# 2012 Road School

## Light Weight Deflectometer (LWD)

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# Outline

- Testing for Compaction NO 53 and chemically modified soils (Special Prov.)
- Changing from Density to Modulus
- LWD Equipment
- Test Section Construction/Target Values
- Conclusions
- Limitations

# Three Basic Requirements for Compaction

**Modulus -** it is possible to have high modulus without having particles together. A high modulus may exist if very soft clay dries out. This happens when suction develops between the particles upon drying. This apparent modulus is destroyed as soon as the clay gets wet.

**Density -** One can get two densities at two moisture content (either side of the Proctor Compaction curve).

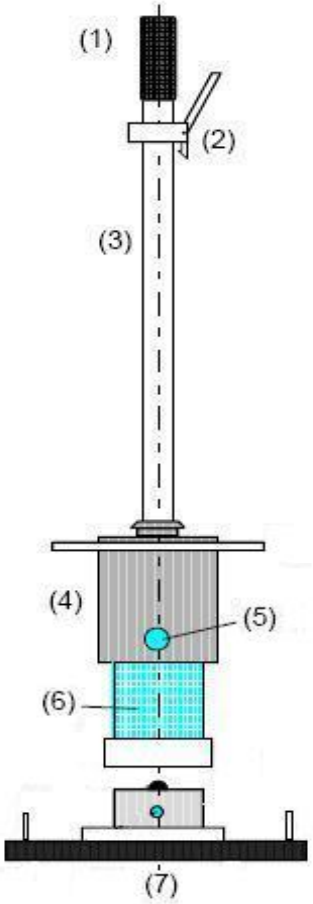
**Moisture -** The moisture content remains a critical quality control Parameter for all compaction operations regardless of Quality Assurance Test Methodology. Therefore, the moisture content needs to be measured. ???

# Correlations of LWD and FWD

- LWD modulus are about 3 to 4 times the conventional FWD modulus
- EFWD = 1.6539 $M_R$
  - Elastic modulus determined with an LWD could in fact be approximately three times higher than laboratory $M_R$
  - Hence, there are good correlations between the elastic modulus determined with the LWD and the FWD

# LWD Setup

Note: European Design- all info will be in metric.




(1) grip
(2) top fix and release mechanism
(3) guide rod **(70 cm drop height)**
(4) 10 kg - falling weight
(5) lock pin
(6) set of steel springs
(7) loading plate diameter (300 mm)

**Three Major Elements -**

(a) Weight to induce the pulse
(b) The loading plate
(c) Accelerometer (to determine settlement)

$$E_{LWD} = \frac{2(1-\mu^2)\rho * R}{s}$$

Boussinesq Half Space Equation

Where ρ = applied stress,
R = plate radius,
μ = Poisson ratio,
s = deflection

1. LWD---- is device that measures the deflection from a falling weight and estimates the modulus.
2. The LWD shall have one accelerometer below the falling weight.

# Mechanism of LWD

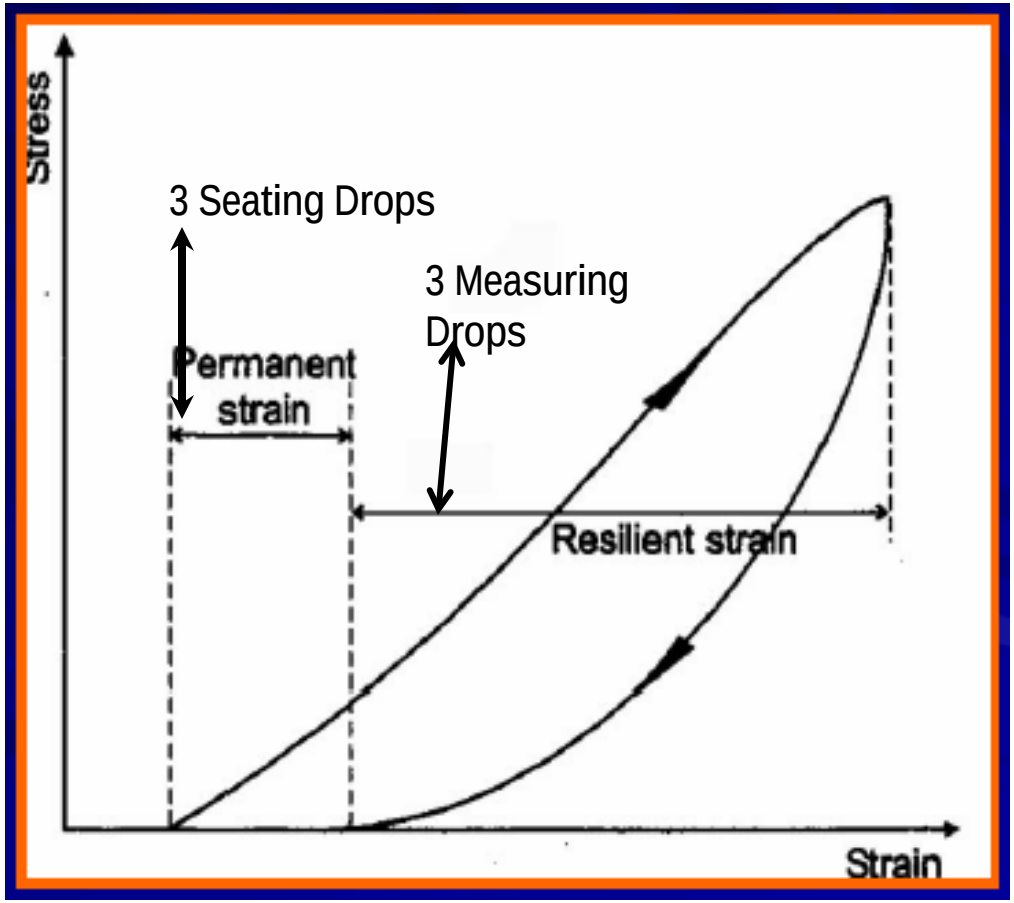
- Impact Force of a Falling LWD is a Type Static Load
- Subbase or Subgrade is uniform elastic body.

# Equipment Listing:

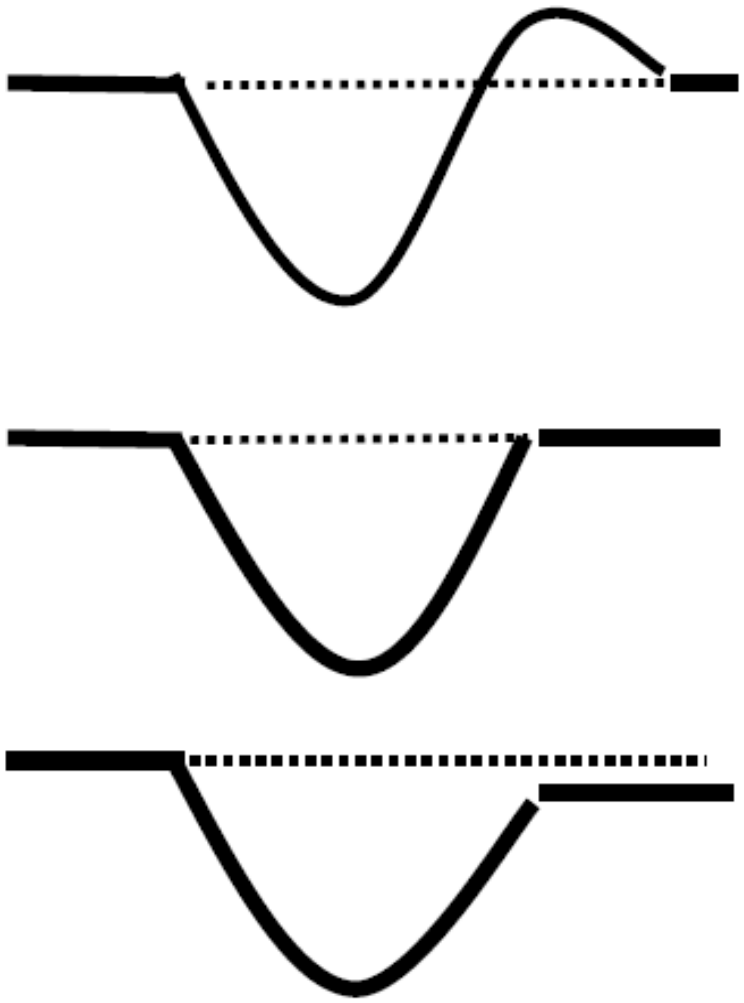
1. **Handle grip:** is located at the top of the device. It is used to hold the LWD guide rod plumb and to limit the upward movement of the falling weight.
2. **Top fix and release mechanism:** holds the falling weight at a constant height.
3. **Guide Rod:** allows the falling to drop freely.
4. **22 lb. Falling Weight:** is manually raised to the bottom of the grip and held into place using top fix/release mechanism,
5. **Lock pin:** has two positions (locked and unlocked),
6. **Steel rings:** provide a buffer system that transmits the load pulse to the plate resting on the material to be tested.
7. **12 in. Loading plate:** Provides an approximate uniform distribution of the impulse load to surface.

# Resilient Modulus

## Dynamic Deviator Stress/Resilient Strain



# Typical Signal Responses from LWD



Loose Material or Excessive Moisture

Ideal

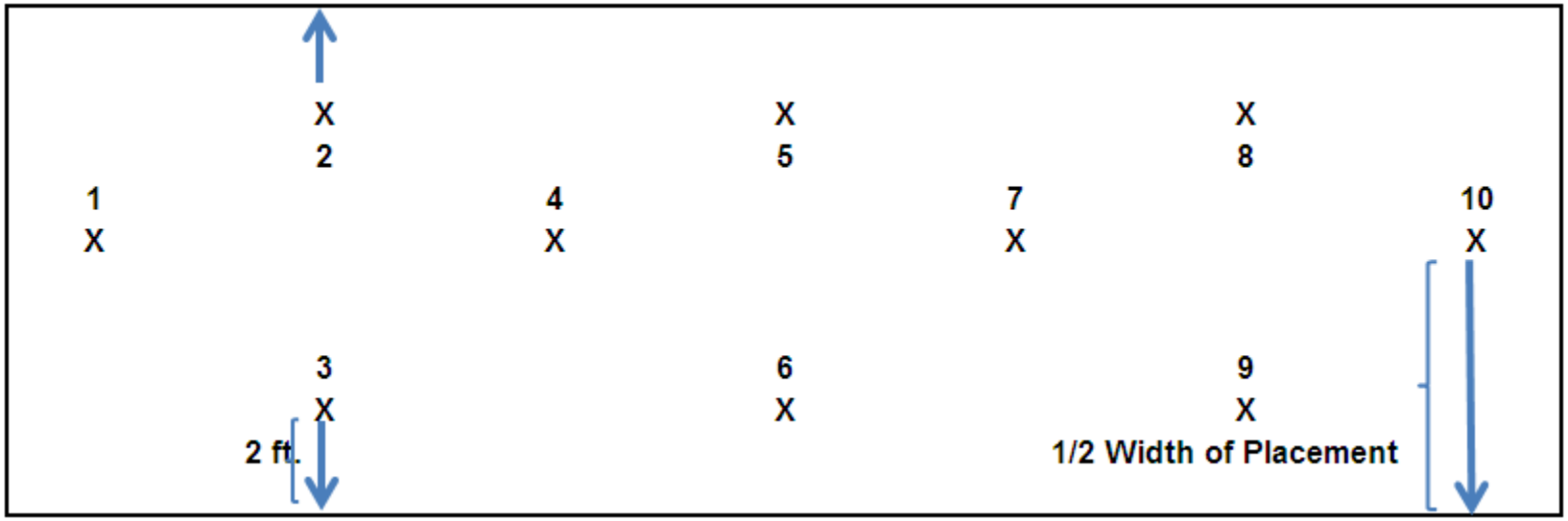
Poor Compaction

# LWD Provides the following:

1. A more representative picture of the subbase and subgrade ability to handle traffic.
2. Relates with the lab Resilient Modulus Test.
3. NO lab work so the inspector stays on site.
4. Quick results.
5. Increases the compaction uniformity.
6. Improves the inspector safety.
7. Increases the productivity.
8. Improves the documentation

# LWD Test Section

1. AASHTO T-11, T-27, and T-99.
2. Subgrade shall be proof-rolled.
3. Section Test Section (100 x Width of Material)  Smaller section may be selected.




4. Approved subgrade and at each of the 10 sites, perform 1 complete test on subgrade.  Record data on the TD 409 LWD Form (Information only).

# LWD Test Section (Con't.)

5. Determine the average moisture content of the aggregate (-3% to -1% Mc).
6. Place aggregate and apply 4 compaction passes.
7. At each of the 10 Test sites, perform 1 complete LWD Test.
8. Record data on the TD 409 LWD Form and calculate the average deflection.
9. Apply additional passes and at the 10 Test Sites, perform 1 complete LWD Test.
10. Calculate the average deflection for all 10 Test sites.
11. Compare the average deflection between the last 2 passes. If the difference is
    - >.01 mm – additional compaction is needed,
    - ≤.01 mm – Test Section is complete.
12. Average deflection is the **Maximum Allowable Deflection**.

# LWD Test Section (Con't.)

## LWD Test Section Using Nuclear Gauge

1. Perform Proof Rolling.
2. Perform 10 LWD Tests on subgrade (for information only).
3. Perform 10 complete LWD Tests along with the Nuclear Gauge.
4. Density Tests shall meet the requirement of Section 301.06.
5. Record data on TD-409 LWD Form.
6. Calculate the average deflection for all 10 Tests.
7. The average deflection will be the **Maximum Allowable Deflection** for the remainder of the project.

# Test Section on Chemically Modified Soils

1. Wait for 24 hours after mixing and compaction.
2. Select section (100 x ---)
3. Perform 10 DCP tests in accordance with 215.09.
4. At each of the 10 test sites, perform 1 complete LWD Test.
5. Record data on the LWD form and calculate the average deflection.

# Test Section on Chemically Modified Soils (Con't.)

6. Maximum allowable deflection is the average deflection.
7. Send the data to the Office of Geotechnical Services for review.

# LWD Acceptance Test

1. LWD Test per Frequency Manual (1 Test / 800T) for Aggregate.
2. Select random stations per ITM 802.
3. Perform 3 complete LWD Tests at random locations.
4. Spread 3 LWD Tests across the full width of the area
    1. 2’ from the left edge
    2. At center
    3. 2’ from the right edge

# LWD Acceptance Test (Con't.)

5. Record the data (TD 409, LWD Acceptance Form) and calculate the average deflection.
6. Average deflection at random stations ≤ max. allowable deflection.

Moisture Content at Time of Placement 9.5%
Moisture Content at Time of Testing 6.7%
*Nuclear Gauge Operator James Canavera*
LWD Operator Michael Crill
Sample # R112472210124
Optimum Moisture 9.5%
Max DD 129.7 #/cf
Max WD 142.0 #/cf

# LWD Test Pad Example

| Test# | Location | WD | DD | Strike 1 | Strike 2 | Strike 3 | Average |
|---|---|---|---|---|---|---|---|
| 1 | 218+00 EB | 138.9 | 130.2 | 0.39 | 0.38 | 0.36 | 0.3767 |
| 2 | 218+20 EB | 146.6 | 137.4 | 0.33 | 0.31 | 0.3 | 0.3133 |
| 3 | 218+40 EB | 146.9 | 137.7 | 0.32 | 0.31 | 0.3 | 0.31 |
| 4 | 218+60 EB | 145.7 | 136.6 | 0.27 | 0.27 | 0.26 | 0.2667 |
| 5 | 219+00 EB | 144.2 | 135.1 | 0.33 | 0.3 | 0.3 | 0.31 |
| 6 | 219+00 EB | 139.2 | 130.5 | 0.31 | 0.3 | 0.29 | 0.3 |
| 7 | 218+50 EB | 140 | 131.2 | 0.39 | 0.39 | 0.37 | 0.3833 |
| 8 | 218+30 EB | 139 | 130.3 | 0.42 | 0.4 | 0.39 | 0.4033 |
| 9 | 218+10 EB | 138.7 | 130 | 0.36 | 0.35 | 0.34 | 0.35 |
| 10 | 218+00 EB | 138.4 | 129.7 | 0.35 | 0.35 | 0.34 | 0.3467 |
| | | | | | 3.36/10=.336 | | 3.36 |

# Conclusions:

1. Quick and easy.
2. Inspector remains on grade at the test site.
3. Roller operator sees the results. Contactor more aware of final test results.
4. Better understanding of water content.
5. Test takes about three minutes.
6. Easily Electronically transfer the data.

# Conclusions (Con't.):

- LWD is suitable for:
  - Aggregate No. 53, 73, 11, 12,
  - Structural Backfill No. 1" and 1 ½"
  - Granular Soils with Aggregates retained on ¾ in sieve
  - Chemically Modified Soils

# Limitations:

1. The aggregates larger 1.5 in. shall not be *over* 15% in testing location.
2. The testing location shall not exceed 5%.
3. The surface inclination shall not be frozen.
4. Measurement shall not be executed when deflection measurements are less than 0.2 mm.

# LWD Special Provision

1/6/12

## LIGHT WEIGHT DEFLECTOMETER TESTING

**Compaction Acceptance with Light Weight Deflectometer**

The compaction of aggregates and chemically modified soils will be determined by testing with a Light Weight Deflectometer, LWD, in accordance with ITM 508. The moisture content of aggregates shall be controlled within -3 and -1 percentage points of the optimum moisture content determined in accordance with AASHTO T 99 Method C. LWD testing for the chemically modified soils will replace the requirements of 215.09.

The Department will establish the criteria for LWD acceptance of compaction by performing optimum moisture, maximum density, and gradation testing in accordance with AASHTO T 99 Method C, T11, and T 27 respectively, on representative samples of the aggregates.

**Test Sections**

The maximum allowable deflection will be determined based on a test section for each material type. Test sections shall be constructed in the presence of a representative of the Office of Geotechnical Engineering with the available equipment of the Contractor to determine the roller type, pattern, and number of passes for the maximum allowable deflection.

The Engineer will select an area approximately 100 ft (33 m) by 20 ft (6 m) for the test section for aggregates or chemically modified soils. The subgrade shall be proofrolled in accordance with 203.26 prior to construction of the test section for aggregates. Chemically modified soils shall be cured at least 24 hours prior to DCP and LWD testing of the test section. Moisture tests will be performed in accordance with AASHTO T 255 for aggregates at two random locations in the test section and the moisture content shall be controlled within -3 and -1 percentage points of the optimum moisture content. LWD testing will be performed at 10 random locations determined in accordance with ITM 802 in the test section.

**Aggregate Test Section with Density Control**

In the aggregate test section, LWD testing will be performed concurrently with density testing performed in accordance with AASHTO T 310. The density shall meet the requirements of 301.06. The maximum allowable deflection will be the average of the 10 LWD test values.

**Aggregate Test Section with LWD only**

A test section shall be constructed and LWD testing will be performed to determine the maximum allowable deflection if only the LWD test device is used. The roller shall be operated in the vibratory mode and initially 4 passes shall be placed on the aggregate in the test section. The average deflection of the 10 random tests will be determined after completion of the 4 passes. One additional pass of the roller in the vibratory mode shall be made and 10 LWD tests will be taken at the same locations. If the difference of the average LWD test values obtained

1/6/12

from 4 and 5 passes is less than 0.01 mm, the compaction will be considered to have peaked and the average of the 10 LWD values at 5 passes will be used as the maximum allowable deflection. If an average LWD value of more than 0.01mm increase was obtained, an additional roller pass in the vibratory mode shall be placed and 10 LWD tests will be taken at the same locations. This procedure will continue until the difference of the average of the 10 LWD tests between consecutive roller passes is less than 0.01 mm. The maximum allowable deflection will be the average of the 10 LWD test values obtained upon completion of the compaction of the test section.

**Chemically Modified Soil Test Section with LWD and DCP**

The LWD testing of the chemically modified test section will be conducted concurrently with the requirements of 215.09. The maximum allowable deflection will be the average of the 10 LWD test values.

# Questions?