

NEBRASKA DEPARTMENT OF ROADS  
NDR STANDARD TEST METHOD T 2835

DEFLECTION MEASUREMENT OF SOILS USING A LIGHTWEIGHT DEFLECTOMETER (LWD)  
*Modified*

*ASTM Designation: E 2835*

**A.1 SCOPE**

1. This method covers the measurement of soil deflection by use of a type of plate-bearing test. A force is generated by a falling weight dropped onto a plate which is resting on the material to be tested.
2. The falling weight is raised to a preset height of 720 mm (28 in.). When dropped, the weight will apply the required force pulse. The weight is dropped and the resultant surface deflection is measured using the LWD's instrumentation.
3. The deflection values resulting from the applied force at each test location is recorded in millimeters, or as appropriate.
4. The drop height of the falling weight is fixed and shall not be changed by the user.

**A.2 EQUIPMENT**

The LWD consists of the following components (See Figure 1).

1. Handle Grip – Used to hold the LWD guide rod vertical and to limit upward movement of the falling weight. Note, there is a bubble level at the top to help hold the guide rod plumb.
2. Release Mechanism – Holds the falling weight at a constant height and when the release mechanism is pressed, allows the falling weight to drop freely.
3. Guide Rod – Allows the falling weight to drop freely the required distance of 720 mm (28 in.).
4. Falling Weight Grip – Provides a grip for the operator to catch the falling weight after it impacts the plate and to raise the falling weight to the top release mechanism.
5. 10-kg Falling Weight – Is manually raised to the bottom of the grip and held in place with the release mechanism.
6. Lock Pin – When pushed in the pin keeps the weight from moving up the guide rod during storage and transport. When pin is pulled the weight is free to move up and down the guide rod.
7. Steel Spring – Provides a buffer system that transmits the load to plate resting on the material being tested. The steel spring is protected by a sealed rubber boot.
8. Anti-Tipping Fixture – Prevents the guide rod and falling weight from tipping when standing freely on the load center ball.
9. Load Center Ball – Serves as a connector between the anti-tipping fixture and the loading plate.

10. Carry Grip – Provides handles for easier carrying of the loading plate by the operator.
11. Loading Plate – Provides an approximate uniform distribution of the load applied from the falling weight to the surface being tested. Loading plate has a diameter of 300 mm (11.8 in.).
12. Cable – Used to connect the loading plate sensor to the recording and storage instrument.

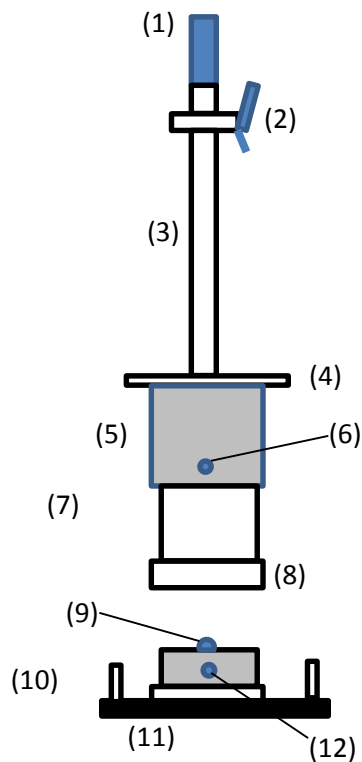


Figure 1. LWD individual components.

13. Measuring Instrument – Data processing device that records, displays, and stores deflection data (See Figure 2).



Figure 2. Hand-Held Measuring Instrument

## B.1 STANDARDIZATION

1. Repeatability testing shall be performed:
  - a. Upon receipt of a newly purchased device.
  - b. Prior to recommissioning a device after calibration.
  - c. When measurements are questionable or are no longer repeatable.
  - d. Annually or after 10,000 test measurements.

## B.2 REQUIREMENTS

1. Designate a test pad location at the office or location in which the device is being stored that is bare, sound concrete with a minimum thickness of 6 inches.
2. Using the load plate as a template mark the the circular location of the test pad area for future reference of the test pad location.
3. Position the loading plate on the prepared test surface.
4. Place the upper portion of the LWD (falling weight and guide rod) on top of the loading plate, using the load center ball as a guide.
5. Plug in chord from the hand-held measuring instrument into load plate and turn on measuring instrument.
6. Press "OK" to start measurements. Turn off Pre-Load Settings<sup>1</sup>.
7. Perform 9 falling weight drops using the following following procedure for each drop:
  - a. Raise the falling weight to the preset drop height and snap falling weight into the release mechanism.
  - b. Adjust guide rod to plumb, using the bubble level as a guide.
  - c. Release the falling weight, allowing it to free-fall.
  - d. Catch the falling weight after it rebounds off the load plate.
  - e. Snap weight into release mechanism.<sup>2</sup>

<sup>1</sup>Note: Refer to LWD Repeatability Form.

<sup>2</sup>Note: Record deflection measurements after drops 1 through 9.

8. Use the following calculations to determine the repeatability of deflection measurements:
  - a.  $S_{\max} - S_{\min} \leq 0.04 \text{ mm}$ 
    - i.  $S_{\max} = \max \text{ of } (S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9)$
    - ii.  $S_{\min} = \min \text{ of } (S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9)$
    - iii. Definitions:
      - a.  $S_{\max}$  = maximum deflection measurement, mm.
      - b.  $S_{\min}$  = minimum deflection measurement, mm.

- b.  $|S_{\text{mean}} - S_i| \leq 0.02 \text{ mm}$
- i.  $S_{\text{mean}}$  = average deflection for tests ( $S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9$ )
  - ii.  $S_i$  = deflection measurements for drop  $i$  (where  $i = 1$  to  $9$ )
9. Repeat testing on test pad when the calculations in step 8 are not met. This step is taken to remove operator errors or extraneous factors, if any, that may have caused non-repeatable results.
10. Submit device for calibration when the calculations in step 8 are still not met after repeat testing.

### C.1 TESTING CONSTRAINTS

1. Perform tests immediately after compaction.
2. Perform testing in an air temperature range of 32 to 120 degrees Fahrenheit.
3. Ensure soil is not frozen.

### C.2 SITE TESTING LOCATION AND PREPARATION

1. Create a smooth and level spot that allows the LWD guide rod to remain vertical and prevents the loading plate from sliding during testing.
2. Prepare a test area that is 1.5 times larger than the diameter of the loading plate (1.5-ft square).
3. Remove any disturbed material and any additional material as necessary to expose the top of the material to be tested.
4. Position the loading plate on the prepared test surface. Using the loading plate handles, turn the loading plate left and right to help seat the plate.
5. Place the upper portion of the LWD (falling weight and guide rod) on top of the loading plate, using the load center ball as a guide.
6. Plug in chord from the hand-held measuring instrument into load plate and turn on measuring instrument.
7. Press "OK" to start measurements.
8. Perform six falling weight drops using the following procedure for each drop:
  - f. Raise the falling weight to the preset drop height and snap falling weight into the release mechanism.
  - g. Adjust guide rod to plumb, using the bubble level as a guide.
  - h. Release the falling weight, allowing it to free-fall.
  - i. Catch the falling weight after it rebounds off the load plate.
  - j. Snap weight into release mechanism.<sup>1,2</sup>

<sup>1</sup>Note: Record deflection measurements after the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> drops and the average deflection after the sixth drops. The device automatically saves the data to the memory card.

<sup>2</sup>Note: Press "OK" after test is complete to view the average test result.

9. Write down LWD test number from measurement device (result #) and record all pertinent information onto LWD field Test Form.
10. Repeat deflection measurements at another location (move approximately 1.5-ft longitudinally) when the following conditions occur during the test<sup>3</sup>:
  - a. The falling weight is not caught after rebound.
  - b. The load plate slides.
  - c. The falling weight is not dropped from the calibrated height.

<sup>3</sup>Note: A faulty test cannot be repeated at the same location.

11. Obtain the moisture content sample from approximately 3 to 9 inches below the surface of the LWD test location. Perform moisture content test using either the burner/stove, hot-plate, speedy, microwave, or oven-dry method. Record the moisture content on the LWD Field Test Form.

#### **D.1 SAFETY**

1. Keep back straight and lift with legs to help prevent injury when elevating and dropping the falling weight.
2. Keep hands and extremities from beneath the falling weight or load plate to avoid injury.
3. Secure falling weight into lower position with lock pin prior to transport to prevent injury from movement of the falling weight.

#### **E.1 MAINTENANCE AND HANDLING**

1. Inspect equipment for necessary repairs. Ensure rubber boot around steel spring provides a tight seal.
2. Store LWD in dry place when not in use.
3. Make sure guide rod is not directly resting on soils.
4. Clean the LWD by removing any dirt with a dry cloth or with compressed air. Do not use grease or oil on the guide rod.
5. Check the drop height to ensure that slippage of the release mechanism has not occurred. If slippage has occurred, correct the drop height and tighten set-screws on release mechanism.
6. Recharge battery after 3 to 12 hours of use or at 3-month intervals when not in use.
7. Charge or replace the battery when charging level is less than 50 percent.

#### **F.1 CALIBRATION**

1. Calibrate the force generation device and deflection sensor as recommended by the Manufacturer, when deflection measurements are no longer repeatable, or after 10,000 measurements, whichever comes first.