

Mn/DOT Grading and Base Manual

5-xxxx DEFLECTION METHOD (ZORN [ZFG2000] LIGHT WEIGHT DEFLECTOMETER [LWD]) (05/12/09)

A. Summary of Test Method

1. This test method is a type of plate-bearing test. The load is a force pulse generated by a falling weight (mass) dropped onto a system that transmits the load pulse through a plate resting on the material to be tested.
2. The weight is raised to a preset height that, when dropped, will impart the desired force pulse. The weight is dropped and the resulting vertical surface deflection is measured using suitable instrumentation. Multiple tests at the same pre-set drop height may be performed at the same location.
3. The peak deflection resulting from the force pulse at each location is recorded in micrometers, millimeters, mils or inches, as appropriate.
4. The drop height of the falling weight is fixed and not changeable by the user.

B. Equipment

The LWD is comprised of the following elements (see Figure 1).

1. “*Handle Grip*” is located at the top of the device. It is used to hold the LWD guide rod plumb and to limit the upward movement of the falling weight.
2. “*Top Fix and Release Mechanism*” holds the falling weight at a constant height. The release mechanism is depressed to allow the falling weight to freely drop and transmit the load pulse through the plate resting on the material to be tested.
3. “*Guide Rod*” allows the falling weight to drop freely the set distance of about 500 mm (19.7 in). The guide rod and the falling weight together weigh about 15 kg (33 lb).
4. “*Falling Weight Grip*” provides a grip for the operator to raise the falling weight to the top fix and release mechanism.
5. “*10-kg (22-lb) Falling Weight*” is manually raised to the bottom of the grip and held into place using the top fix / release mechanism.
6. “*Lock Pin*” has two positions (locked and unlocked). Pull the pin to release the falling weight for measurements.
7. “*Steel Spring*” provides the buffer system that transmits the load pulse to the plate resting on the material to be tested.
8. “*Anti-Tipping Fixture*” prevents the guide rod and falling weight from tipping when these parts are placed, and standing freely, on the load center ball / loading plate.

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9. “*Load Center Ball*” serves as a connector between the anti-tipping fixture and the loading plate. It also allows for disassembly, which reduces the size of the instrument for transport.
10. “*Carry Grip*” provides handles to assist the operator with carrying the loading plate.
11. “*Loading Plate*” provides an approximate uniform distribution of the impulse load to the surface. The loading plate weighs about 15 kg (33 lbs).
12. “*Cable*” is used to connect the loading plate sensor to the data processing and storage system.

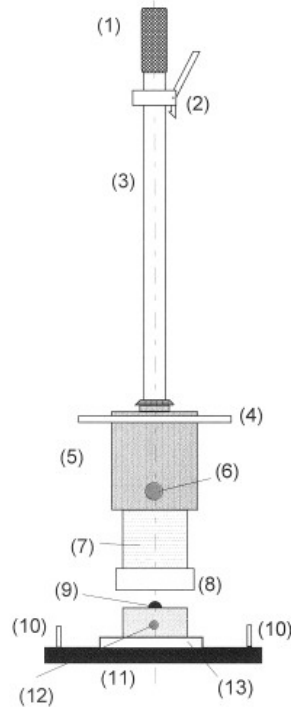


Figure 1. Schematic drawing of light weight deflectometer (2).

Data Processing and Storage System (see Figure 2):

Deflection data is displayed and recorded on the data processing and storage system.



Figure 2. Sketch of electronic output device (2).

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C. LWD Configuration

The standard LWD configuration is as follows:

- Falling Weight: 10 kg (22 lb)
- Load Plate Diameter: 200 mm (8 in)
- Drop Height: See calibration plate connected to the LWD device.

D. Testing Constraints

1. Perform test immediately after compaction.
2. Complete testing in the air temperature range of 2 to 50 degrees Celsius (36 to 120 degrees Fahrenheit).
3. Ensure soil is not frozen (3).
4. Execute test when the deflection measurements are greater than or equal to 0.2 mm (0.008 in).

E. Site Selection and Preparation

1. Visually inspect the percentage of gravel in the soil. Ensure the percentage of gravel, larger than 38.1 mm (1.5 in), is less than 25 percent.
2. Create a relatively smooth and level spot that will allow the LWD guide rod to remain vertical and prevent sliding of the loading plate during testing.
3. Select the most yielding area.
5. Prepare a test area that is at least 1.5 times larger than the diameter of the loading plate (1-ft square) (3).
6. Remove loose, dried, cracked or uneven material prior to testing (3).
7. Perform tests at a uniform depth, representative of the compaction state. Ensure consistent test depths are used, throughout the project, for given material types. Use the following test depths:

Material Type	LWD Test Depth ¹
Granular Soils	0 to 150 mm (0 to 6 in) ² (see Figure 3 [a])
Granular Base / Stabilization Layer	Compacted Surface
Non-Granular Soils	<u>Compacted with Padfoot Roller:</u> Bottom of deepest indentation of the padfoot penetration. (see Figure 3 [b])
	<u>Compacted with Smooth-Drum Roller</u> Compacted Surface

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Note 1— The influence depth is approximately 1 to 1.5 times the plate diameter, consequently, deflection measurements obtained for lifts less than this depth are a composite deflection measurement.

Note 2— Complete test at compacted surface for cases where disturbance effects exist (i.e., deflection measurements increase, due to disturbance caused by the test, from that observed at the surface).



(a) Test depth at one-half the lift thickness.

(b) Test depth at bottom of padfoot penetration.

Figure 3. Photos of deflection test depths.

F. Procedure

1. Position loading plate on test site. (3)
2. Turn loading plate left and right 45 degrees. (3)
3. Perform six falling weight load pulses.^{3,4} Use the following procedure for each load pulse:
 - a. Raise falling weight to calibration height (preset drop height).
 - b. Snap falling weight into fix and release mechanism.
 - c. Adjust guide rod to vertical.
 - d. Release falling weight and allow it to freely fall.⁵
 - e. Catch falling weight after rebound.
 - f. Snap weight into fix and release mechanism after rebound.⁶
4. Store resulting deflection measurements from drops 1 through 6 on Smartcard.
5. Record the Smartcard number for seating (drops 1-3) and the Smartcard number and deflections measurements for the test (drops 4-6) on data collection form.
6. Record supporting information such as location measurements and identification data.

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7. Repeat deflection measurements at another location (move 305 mm [1-ft] longitudinally) when conditions such as the following are present:
 - a. Miss catch of falling weight after rebound.
 - b. The load plate slides.
8. Obtain the moisture content on a sample collected 76 to 229 mm (3 to 9 inches) below LWD test depth surface using either the Burner Method (5-692.231) or Speedy Method (5-692.232). Record the moisture content information on the LWD form.

Note 3— Use the first three drops for “seating” and the next three drops for analysis.

Note 4— Position the test device at a new test location when a faulty drop occurs. Testing cannot be repeated at the same location. Retest 300 mm (1 ft) longitudinally from original test location.

Note 5— Make sure the falling weight falls exactly from the calibration height (4).

Note 6— Ensure the following for LWD equipment constructed using a centering ball: (1) the guide rod is not removed from the centering ball and (2) the load plate is not displaced during testing. (3)

G. Safety

1. Keep back straight and lift with leg muscles to help prevent injury when elevating and dropping the falling weight.
2. Make sure hands or extremities are not positioned beneath the lifted, falling weight or loading plate to avoid injury.
3. Secure falling weight into the lower position prior to transport to prevent injury from movement of the falling weight.

H. Maintenance and Handling

1. Inspect equipment for necessary repairs.⁸
2. Store LWD in dry place when not in use.
3. Make sure guide rod is not directly resting on soils.
4. Clean the loading device by removing any dirt with a dry cloth. Do not grease/oil the guide rod.
5. Check the drop height regularly to ensure that slippage of the release mechanism has not occurred.
6. Recharge batteries after 3 to 12 hours of use or on 3-month intervals when not in use. (3)
7. Charge or replace the battery when the charging level is less than 50 percent. (3)

Note 8— Ensure rubber bellow is providing a tight seal around the spring for deflectometers with spring systems.

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I. Calibration

1. Calibrate the force generation device and the deflection sensor as recommended by the Manufacturer, when deflection measurements are no longer repeatable, or after 10,000 measurements, whichever comes first.
2. Coordinate Calibration through the Office of Materials and Road Research.

J. Repeatability Testing

1. Submit test device to the Office of Materials and Road Research for repeatability testing.
2. Repeatability testing will be performed:
 - a. Immediately upon receipt of a newly purchased device,
 - b. Prior to re-commissioning the device after calibration by Test Institute,
 - c. Annually, or when
 - d. Measurements are no longer repeatable or are questionable.

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1. ASTM Standard E 2583 – 07, “Standard Test Method for Measuring Deflections with a Light Weight Deflectometer (LWD),” ASTM International, West Conshohocken, PA, www.astm.org.
 2. Zorn Company. *Operating Manual: Light Drop-Weight Tester ZFG 2000 (Light Weight Deflectometer, Portable Falling Weight Deflectometer) for the dynamic plate loading test, corresponding to the German “Technical Specification for Soil and Rock in Road Construction TP BF – StB Teil B 8.3.* Stendal, Germany, 1992 – 2005.
 3. European Committee for Standardization. Measuring Method for Dynamic Compactness and Bearing Capacity with SP-LFWD (Small – Plate Light Falling Weight Deflectometer. Final Draft prCWA XXX N009. Ref. No. CWA XXX:2007. English Version. CEN Workshop Agreement. ICS 93.020. Brussels, October 2007.
 4. Road and Transportation Research Association: Working Group for Foundation and Soils Engineering. *Dynamic Plate-Load Testing with the Aid of the Light Drop-Weight Tester.* Technical Test Code for Soil and Rock Mechanics in Road Construction, TP BF-StB: Part B 8.3.