

S-xx

**PILOT LIGHT WEIGHT DEFLECTOMETER (LWD)  
DEFLECTION METHOD**

**(2105 or 2106 Excavation and Embankment)**

05/11/11

“Light Weight Deflectometer (LWD) Deflection Method” is a type of plate bearing test. 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. The peak deflection resulting from the force pulse is recorded.

S-xx.1 Definitions

“Deflection Test Measurement” is the average deflection measured from the fourth, fifth and sixth drop in the testing sequence. The first, second and third drop in the testing sequence are seating drops.

“LWD-TV” is the LWD Target Value determined using calibration area or comparison testing for a given soil type or source.

S-xx.2 LWD Testing Constraints

- (A) The LWD Deflection Method cannot be used when:
  - (1) embankment thicknesses are less than 1 m (**3 ft**), or
  - (2) when testing within 1 m (**3 ft**) of the water table.
- (B) The required surface material thicknesses, to remove prior to LWD testing, is presented in the document “LWD Deflection Method Test Procedures” which is available on the Grading and Base Website.

S-xx.3 Option #1: Determine the LWD-TV using a Calibration Area

- (A) Calibration Area Requirements
  - (1) Construct the Calibration Area to determine the LWD-TV for each type or source of embankment materials.
  - (2) Construct a new Calibration Area when:
    - (a) There is an observable variation in material properties on a test layer,
    - (b) The moisture content of the embankment material is  $\pm 2$  percent of the calibration area moisture content, or
    - (c) as determined by the Engineer.

(3) Calibration Area Dimensions

| <b>Table 1</b>   |                                |  |  |
|--|--------------------------------|--|--|
| <b>Calibration Area Dimensions (Note 1)</b>  |                                |  |  |
| <b>Embankment</b>  | <b>Length</b>                  | <b>Width (ft)</b>                                | <b>Fill Thickness</b>  |
| Roadbed Embankment Soil<br>(Excavation & Borrow)   | $\geq 100$ m ( <b>300 ft</b> ) | Equal to the<br>excavated<br>embankment<br>width | Equal to the planned<br>layer thickness, but not<br>exceeding a maximum<br>thickness of<br>1.2 m ( <b>4.0 feet</b> ) |
| Misc., Trench, Culvert or<br>other Tapered Constr.<br>Embankment Soil<br>(Excavation & Borrow) | $\geq 3$ m ( <b>10 ft</b> )    |  |  |

NOTE 1: Or as determined by the Engineer.

(4) Moisture Requirements

- (a) Determine the Target Moisture Content by one of the following:
- (i) Standard Proctor
  - (ii) 1-Point Proctor
  - (iii) Estimated Optimum Moisture Content (EOMC) Form (for Granular only)
- (b) Maintain the moisture content of the embankment materials from 65 to 95 percent of the Target Moisture Content.

- (5) Include the Calibration Area into the final embankment.
- (6) Save a material sample from each calibration area for comparison to the embankment material being compacted.
- (7) Calibration Area construction is incidental to the embankment compaction requirements.

(B) Calibration Area Testing Rate

| Table 2  |               |                              |   |         |   |                                   |
|--|---------------|------------------------------|---|---------|---|-----------------------------------|
| Material   | Spec. No.     | Form No.<br><br>(See Note 1) | Minimum Required Contractor Quality Control Testing<br>(QC Production Testing Rate) |         | Minimum Required Agency Acceptance Testing<br>(Field Testing Rate) (Note 2) |                                   |
|  |               |                              | Metric  | English | Metric  | English                           |
| (1) Deflection Method – LWD<br>(a) Roadbed Embankment Soil<br>(Excavation & Borrow)          | 2105/<br>2106 | Grading &<br>Base Website    | Contractor is encouraged to perform compaction tests for process control.           |         | 3 Tests / Roller Pass<br>(Note 2)   | 3 Tests / Roller Pass<br>(Note 2) |
| (b) Misc., Trench, Culvert or other Tapered Constr. Embankment Soil<br>(Excavation & Borrow) |               |                              |   |         | 1 Test / 6 m / Roller Pass<br>(totaling 2 LWD Test Locations)<br>(Note 2)   | 1 Test / Roller Pass<br>(Note 2)  |

NOTE 1: Forms are available on the Grading & Base website at:  
[www.dot.state.mn.us/materials/gradingandbase.html](http://www.dot.state.mn.us/materials/gradingandbase.html)

NOTE 2: Continue roller passes and testing to determine the minimum deflection value.

(C) Calibration Area Construction

- (1) Compact the bottom of the calibration area by the Quality Compaction Method.
- (2) Place the embankment material to the maximum lift thickness allowed in Mn/DOT Specification 2105.3E
- (3) Construct the embankment material for uniformity, moisture content and compaction until embankment thickness is at the test layer described in Table 3.
- (4) The Engineer begins LWD testing on the test layer prior to achieving the desired compaction.
- (5) LWD-TV Compaction is obtained when:
  - (a) The Moisture content is within the acceptable range.
  - (b) The average of the Deflection Test Measurements, for three consecutive passes, does not significantly change with additional compaction. The LWD-TV is the lowest, average Deflection Test

Measurement from these passes. (See Table 3 for LWD-TV to use for each test layer)

- (6) After the LWD-TV is obtained, repeat steps (2) through (5) until the next test layer is reached.

(D) LWD-TV

| <b>TABLE 3</b>                  |   |
|---------------------------------|---|
| <b>Fill or Subcut Thickness</b> | <b>LWD-TV</b>                                   |
| < 1.2 m (4 ft)                  | LWD-TV obtained on the respective test layer.   |
| ≥ 1.2 m (4 ft)                  | LWD-TV obtained on the 1.2-m (4-ft) test layer. |

S-xx.4 Option #2: Determine the LWD-TV using the Modified Penetration Index (Mod PI) or Specified Density Method

- (A) Compaction must comply with the Mod PI or Specified Density Method.
- (B) The LWD Deflection and Mod PI method test procedures are on the Mn/DOT Grading and Base Website.
- (C) Perform six (6) comparison tests, using the LWD Deflection Method and Mod PI or Specified Density, spaced 300-mm (1-ft) longitudinally.
  - (1) Testing Rate = 6 Comparison Tests in the first 3,000 m<sup>3</sup> (4,000 yd<sup>3</sup>) (CV).
- (D) The LWD-TV is the Deflection Test Measurement at the comparison location with the highest DPI or lowest density measurement. Use the smallest deflection measurement for instances where the highest DPI or lowest density measurement is the same for multiple locations.
- (E) Perform a maximum of ten (10) LWD Deflection tests.
  - (1) Testing Rate = 1 LWD Test per 3,000 m<sup>3</sup> (4,000 yd<sup>3</sup>) (CV).
- (F) Complete three (3) comparison tests, using the LWD Deflection Method and Mod PI or Specified Density, spaced 300-mm (1-ft) longitudinally.
  - (1) Testing Rate = 3 Comparison Tests in the next 3,000 m<sup>3</sup> (4,000 yd<sup>3</sup>) (CV).
- (G) The LWD-TV is the Deflection Test Measurement at the comparison locations (steps C and F [including previous step F values]) with the highest DPI or lowest density measurement. Use the smallest deflection measurement for instances where the highest DPI or lowest density measurement is the same for multiple locations.
- (H) Repeat steps (E) through (G).
- (I) Repeat steps (A) through (H) for new soil types or sources.
- (J) Submit comparison test results to Grading and Base Office within 24 hours.

S-xx.5 Construction Requirements

- (A) Contractors Quality Control (QC)
  - (1) Moisture Requirements
    - (a) Maintain the moisture content of the embankment materials from 65 to 95 percent of the Target Moisture Content.
  - (2) Compaction Requirements
    - (a) The Contractor is encouraged to perform compaction tests for quality control.
    - (b) Perform corrective action at locations failing to meet specification before placement of next lift.
- (B) Engineer Quality Acceptance (QA)
  - (1) Moisture Requirements
    - (a) Determine the Target Moisture Content by one of the following:
      - (i) Standard Proctor
      - (ii) 1-Point Proctor
      - (iii) Estimated Optimum Moisture Content (EOMC) Form (for Granular only)
  - (2) Compaction Requirements
    - (a) LWD test procedures are on the Mn/DOT Grading and Base Website.
    - (b) Compaction of the material is achieved when each Deflection Test Measurement is
      - (i)  $\leq 1.10 * \text{LWD-TV}$  (Option 1: Calibration Areas)
      - (ii)  $\leq \text{LWD-TV}$  (Option 2: Comparison Testing)
    - (c) Perform additional measurements for acceptance of re-compacted areas.
    - (d) Re-evaluate the selected LWD-TV when:
      - (i) Deflection Test Measurements are consistently less than the LWD-TV, where more than 20 percent of the Deflection Test Measurements are  $\leq 0.80 * \text{LWD-TV}$ .
      - (ii) Failing results consistently occur and adequate compaction is observed through quality compaction.

S-xx.6 LWD Test Layer Table (Option 1: Calibration Areas)

| <b>Table 4 (Notes 1 and 2)</b>                                  |  |
|---|--|
| <b>Granular Materials</b><br>(Meeting Spec. 3149)               |  |
| <b>Embankment Thickness</b>                                     | <b>Test Layer Location</b>   |
| $\leq 600$ mm ( <b>2 feet</b> )                                 | Top of Embankment  |
| $> 600$ mm ( <b>2 feet</b> ) and $\leq 1.2$ m ( <b>4 feet</b> ) | Mid-point and Top of Embankment  |
| $> 1.2$ m ( <b>4 feet</b> )                                     | 600-mm ( <b>2-foot</b> ) Intervals (Starting from Bottom to Top) and Top of Embankment |
| <b>Non-Granular Materials</b>                                   |  |
| <b>Embankment Thickness</b>                                     | <b>Test Layer Location</b>   |
| $\leq 300$ mm ( <b>1 foot</b> )                                 | Top of Embankment  |
| $> 300$ mm ( <b>1 foot</b> )                                    | 300-mm ( <b>1-foot</b> ) Intervals (Starting from Bottom to Top) and Top of Embankment |

Note 1 The Engineer may adjust the test layer embankment thickness for project specific conditions.

Note 2 Test layers are for construction of calibration areas and QA testing when option #1 is followed.

S-xx.7 Testing Rates

| Table 5  |           |                                   |  |         |   |                               |
|--|-----------|-----------------------------------|--|---------|---|-------------------------------|
| Material   | Spec. No. | Form No.<br>(See Note 1)          | Minimum Required Contractor Quality Control Testing (QC Production Testing Rate) |         | Minimum Required Agency Acceptance Testing (Field Testing Rate) |                               |
|  |           |                                   | Metric   | English | Metric  | English                       |
| (1)Moisture Content (Dry Weight)<br>(a) Embankment Soil (Excavation & Borrow)              | 2105/2106 | 02115-03 & 21850-02               | Contractor is encouraged to perform compaction tests for process control.        |         | 1/7,500 m <sup>3</sup> (CV)                                     | 1/10,000 yd <sup>3</sup> (CV) |
| (2) LWD Deflection Method<br>(a) Roadbed Embankment Soil (Excavation & Borrow)             | 2105/2106 | 02115-03 & Grading & Base Website |  |         | 1/3,000 m <sup>3</sup> (CV)                                     | 1/4,000yd <sup>3</sup> (CV)   |
| (b) Trench, Culvert or other Tapered Constr. Embankment Soil (Excavation & Borrow)         |           |                                   |  |         | 1 per 600-mm Thickness/ 75 m                                    | 1 per 2-ft Thickness / 250 ft |
| (c) Granular Bridge Approach Treatments & Other Embankment Adj. to Structures (See Note 2) |           |                                   |  |         | 1 per 600-mm Thickness  | 1 per 2-ft Thickness          |

NOTE 1: Forms are available on the Grading & Base website at:  
[www.dot.state.mn.us/materials/gradingandbase.html](http://www.dot.state.mn.us/materials/gradingandbase.html)

NOTE 2: This testing rate applies to when the embankment adjacent to structures is constructed separately from the roadbed embankment construction.