cyclic loading and other types of pavement deflection testing equipment.

1.3 Reference calibration are performed at least once per year, or as soon as possible after a deflection sensor has been replaced on the FWD.

1.4 Relative calibration are performed on the deflection sensors at least once per month. It is also to be performed immediately after a deflection sensor is replaced.

1.5 The procedure results in calibration factors which are entered into the FWD software as multipliers. When the FWD measurements are multiplied by the calibration factors the result is a set of measurements which have been corrected to agree with the calibration instrumentation.

1.6 Calibration procedures may vary slightly between FWD manufacturers. It is possible to use this procedure for all types of FWDs with minor modifications of the hardware and of the data acquisition software.

1.7 It is necessary that there be a place in the FWD software to enter the calibration factors.

1.8 To use this procedure, FWDs must have software versions having the pause feature and which allows programming the required number of drops in the test sequence. Furthermore, the load plate must remain down during the drop sequence.

1.9 This practice may involve hazardous materials, operations, and equipment. It does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this practice to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 AASHTO Standards

PP8 Calibrating the Reference Load Cell Used for Reference Calibrations for Falling Weight Deflectometer.

3. Summary of Method

3.1 In this procedure, the deflection sensors and load transducer from the FWD are first calibrated individually against independently-calibrated reference devices. This is called "reference calibration," and can be performed at a Long Term Pavement Performance (LTPP) Regional Calibration Center, or any other properly equipped location.

3.1.1 The FWD load cell is calibrated against a custom made reference load cell which enables the FWD load cell to be calibrated without removing it from the testing equipment.

3.1.2 The deflection sensors are calibrated against a reference Linear Variable Differential Transformer (LVDT) under the same loading as used for testing.

3.2 The calibration of the FWD deflection sensors is further refined by comparing them to each other in a process referred to as "relative calibration". Relative calibration of the FWD deflection sensors is used to ensure that all sensors on a given FWD are in calibration with respect to each other. As such, it serves as the final step in the overall FWD calibration

¹ This standard is based on SHRP Product 5003.

² Approved in October 1994, this provisional standard was first published in March 1995. Reconfirmed January 2000.

process, and as a quick means to periodically verify that the sensors are functioning properly and consistently.

3.2.1 Relative calibration uses the relative calibration stand supplied by the FWD manufacturer. The sensors are stacked vertically in the stand, one above another, so that all sensors are subjected to the same pavement deflection. Relative calibration assumes that the overall mean deflection, as determined from simultaneous measurements by the full set of deflection sensors, yields an accurate estimate of the true deflection. This assumption requires that the deflection sensors must have first been subjected to the reference calibration procedure.

3.2.2 When done in conjunction with reference calibration, the relative calibration procedure shall be repeated at least twice. Acceptance criteria based upon the repeatability of the calibration factor are identified in the relative calibration procedure.

3.3 There is no corresponding relative calibration procedure for the load measurement system.

4. Significance and Use

4.1 Calibration of both the load cell and the deflection sensors provides a means of comparison of results from varying FWD types and manufacturers.

4.2 Calibration ensures consistency in the data collection among various agency FWDs.

5. Description of Terms Specific to the Standard

5.1 FWD Load Cell is the device located under the loading mechanism in an FWD which measures the load response of the FWD system.

5.2 FWD Deflection Sensor is the device used to measure the deflection response for a given load.

These can be geophones, accelerometers or other devices.

5.3 Reference Calibration is the term used to describe the calibration of either the FWD load cell or deflection sensor against a separate reference measuring system. For load cell calibration the reference system is a custom made reference load cell and for deflection sensors it is an LVDT.

5.4 Relative Calibration is the term used to describe a calibration procedure in which the deflection sensors are calibrated relative to one another. No outside reference system is used, the sensors are simply compared to each other.

5.5 Reference Load Cell is a custom made device which can be placed directly beneath the loading plate of the FWD to record the actual load applied by the FWD.

5.6 Data Acquisition System is the system comprised of the signal conditioner, data acquisition board, data acquisition software, computer and cabling.

5.7 Interim Deflection Sensor Calibration Factor is the calibration factor for the deflection sensor resulting from the reference calibration. This factor is later revised based on the results from the relative calibration.

5.8 Final Calibration Factor is the resulting factor derived from the relative calibration procedure. The final calibration is entered into the FWD operating program as the final step in the calibration process.

6. Apparatus

6.1 Facilities - Indoor space with easy access for FWD and towing vehicle, a level floor large enough so that the FWD trailer and the towing vehicle can sit level during the test, a reasonably constant temperature (between 10 and 38°C) and humidity (40-90 percent), heated, but not necessarily air conditioned and good security for the calibration equipment.

6.1.2 Test pad - 4.6 m by 4.6 m (15 ft. by 15 ft.), with a 2.4 meter (8 ft.) wide clear zone around perimeter (for maneuvering FWDs and the reference data acquisition system) having a smooth, crack-free portland cement concrete surface.

Note 1 - A modest amount of hairline cracking is permissible. Should the test pad develop cracks which are visibly open (1.5 mm or more), it shall be replaced.

6.1.3 The test pad must be isolated (by impregnated felt bond breaker, or sawed and caulked joint) from the area where the concrete inertial block supporting the aluminum reference beam will rest.

6.1.4 The test pad shall have a slab deflection of at least 400 microns (16 mils) due to 71 kN (16,000 lb) load at the position of the deflection sensor holder

when the FWD is in the specified position for calibration.

Note 2 - Fatigue calculations indicate that acceptable fatigue life can be achieved with a 127 mm (5 in.) thick portland cement concrete slab resting on an 203 mm(8 in.) open-graded crushed stone base. A layer of filter fabric shall be placed below the base to protect it from intrusion of subgrade fines. To achieve adequate deflections, the subgrade modulus shall be less than 80 MPa (12,000 psi) with bedrock deeper than 7.6-9.1 m (25-30 ft.). Where bedrock exists at depths of 4.6 to 7.6 m (15 to 25 ft.), a subgrade modulus of 50 MPa (7,500 psi) or less will be needed. Test pads located where bedrock is less than 4.6 m (15 ft.) deep are likely to be very sensitive to minor variations in subgrade moisture, and hence are not advisable.

6.1.5 The sensor holder shall be located not closer than 0.6 m (2 ft.) from the edge of the test pad, but it is not required, nor is it possible, that the test pad shall deflect uniformly across the entire area of the pad. Because the inertial block supporting the aluminum reference beam must be placed adjacent to, but not on the calibration test pad, the maximum

possible distance from the sensor holder to the edge of the test pad will be about 1.5 m (5 ft.).

6.2 Equipment - The following equipment is needed in the calibration facility:

6.2.1 Concrete inertial block weighing at least 17.8 kN (4,000 lbs).

6.2.2 1.5 meter (5 ft.) aluminum reference beam.

6.2.3 Air-Cell low frequency rubber isolation pads for support of the concrete block.

6.2.4 LVDT mounting hardware.

6.2.5 Deflection sensor holder assembly.

6.2.6 Magnetic tip for LVDT.

6.2.7 Schaevitz Model GCD-121-125, 3.175 mm (0.125 in.) stroke DC LVDT with Cannon connector, or equal.

6.2.8 Schaevitz metric LVDT calibrator C-41M, or equal.

6.2.9 Measurements Group Inc. Vishay Model 2310 signal conditioner, with factory modification for +15 VDC and -15 VDC excitation, or equal.

6.2.10 Keithly-MetraByte Model DAS-16G A/D data acquisition board, with STA-16 screw terminal board and C-1800 ribbon cable, or equal. The G2 version of the data acquisition board is recommended for IBM PC-XT and PC-AT computers, and compatibles; the GI version is acceptable. A Model μ DAS-16G board shall be used with IBM PS/2 (microchannel bus) computers.

6.2.11 Connecting cables, Vishay to LVDT, Vishay to MetraByte and Vishay to load cell.

6.2.12 Custom Built reference load cell (300 mm diameter, 177.9 kN capacity).

6.2.13 Computer with a 80386 processor or higher, 25 MHz or faster processor speed, co-processor if applicable, minimum of 1 megabyte RAM, 100 megabyte hard drive, an 8-bit expansion slot for the MetraByte board, color monitor, VGA recommended but EGA acceptable, and a printer.

6.2.14 Data acquisition software.

6.2.15 FWD relative calibration stand with as many positions as the number of active deflection sensors.

Note 3 - Drawings of each of the special items of equipment, and cabling diagrams as well as a demonstration version of the data acquisition software "FWDREFCL" software are available from the Long-Term Pavement Performance (LTPP) Division at the Federal Highway Administration, Turner-Fairbank Highway Research Center, McLean, Virginia.

7. Preparation of FWD

7.1 The FWD shall be in good operating condition prior to performing reference calibration. Particular attention shall be paid to cleaning the deflection sensor bases to insure that they seat properly. Also verify that the FWD load plate is firmly attached to the load cell. All electrical connectors shall be inspected and, if necessary, cleaned and firmly seated.

7.2 The FWD shall be at room temperature and should be setup as it is used under normal testing procedures.