



**INDIANA DEPARTMENT OF TRANSPORTATION  
DIVISION OF MATERIALS AND TESTS**

**LWD – VERIFICATION PROCEDURE  
ITM No. 521-24**

**1.0 SCOPE.**

- 1.1 This test method covers the procedure or performing the LWD Verification Test used in ITM 508.
- 1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The ITM user is responsible for establishing appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.
- 1.3 This ITM applies to the Zorn Model only.
- 1.4 The Geotechnical Engineering Division will establish the verification of lightweight deflectometer (LWD) deflection measurements under defined conditions. These procedures have been customized to meet INDOT conditions while complying with the overall process detailed in ASTM E2835 Section 8.

**2.0 REFERENCES.**

- 2.1 **ASTM Standards.**  
E2835 Standard Test Method for Measuring Deflections Using a Portable Impulse Plate Load Test Device
- 2.2 **ITM Standards.**  
508 Field Determination of Deflection using Light Weight Deflectometer

**3.0 TERMINOLOGY.** Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

**4.0 SIGNIFICANCE AND USE.** This ITM shall be used as follows:

- 4.1 Immediately upon receipt of a newly purchased device
- 4.2 Immediately after full calibration
- 4.3 After significant repairs

**4.4** Annually

**4.5** When measurements are no longer repeatable or are questionable.

## **5.0 APPARATUS.**

**5.1** “Concrete Foundation” is the testing platform used during verification testing. A smooth, sound concrete floor located in an indoor, temperature-controlled location shall be used.

Note 1: Subsurface drainage and foundation soil types may influence results due to changes in pore water pressure.

**5.2** “Test Section” allow deflection measurements to range between 0.2 mm and 0.7 mm when placed on the concrete foundation. The minimum test pad dimension is no smaller than 1.0 times the LWD load plate diameter. Nitrile rubber FWD pads (300mm, Part Number 1002384) from Dynatest, Inc. may be effective on some foundations. Rubber pads of other thicknesses and configurations may be used to accomplish the required verification deflections. There should be four test pads.

**5.3** Record the air temperature of the room where the test is being performed.

## **6.0 PROCEDURE.**

**6.1** Measure the drop height and adjust according to ITM 508 Section 5.1.

**6.2** Clean LWD rod with soft cotton cloth.

6.2.1 Record any bearing drag on the data collection sheet.

**6.3** Place test pads on the concrete foundation as specified in 5.0.

**6.4** Position load plate on center of test pad. The plate should not move laterally.

**6.5** Perform 12 falling weight load pulses to seat and precondition as shown in Configuration 1. This data is not recorded.

**6.6** Perform four tests, with each test consisting of three drops. These tests will be performed on pad number 1. These four tests are all recorded. Use the following procedure for each load pulse:

6.6.1 Adjust guide rod to vertical.

6.6.2 Raise falling weight to preset drop height.

6.6.3 Snap falling weight into fix and release mechanism.

- 6.6.4 Release falling weight and allow it to fall freely.
- 6.6.5 Catch falling weight after rebound. If the catch is missed, the test should be repeated.
- 6.6.6 Snap weight into fix and release mechanism after rebound for the next drop.
- 6.6.7 Repeat steps 6.6.2-6.6.6 until three drops have been performed.
- 6.6.8 Use “INDOT ITM xxx LWD Verification ” Excel spreadsheet for data collection and analysis. Record individual deflections and average deflection results of the LWD Test.
- 6.6.9 Repeat steps 6.6.2-6.6.8 until you have completed all four tests for Combination 1.
- 6.6.10 Record all the data for Combination 1. There should be a total of 12 individual deflections and 4 average deflections.
- 6.6.11 Do not perform any seating drops between the Tests.
- 6.6.12 Retest (3 drops) if a “wild” result occurs and record the “wild” data in the “Wild Data Excluded” section. Record the retest data in the test section that was tested.
- 6.6.12.1 The “wild” results are defined as a +/- 10% between any 2 consecutive readings in a set of 3 drops
- 6.6.12.2 The maximum deflection between the two pad combinations should not be more than double.
- 6.7** Record resulting peak deflection values.
- 6.8** Complete the following calculations to determine the verification of deflection measurements for the recorded combination:

$$S_{\max} - S_{\min} \leq 0.04 \text{ mm}$$

$$|S_{\text{mean}} - S_{\min}| \leq 0.02 \text{ mm}$$

$$|S_{\text{mean}} - S_{\max}| \leq 0.02 \text{ mm}$$

Definitions:

$S_i$  = Deflection measurements for drop  $i$  (where  $i = 1$  to  $12$ ), mm  
 $S_{\max}$  = Max ( $S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}$ )

- Maximum deflection measurement, mm.
- $$S_{\min} = \text{Min} (S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12})$$
- Minimum deflection measurement, mm.
- $$S_{\text{mean}} = \text{Average} (S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12})$$
- Average deflection measurement, mm.

- 6.9** Repeat testing on the test pad combination where the conditions outlined in 6.8 are not met. These steps are taken to remove operator errors and extraneous factors, if any, that may have caused non-repeatable results.
- 6.10** Submit device for calibration when the conditions outlined in 6.8 are still not met, for any test pad combination, after repeat testing. Recalibrated LWD shall be subjected to verification testing in accordance with this ITM.
- 6.11** Do not remove the previous pad when testing a new combination. Place the next pad to be tested on top of the previous pad(s) and then test the next combination without seating.
- 6.12** Repeat steps 6.6-6.11 for all 4 test pad combinations.

## 7.0 IDENTIFICATION OF OUTLIERS

**7.1** The verification results from a single verification test site shall be used for the identification of LWD that are generating test results that are outliers from the overall grouping of LWD.

**7.2** The “LWD by No. of Pads” Excel spreadsheet shall be used for data collection.

7.2.1 The average deflection from every LWD for each of the four verification pad configurations shall be recorded.

7.2.2 The “LWD by No. of Pads” file shall be continuously updated as additional devices are tested.

7.2.3 The data shall be entered for each calendar year and maintained for the last 6 calendar years.

**7.3** The updated “LWD by No. of Pads” Excel spreadsheet shall be sent to the INDOT Manager, Geotechnical Operations, by March 15 every year, and whenever additional LWD are tested for verification throughout the year.

7.3.1 The INDOT Manager, Geotechnical Operations will review the data and identify devices that are outliers from the group. For INDOT Districts, the district testing engineer will perform this function.

7.3.1.1 Outliers will be based on the tools provided in the spreadsheet as well as the judgment of the Engineer.

7.3.1.2 Focus will be on pad configurations that are at or near the LWD specification limits for acceptance of various materials.

7.3.1.3 Additional focus will be on devices with outliers in two or more pad configurations.

7.3.1.4 Evaluate data collection sheets of the suspected outlier(s) for erratic results that may be indicative of a failing spring or other breakdown.

7.3.1.5 The INDOT Manager, Geotechnical Operations will notify the owner of each device that is considered an outlier.

7.3.1.6 The owner may choose to:

7.3.1.6.1 Have the LWD retested for verification and reevaluated as an outlier.

7.3.1.6.2 Send the LWD immediately to a qualified calibration facility (Zorn or Kessler) for repair and recalibration.

7.3.2 Consultants shall perform the verification test in accordance with ITM and provide the verification testing to district testing engineer when requested.

## **8.0 RECALIBRATION**

**8.1** Recalibrated LWD shall be subjected to verification testing in accordance with this ITM before resumption of acceptance testing.

## **9.0 DOCUMENTATION**

**9.1** Verification Testing in accordance with Section 6.0 shall be documented on the "INDOT ITM xxx LWD Verification" Excel spreadsheet. A printed copy of the verification results and current full calibration shall be retained with the LWD device. The original spreadsheet shall be retained at the verification test site. A copy of the spreadsheet shall be sent to the INDOT Manager, Geotechnical Operations.

INDOT ITM xxx LWD Verification 06-06-2024.xlsx

LWD Owner:		Commission Number:		Serial Number		
Verification Site:		District:	Crawfordsville	Status:		
Date:		Time:		Temperature:		
Tested By:				Last Full Calibration Date:		
<p>Follow INDOT LWD Repeatability Verification Procedure ITM xxx                      Precondition with 12 drops, not recorded, on Pad 1 at Marked Location                      Record results of next 12 drops, on each pad configuration. No additional seating or preconditioning drops.                      Retest (3 drops) if a "wild" result occurs (+/-10%). (Maximum of twice per pad configuration).                      Review the Data and Analyze Per ITM xxx Procedure.                      Compare to other Verification Site LWD results for Outliers.</p>						
Configuration 1. Dynatest Pad 1		LWD Test Number	Drop 1	Drop 2	Drop 3	Test Average
Notes						
Wild Data excluded						
Wild Data excluded						
Configuration 2. Dynatest Pad 2 on 1		LWD Test Number	Drop 1	Drop 2	Drop 3	Test Average
Notes						
Wild Data excluded						
Wild Data excluded						
Configuration 3. Dynatest Pad 3 on 2 on 1		LWD Test Number	Drop 1	Drop 2	Drop 3	Test Average
Notes						
Wild Data excluded						
Wild Data excluded						
Configuration 4. Dynatest Pad 4 on 3 on 2 on 1		LWD Test Number	Drop 1	Drop 2	Drop 3	Test Average
Notes						
Wild Data excluded						
Wild Data excluded						
	Smean-Si Min  ≤ 0.02mm	Smean-Si Max  ≤ 0.02mm	Smax-Smin ≤ 0.04mm	Smin (Si min)	Smax (Si Max)	Smean
Configuration 1			0.000	0.000	0.000	
Configuration 2			0.000	0.000	0.000	
Configuration 3			0.000	0.000	0.000	
Configuration 4			0.000	0.000	0.000	
Notes:						

**9.2** Outlier Identification in accordance with Section 7.0 shall be documented on the “2023-2031 LWD Verification Outliers 06-27-2024” Excel spreadsheet. The original spreadsheet shall be retained at the verification test site and a copy shall be sent to the INDOT Manager, Geotechnical Operations, as noted in Section 7.3.

Test version for error checking of formulas and charts. All OK 06/25/2024. KES>												
Substrate	Commission	S/N	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
1 Pad	1000001	1001	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1 Pad	1000002	1002	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
1 Pad	1000003	1003	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352
1 Pad	1000004	1004	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372
1 Pad	1000005	1005	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374
1 Pad	1000006	1006	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339
1 Pad	1000007	1007	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332
1 Pad	1000008	1008	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343
1 Pad	1000009	1009	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
1 Pad	1000010	1010	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297
1 Pad	1000011	1011	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
1 Pad	1000012	1012	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
1 Pad	1000013	1013	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345
1 Pad	1000014	1014	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325
1 Pad	1000015	1015	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340
1 Pad	1000016	1016	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342
1 Pad	1000017	1017	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370
1 Pad	1000018	1018	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354
Average			0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336
Std Dev			0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
Maximum			0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
Minimum			0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Range			0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192
CoV			12.354	12.354	12.354	12.354	12.354	12.354	12.354	12.354	12.354	12.354
Max/Min-1			96.0%	96.0%	96.0%	96.0%	96.0%	96.0%	96.0%	96.0%	96.0%	96.0%
QTL1			0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332
QTL3			0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354
IQR			0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
QTL1-1.5*IQR			Lower Limit	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
QTL3+1.5*IQR			Upper Limit	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
Average+1.96*Stdev			Upper Limit	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
Average-1.96*Stdev			Lower Limit	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255