CALIBRATION METHOD **WA 2060.5 – 2025**

CALIBRATION OF FALLING WEIGHT DEFLECTOMETERS

1 SCOPE

This method is in general accord with SHRP/LTPP FWD Calibration Protocol March 1994, procedure for calibration of the falling weight deflectometer (FWDs) which was originally developed by the Strategic Highway Research Program (SHRP). This protocol is now administered by the Long-Term Pavement Performance (LTPP) Division in the Federal Highway Administration.

This procedure is written primarily for use with the Dynatest, Carl Bros, KUAB & JILS Falling Weight Deflectometers.

2 SAFETY

This method does not attempt to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this method to establish appropriate occupational health and safety practices that meet statutory regulations.

3 REFERENCES

1. SHRP/LTPP FWD Calibration Protocol – March 1994

2. Test Method WA 326.2 – Pavement Deflection and Curvature – Falling Weight Deflectometer (FWD)

3. Cornell Local Roads Program (2010), *WinFWDCal* version 2.2.14, Cornell Local Roads Program, Ithaca, NY.

4. Orr, D.P. and Irwin, L.H. (2007) “FWD Calibration Center and Operational Improvements: Final Report“, Federal Highway Administration, Washington, DC.

5. AGPT05-11 Austroads Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design

4 DEFINTIONS

4.1 In this method, the deflection and load sensors from the FWD are first calibrated individually against independently calibrated reference devices. These are called the "load cell reference calibration" and the “deflection sensor reference calibration”.

The calibration of the FWD deflection sensors is then further refined by comparing them to each other in a process referred to as the "relative calibration". The relative calibration is done as a final step in conjunction with the performance of the deflection sensor reference calibration, or it can also be carried out alone, at any suitable location as a check of the performance of the FWD. There is no corresponding relative calibration procedure for the load measurement system.

4.2 The above procedures result 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 measurement, which has been corrected to agree with the calibration instrumentation. It is necessary that there be a place in the FWD software to enter the calibration factors. This is the responsibility of the FWD manufacturer.

4.3 To use this procedure, Dynatest FWDs must have Edition 10 or higher software. A calibration should be performed immediately after a deflection sensor has been replaced on the FWD.

Note: Due to the distances required in some instances to travel to a calibration facility, a reference calibration should be performed as soon as practicable after replacement of a deflection sensor.

4.5 The final stage of the FWD calibration, in addition to the reference and relative calibration procedures described above, comprises an operational test. The operational test will be conducted on a designated pavement. The intent of this test is to validate the performance of the FWD in its full operating configuration on a pavement with known Deflection and Curvature properties.

5 APPARATUS

5.1 Equipment Preparation

5.1.1 The FWD must be in good operating condition before a calibration will be performed. The pre calibration check list at Appendix D must be filled in and signed by the FWD operator and faxed to the MRWA Calibration Centre at least 1 week prior to the scheduled calibration.

5.1.2 The FWD should be at room temperature. If the FWD has been outdoors at a very low or a very high temperature, sufficient time should be allowed for it to equilibrate to room temperature.

Note: Overnight conditioning in the FWD facility is recommended.

5.1.3 A series of 60 warm-up drops shall be performed immediately prior to beginning calibration, to ensure that the rubber buffers have been thoroughly warmed up.

5.1.4 Set the FWD mass and each of the four drop heights to produce loads within ±10 percent of 27, 40, 53, and 72 kN (6, 9, 12, and 16 kips). These loads are required for the Carl Bros, Dynatest and KUAB Falling Weight Deflectometers. The mass required for the JILS

FWD is +/- 10% of 40, 53, 67 and 80 kN (9, 12, 15 and 18 kips).

Notes:

1. For the Dynatest FWD, it is possible to be within this tolerance for the highest load, and yet to have the drop height set too high. *Before* placing the reference load cell under the load plate, and with the mass positioned at the fourth drop height (the highest position), verify that there is at least a 10.2 cm (4 in) clearance between the highest point on the mass sub-assembly and the underside of the brace between the two columns that surround the cylinders that raise and lower the load plate. If the clearance is too small, reposition the target for the fourth drop height to achieve the required clearance. This should assure that there will be adequate clearance when the reference load cell is in position under the load plate.

2. kips – kilo pounds (measure of force).

5.1.5 Before beginning any reference calibration testing verify that the "peak smoothing" processor has been turned off.

5.2 Procedure

5.2.1 The FWD load cell should be calibrated at least twice. Multiple calibration tests are performed on the load cell, and the results are averaged. Acceptance criteria based upon the repeatability of the calibration factor are identified in the load cell calibration procedure. If the results persist in failing the acceptance criteria, then the cause of the erratic results should be identified and corrected.

5.2.2 Each deflection sensor shall be calibrated once. The deflection sensors are calibrated together in the calibration frame. No spare sensors are calibrated under this revised calibration procedure.

5.2.3 A sample reference calibration setup screen for the Dynatest FWD with Edition 10 or Edition 20 software is given in Figure 1. The information in Figure 1 can also be used as the basis for setup of Dynatest FWDs running Edition 25 and higher software.

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Reference Calibration

1.  Test UNITS...: lbf.mil.inch              (kPa.mu.mm)
2.  Temperature...: Fahrenheit               (Centigrade)
3.  Stn.Request...: OFF                      (ON)
4.  Test Checks...: NONE                     (Decreasing defls, Roll-Off, RollOFF+Decr)
5.  Reject prompt.: OFF                      (ON)
6.  Stationing....: [Doesn't matter]
7.  Temp.Request..: OFF                      (ON)
8.  Cond.Request..: OFF                      (ON)
9.  Variation: Load NOT Checked!             Deflections NOT Checked!
10.Diameter of Plate: 11.8
11.Deflector distances: [Doesn't matter.     Keep what you have.]
12.Drop No 123P4P5P6P7P8P9P0P1P2P3P4P5P6P7P8P9P0P1P2P3P4P5P6P7S...
13.Heights CCCP1P1P1PIP1PIP2P2P2P2P2P2P3P3P3P3P3P3P4P4P4P4P4P4P11111111111
14.Test Plots: ..........................................................
15.Save Peaks: ...*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*.*..........
16.Load His: ..........................................................
17.Whole His: ...........*.........*.........*..........*...................
18.Load another TEST SETUP.
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Figure 1 - Reference Calibration Test Setup for the Dynatest FWD

5.2.4 A complete summary of the data to be recorded is given in Table 1. Before beginning to perform the calibrations, FWD-specific information should be recorded via printouts from the FWD data acquisition program screens (e.g., showing the

Table 1 - FWD Calibration Data Reporting Requirements

Data Item	Mode of Entry	Source [1]
FWD Operator Name	PDDX file *	FWD operator
Calibration System Operator Name	Automatic	Centre Configuration File
Date and Time of Calibration	Automatic	Computer Clock
FWD Serial/ID Number	PDDX file	FWD Computer
FWD Manufacturer	PDDX file	FWD Computer
FWD Owner	Manual	Operator
FWD Load Cell Serial Number	PDDX File	FWD Computer or Operator
FWD Deflection Sensor Serial Numbers	PDDX file	FWD Computer or operator
Reference Load Cell Serial Number	Automatic	Configuration File [2]
Reference Accelerometer Serial Number	Automatic	Configuration File[2]
FWD Calibration Centre Location	Automatic	Configuration File[2]
Current Calibration Factor for FWD Load Cell	PDDX file	FWD Computer
Current Cal. Factors for FWD Deflection Sensors	PDDX file	FWD Computer
Ref. Load Cell Calibration Constants	Automatic	Configuration File[2]
Ref. Load Cell Calibration Date	Automatic	Configuration File[2]
Ref. Accelerometer Calibration Constants (daily)	Computed	WinFWDCal Software
Ref. Accelerometer Calibration Date/ time	Automatic	Calibration Computer
FWD Load Cell Readings (24 total)	PDDX file	FWD Computer
Ref. Load Cell Readings (24 total)	Computed	Calibration Data Acquisition System
FWD Deflection Readings (40 total)	PDDX file	FWD Computer
Ref. Accelerometer Readings (40 total)	Computed	WinFWDCal Software
Interim Cal. Factors from Reference Calibration	Computed	*WinFWDCal* Software
FWD Relative Calibration Data	PDDX file	FWD Computer
Calibration Factors from Relative Calibration	Computed	*WinFWDcal* Software
Final Calibration Factors		*WinFWDCal* Software

[1] For SHRP FWDs. Source may be different for FWDs from other manufacturers.
[2] Reference calibration configuration file (**FWDREFCL.CNF**).

deflection sensor serial numbers and calibration factors, load cell serial number, calibration factor, and sensitivity, and voltage screens from the Dynatest software), which have been annotated with the date and FWD identification information (i.e., FWD model and serial number).

Note: The above information may be stored in electronic format with a copy retained on the clients calibration file.

5.2.5 Locate the calibration data acquisition system as close as possible to the FWD computer so that the two systems operators will be able to converse easily. Load the reference calibration software **WinFWDCal** into the reference system computer. Directions for performing reference calibration using this software are provided in the **WinFWDCal** User's Guide.

6 FWD LOAD CELL CALIBRATION

6.1 Calibration Procedure

6.1.1 If the reference load cell has not been calibrated within the last 24 months, then it must be recalibrated in accordance with the procedure given in Appendix A before proceeding with the FWD calibration.

6.1.2 All equipment must conform to the requirements specified in Appendix A.

6.1.3 Prior to commencement of the calibration, the Falling Weight Deflectometer should be warmed up using the standard operating procedure for the brand of FWD.

6.1.4 An electronic copy of the existing calibration factors entered in the FWD Field Program shall be obtained from the FWD operator. The warmup file from the FWD will contain all the required information (F20 or F25 File Format).

6.1.5 Attach the cable from the signal conditioner to the reference load cell, turn on the signal conditioner,

and allow the system to warm for the required period as prompted by software application.

6.1.6 Initialise the computer data acquisition program. This will include entry of operator names, FWD serial number, FWD load cell serial number, and its current calibration factor.

6.1.7 Ensure that the FWD computer and the Calibration computer are registering the correct date and time and correct if necessary prior to proceeding.

6.1.8 Position the FWD trailer on so that the load plate is near the centre of the test pad. Ensure there is no sand or other loose debris under the reference load cell or on the load cell or rubber test pad.

6.1.9 Position the reference load cell beneath the FWD load plate, making sure that the three guides are aligned around the plate. Zero the signal conditioner with the load plate raised, so that there is no external load on the reference load cell.

Note: For accurate results it is critically important that the reference load cell be zeroed with the FWD load plate in the raised position. Also, the signal conditioner excitation and gain must be set exactly to the levels at which the reference load cell was calibrated.

6.1.10 The WinFWDcal software will advise the centre operator on the recommended number of replicate drops that are required for the selected load levels. More than the recommended number of drops may be used, but not to exceed ten drops per load level. The same number of drops is to be used at each load level.

Note: The plate should not be raised at any time during the sequence. Data from both the FWD load cell and the reference system should be recorded for all drops except the three seating drops.

6.1.11 Perform the load cell reference calibration twice. If the two calibration factors agree within 0.003, then the results of the two tests shall be averaged. If they are outside this limit, then a third calibration of the load cell shall be performed. If the standard deviation of the three results is less than 0.0030 (based on n – 1 degrees of freedom) then the three results shall be averaged. If the standard deviation exceeds 0.0030, then all three-calibration factors shall be discarded, and the load cell calibration procedure should be repeated. If the repeat procedure is also unsuccessful, the calibration should be abandoned and repairs carried out as necessary.

6.1.12 At the completion of the calibration testing, raise the FWD load plate and remove the reference load cell.

6.2 Load Cell Calibration Acceptance Criteria

6.2.1 The *WinFWDCal* Software will calculate and display the gain factors and the standard errors. The presence of any of the following conditions invalidates the load cell calibration test results:

- Excessive noise messages. For the low drop height, e.g. the 6,000 pound (27 kN) load level, there is seldom enough free fall time for the vibration caused by the release of the mass to attenuate before the mass strikes the plate. Thus excess noise messages at the low drop height may, in general, be disregarded. The noise, due either to electrical noise or mechanical vibrations, is of concern only if it results in an erroneous zero value or an erroneous peak reading. For drop heights 2, 3 and 4 the time history graphs provided by the *WinFWDCal* software should be viewed to determine if the noise is of concern before rejecting the calibration.

- The standard deviation of the five readings at any drop height that differ by more than a factor of three from the reference system data set and the FWD data set.

- Standard error of the adjustment factor (see Reference Calibration Data Analysis) in excess of 0.0020.

- Failure to satisfy the repeatability criteria outlined at 6.1.9 for multiple calibration tests.

6.2.2 Should any of these conditions occur, the load cell calibration test procedure must be repeated after identifying the source of the problem and correcting it. Repeat testing shall only be carried out once.

6.2.3 If the above criteria are all satisfied the Final Load Cell Calibration Factor shall be entered in to the FWD Field Program.

7. FWD DEFLECTION SENSOR CALIBRATION

7.1.1 Prior to removal of the Geophones from the Deflection sensor Holder, the deflection sensor spacing's must be checked to verify that Deflection Sensor spacing's conform to: Table (2) – Deflection Sensor spacing's

Table 2: Deflection sensor spacing's

Number of deflection sensors	Sensor spacing's (mm) (measured from the centre of the applied load)
7	0, 200, 300, 400, 600, 900, 1500
9	0, 200, 300, 400, 500, 600, 750, 900,1500

NOTE: Sensors to be placed to a position within +/- 5 mm of Table 2.

7.1.2 A transferrable oil or substance such as '*glycerol*' can be placed onto the deflection sensor housing bracket (also referred to as the Geophone clamping disk) whilst in the raised and locked position. The raise/lower assembly can then be lowered onto the markable surface (such as a wooden plank surfaced with paper card). Once the surface has been marked raise the assembly and remove plank. Use of a 2 metre steel rule or tape is required to measure and record deflection sensor spacing's.

7.2 Accelerometer Calibration Procedure

7.2.1 Initialise the computer data acquisition program. This includes entry of the operator names, FWD serial number, FWD deflection sensor serial number, and its current calibration factor. An electronic file containing the current calibration factors will be obtained from the FWD operator. The file from the initial warm up test prior to commencement of calibration will be used to obtain the current calibration factors.

7.2.2 Prior to commencement of the geophone calibration (reference calibration), the accelerometer mounted in a protective box, shall be calibrated using the calibration platform. The platform shall be carefully adjusted using the bubble level to assure that the accelerometer is aligned with the Earth's gravity field.
The accelerometer is calibrated in both + 1 g and – 1 g fields by inverting the accelerometer box briefly during the calibration procedure.

Care **MUST** be taken, so as to avoid dropping and causing possible damage, to the accelerometer at all times.

The ***WinFWDCal*** software will guide the Centre operator through the accelerometer calibration procedure and calculate the calibration coefficients. The accelerometer calibration is valid for a **maximum period** of four hours.

7.2.3 The accelerometer box should ***not*** be inverted to negative 1g for more than **20 seconds** during the calibration process to minimise the effects of hysteresis on the readings. If it is inverted for longer than 20 seconds the calibration process should be aborted, and the accelerometer placed in an upright (positive 1 g gravity field) for a period of no less than four times as long as it was inverted, up to a maximum of 24 hours, to return to equilibrium. For example, if unit is turned upside down for 1 minute, then the unit shall be allowed to rest for a period of four minutes before attempting to repeat the calibration.

7.2.4 The accelerometer calibration is temperature sensitive, so it is important that the accelerometer be calibrated shortly before use. The temperature is monitored continuously by the ***WinFWDCal*** Software and the Centre Operator will be **alerted** if the temperature changes by more than **10 degrees Celsius**.

7.3 Deflection Sensor Calibration

7.3.1 Obtain the Deflection Sensor calibration factors from the FWD operator in electronic format.

7.3.2 Ensure that the FWD Field Program is set to provide full history data.

7.3.3 Position the FWD trailer so that the load plate is close to the deflection sensor stand. It is important, however, that the FWD should not come in contact with the deflection sensor stand or any other part of the reference system during the testing.

7.3.4 Remove the deflection sensors from their holders on the FWD beam and verify that they are free of dirt and grime that would adversely affect their seating in the reference system deflection sensor stand.

Note: Refer to Pre-calibration Checklist.

7.3.5 Place the deflection sensor stand in the Ball joint base anchor and tighten the Allen screws evenly to leave an approximate 1 mm gap of either side of the Ball joint Base. Ensure the deflection sensor stand can move freely, but is not loose.

7.3.6 Attach the accelerometer to the Deflection sensor stand as soon as possible post calibration.

7.3.7 Place the deflection sensors in the stand as per the diagram on the screen of the calibration computer (see table 6 below). Use a gentle downward pressure on the handles of the calibration stand while the reference calibration is being performed.

7.3.8 Ensure the deflection sensor stand is kept vertical as indicated by a bubble level.
During all trials the sensor stand will be held by person while the drops are being made. For the first reference calibration trial the previously determined series of drops are made and recorded.

7.3.9 Before the second trial invert the sensors as per the reference diagram on the calibration computer screen (refer table 3 below), and repeat the same sequence of drops as per trial 1 and record data.

7.3.10 Transfer the FWD data, electronically to the calibration centre computer. The ***WinFWDcal*** software will compare the FWD output (independent variable) versus the reference deflection sensor (dependent variable) forced through zero for each calibration trial.

Table 3 - Deflection Sensor Positions in Single Column Stand (9 sensors)

Stand Position	Trial 1	Trial 2
A (top)	Empty	D9
B	D1	D8
C	D2	D7
D	D3	D6
E	D4	D5
F	D5	D4
G	D6	D3
H	D7	D2
I	D8	D1
J (bottom)	D9	empty

7.3.9 Before the second trial invert the sensors as per the reference diagram on the calibration computer screen (refer table 3 above), and repeat the same sequence of drops as per trial 1 and record data.

7.3.10 Transfer the FWD data, electronically to the calibration centre computer. The ***WinFWDcal*** software will compare the FWD output (independent variable) versus the reference deflection sensor (dependent variable) forced through zero for each calibration trial.

8. DEFLECTION SENSOR CALIBRATION ACCEPTANCE CRITERIA

8.1 The Win ***FWDCal*** software will calculate and display the Interim Gain Factors and the standard errors for each sensor.

- The presence of any of the following conditions invalidates the deflection sensor test results.
- Standard deviations of the two readings at any drop height that differs by more than a factor of three between the reference system data set and the FWD data set.
- Standard error of the adjustment factor (see Reference Calibration Data Analysis) in excess of 0.0020.

8.2 Evaluate each data set with respect to the acceptance criteria given in the preceding sections.

8.3 Should any of the above conditions occur, the calibration test for the deflection sensors **must be repeated** after identifying the source of the problem and correcting it. If the deflection sensors do not satisfy the criteria after retesting on **two** occasions, a third calibration trial shall be carried out.

8.4 If, for each sensor, the standard deviation of the three calibrations (six acceptable trials) is not more than 0.003 the average of all six results should be used as the Interim Gain Factors for the deflection sensors and the reference calibration test is completed. **If this criterion cannot be met the calibration process is then terminated**.

9. REFERENCE CALIBRATION DATA ANALYSIS

9.1 Analyse the data as follows (calculations are done automatically by the ***WinFWDCal*** software).

9.2 Perform a least squares regression forced through zero for all of the data for each measurement device (i.e., 20 to 40 pairs of data per test –5 to 10 replicates at each of 4 load levels). The result of this regression will be the coefficient for an equation of the form $Y = m X$, where Y represents the response of the reference system, X represents the response of the FWD measurement device, and m is the slope of the regression line. Both X and Y should be measured in the same system of units.

9.3 The coefficient, ***m***, determined in step A, represents the adjustment factor for the calibration factor in the FWD Field Program. The new calibration factor is computed by multiplying the former calibration factor by the coefficient m from step A. This is listed as the new calibration factor on the ***WinFWDCal*** report.

9.4 Enter the acceptable calibration factors for all sensors (load and deflection transducers) in the FWD Field Program before continuing with the relative calibration. The new calibration factor for the FWD ***load cell*** is a ***"final"*** calibration factor, while the new calibration factors for the ***deflection sensors*** are **"interim"** factors, which will be further refined by doing relative calibration.

10. DEFLECTION SENSORS RELATIVE CALIBRATION PROCEDURE

10.1 The 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 process.

10.2 The relative calibration procedure uses the same deflection sensor stand as that used in the deflection sensor reference calibration. The ***WinFWDCal*** software will adjust the data collected in the relative calibration, using the interim calibration factors internally. The FWD operator **shall not** enter the interim factors in the FWD operating system until completion of the relative calibration.

10.3 Two trials are performed. For each trial, forty drops are applied from the highest drop height used in the **reference** calibration. For the first trial the sensors are not moved from the position they were in during the reference calibration.

10.4 For the second trial, the positions in the deflection sensor stand are reversed in accordance with Table 6. On completion of the 40 drops, the ***WinFWDCal*** software will calculate and display an adjustment ratio for each of the deflection sensors, when multiplied by the interim gain factor for each sensor a final gain factor for each sensor is achieved.

10.5 The graphs for each of the two relative calibration trials should be visually scanned to detect outlying results (which may indicate a loose sensor in the stand).

10.6 ***WinFWDCal*** also scans the data and averages the two results to give a single set of final gain factors. If the results of either relative calibration trial are not accepted, then both trials shall be rejected and two additional trials should be done. If acceptable results cannot be obtained after six trials, **if this criterion cannot be met, the calibration process is then terminated**.

11. VALIDATION AND ACCEPTANCE OF FINAL RESULTS

Before accepting the load cell and deflection sensor Final Gain Factors, the factors should be evaluated with respect to three criteria.

1. The final Gain Factors form this calibration should be compared to the corresponding gain factors from the previous calibration (i.e., the initial gain factors). There should be no more than one percent difference, either higher or lower for each individual deflection sensor and for the load cell. If this criterion is satisfied, then the set of final gain factors should be accepted. If this criterion is not satisfied, then evaluate the next criterion.
2. All of the final Gain Factors should fall within the range of 0.980 to 1.020. If this criterion is satisfied, then the set of Final Gain Factors should be accepted. If this criterion is not satisfied, then evaluate the next criterion.

3. If a historical record of previous calibrations is available for a period of four years or more and there are at least three previous calibration results over this period

of time, then the time rate of change of each final gain factor should be no more than 0.1 percent per year. The ***WinFWDCal*** software will assist with determining the rate of change.

12. OPERATIONAL TEST

An operational test in accord with Test Method WA 326.2 shall be conducted on ten clearly delineated pavement test sites on the Operational Test Pad at MRWA Materials Engineering Branch. The tests shall be conducted at a drop stress of 700 kPa ± 50 kPa and the peak smoothing function shall be turned on.

The testing shall comprise of 1 test at each site. The operational testing must be completed on the same day as the reference and relative calibration procedures.

Raw Dynatest FWD test data will be copied to a USB storage device immediately after the testing is completed for processing. Carl Bros, KUAB & JILS FWD processed data will be copied to a USB storage device immediately after the testing is completed. The Average normalised Deflection and normalised Curvature values for the ten test sites will be assessed against the relevant acceptance criteria.

The acceptance criteria applicable to the operational test are;

Average Normalised Deflection (D_o) shall be in the range;

0.160 – 0.188 mm

Average Normalised Curvature ($D_o – D_{200}$) shall be in the range;

0.037 – 0.057 mm

13. DISTANCE METER

13.1 The Falling Weight Deflectometer must have a distance measuring device capable of measuring 500 metres to within ±1 metre.

13.2 A verification test to confirm the accuracy of the distance measuring instrument will be carried out on a 500m surveyed section of road. Glassford Road in Kewdale is suitable for that purpose.

13.3 A calibration certificate will only be issued if the FWD distance meter complies with the requirements described at 13.1.

14 THERMOMETERS

Thermometers used as part of the test procedure must have appropriate calibration certificates.

15. REPORTS

The full FWD calibration report shall consist of the following:

- Printouts (or electronic copies) of the following FWD Field Program screens.
- Load Cell Calibration
- Each of the above printouts is to be annotated with the FWD unit identification (e.g., manufacturer's serial number and agency ID), and the calibration date.
- All printouts (or electronic copies) from the ***WinFWDCal*** software.
- The final printouts (or electronic copies) from the ***WinFWDCal*** software for all relative calibration trials.
- The Final Calibration Computation worksheet
- Operational Test report.
- Thermometer calibration checks
- Distance Meter check.

16 CALIBRATION REPORT EXPIRY

The FWD Calibration report issued to the client is valid for a period of 6 months from the date of the Calibration. The FWD owner, model, serial number, date of calibration and calibration expiry date will be listed on the Main Roads WA web site.

The Calibration expiry date will be extended for up to a further 6 months if a compliant Operational Test is completed within the expiry date of the Calibration report.

17 ISSUING AUTHORITY

Document Owner
Pavements Manager

18 **REVISION STATUS RECORD**

Page No.	Section	Revision Description / Reference
6	16	Amended expiry period

APPENDIX A

REFERENCE CALIBRATION EQUIPMENT AND FACILITIES

A.1 Facilities

Indoor space with:

- Easy access for FWD and towing vehicle.
- Level floor large enough so that both the FWD trailer and the towing vehicle can sit level during the test and be enclosed indoors.
- Reasonably constant temperature (between 50 and 100°F) and humidity (40-90 percent), heated, but not necessarily air-conditioned.
- Good security for calibration equipment

A.2 Test pad

a) The Test Pad shall be 4.57 meters by 4.57 meters, with a 2.44 meter wide clear zone around perimeter (for manoeuvring FWDs and the reference data acquisition system).

b) Smooth, crack-free Portland cement concrete surface. A modest amount of hairline cracking is permissible. Should the test pad develop cracks that are visibly open (1.6 mm or more), it should be replaced.

d) 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. The sensor holder should be located not closer than 250 mm or more than 350 mm from the edge of the test pad but it is not required, nor is it possible, that the test pad should deflect uniformly across the entire area of the pad.

Notes:

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

2. 1 mils = 0.0254 millimetres. **One mil =** A unit of length equal to one-thousandth of an inch, a millilitre, or one cubic centimetre.

A.3 Equipment

a) Isolated concrete test pad used for generating pavement deflections in the desired range for calibration.

b) Deflection Sensor Calibration Stand and hardware sets designed to work with Dynatest, JILS & Carl Bros geophones.

c) Ball joint and anchor assembly designed for holding the Geophone calibration stand.

d) Reference accelerometer with signal cable. +/- 5 g maximum recorded acceleration, (2) point calibration conducted on day of use with guidance from the 'WinFWDCal' software as referenced in section 7.2 of this method.

Note:

Accelerometer to be calibrated by the National Measurement Institute in accordance with 'AUV NMI Project Operations Manual'. Relevant test methods AUV-VP-06 and AUV-VP-15 (based on ISO16063 Parts 16 & 21). To be performed at least once every 24 months.

e) Accelerometer calibration platform, used for the daily calibration of the accelerometer. And also used to store the accelerometer in a +1 g field.

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

g) Keithley- KUSB-3018 data acquisition board with cables to convert the analog output signal into a 16 bit digital value. Connected to the Vishay and calibration computer.

h) FWD reference calibration software (FWDREFCL) and documentation.

i) Custom built reference load cell of 300 mm diameter, 180 kN (30,000 lb) maximum capacity calibrated annually in accordance with calibration method WA2060.4 – 2013 and supplied with NATA endorsed certification.

j) Connecting cable, Vishay to load cell.

Note: Drawings of each of the special items of equipment, and cabling diagrams, are available from the Long-Term Pavement Performance (LTPP) Division at the Federal Highway Administration, Turner-Fairbanks Highway Research Centre, McLean, Virginia.

k) Computer hardware compatible with operational software for the purposes of field operation and calibration.

APPENDIX B

SAMPLE COMPUTATION OF FINAL CALIBRATION FACTORS

	Final Calibration Factors				
	From Relative Calibration			Average Final	Standard
Sensor	Trial 1	Trial 2	Trial 3	Calibration Factors	Deviation
1	1.014	1.011	1.015	1.013	0.0021
2	1.010	1.007	1.012	1.010	0.0025
3	1.012	1.010	1.013	1.011	0.0015
4	1.016	1.020 *	1.017	1.018	0.0021
5	1.017	1.018	1.018	1.018	0.0006
6	1.008	1.013 *	1.011	1.011	0.0025
7	1.012	1.012	1.009	1.011	0.0017
8	1.010	1.0071	1.012	1.010	0.0025
9	1.016	1.020	1.017	1.018	0.0021

Notes:

1. If the results from the first two trials agree within 0.003 for each deflection sensor, then it is not necessary to perform a third test. Average the results of the first two trials, and enter the average final calibration factors in the FWD computer. In the example above, after Trial 2 the data marked (*) did not meet this criterion.

2. If three trials are performed, compute the mean and the standard deviation of the three results for each deflection sensor. If the standard deviations (based on n – 1 degrees of freedom) are all less than 0.0030, enter the average final calibration factors in the FWD computer. If any of the standard deviations exceed 0.0030, repeat the entire relative calibration test.

3. After the “Final Calibration Factors “ have been entered into the FWD Field Program validation testing is conducted if there are any changes to the Initial Calibration Factors. The criteria described in Section 12.3 must be satisfied by the Validation data and the Final Calibration Factors. If the criteria are not satisfied repairs must be carried out to the FWD before further calibration testing is undertaken.

APPENDIX D

FALLING WEIGHT DEFLECTOMETER PRE-CALIBRATION CHECKLIST

Fill out and send this checklist to the calibration centre at least one day prior to the calibration date. Your signature below indicates that you have met all of the pre-calibration requirements.

FWD Operator: _____

FWD Manufacturer / Serial/ID Number: _____

FWD Owner: _____

☐ Client to supply a purchase order for the FWD calibration prior to the commencement of the calibration.

☐ Inspect all connections, fittings, and cables. Repair or replace those which are damaged.

☐ Ensure that your load plate swivel is properly lubricated, if applicable, all bolts are tight. Refer to equipment manual for instructions. Verify that the load plate has a 300 mm diameter. Remove rear sensor extension bar.
Remove, clean and inspect all deflection sensors and signal cables prior to calibration. Remove any stones that may be embedded in the load plate rubber pad.

☐ Provide a USB thumb drive for transfer of the FWD data to the Calibration Centre computer.

☐ Store your operating manuals in the FWD vehicle, in case of any unforeseen problems.

☐ Check the integrity of all batteries with a hydrometer or load tester. Check battery terminals for corrosion and clean if necessary.

☐ Check hydraulic fluid level(s) and ensure they are at the correct fill point. Inspect the hydraulic system for any leaks and repair before presenting for calibration. (The hydraulics should be bled on a regular basis to reduce noise in the system)

☐ Verify that the required test setups are programmed into the FWD software for both Reference and relative calibration. Name and save the setup files.

Adjust or calibrate the FWD to achieve the target levels within ± 10 percent

☐ Dynatest FWD US Customary (lbf) 6000, 9000, 12,000 and 16,000 Metric (kN) 27, 40, 53 and 72

☐ JILS FWD US Customary (lbf) 9000, 12000, 15,000 and 18,000 Metric (kN) 40, 53, 67 and 80

Generator Revs _____ Geophone Pressure (psi) _____

Load Cell Pressure (at Calibration) (psi) _____ Load Cell Pressure (Field Testing) (psi) _____

☐ Turn off (smoothing) in the FWD Operating System. Have data files and/or hardcopies from the previous calibration(s) available. Smoothing is turned on for the Operational Test.

Operator's signature: _____ DATE: _____