

Appendix D
On-Site TAC Meeting Presentation
“IN DOT Approach for QA Using LWD” (Siddiki)

Light Weight Deflectometer

Nayyar Siddiki, P.E.
Office of Geotechnical Services, INDOT

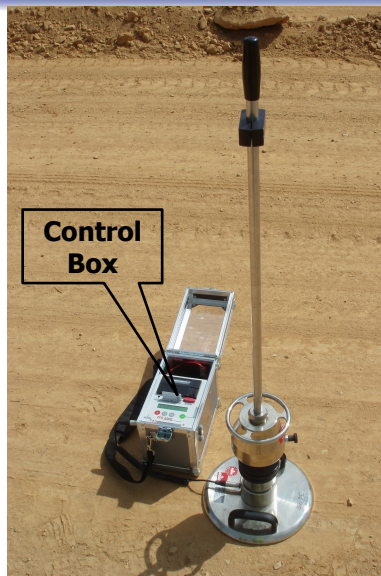
June 2, 2015



LWD – Light Weight Deflectometer

ITM 508

ASTM E 2583- 07
ZORN model ONLY



Research and Technical Reports

JTRP & In-house Research

1998, JTRP Technical Report Series

Cone Penetration Test to Assess the Mechanical Properties of Subgrade Soils

2010, FHWA/IN/JTRP-2010/27 SPR- 3009

Use of Dynamic Cone Penetration And Clegg Hammer Tests For Quality Control of Roadway Compaction and Construction

2014, FHWA/IN/JTRP SPR-3537

QA/QC of Subgrade and Embankment Construction

JTRP SPR#3651 SAC MEETING 2013

Developing Statistical Limits for using the Light Weight Deflectometer, LWD in Construction Quality Assurance

In-House Research

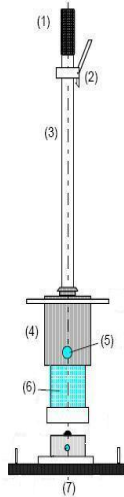


An Overview

- LWD Equipments and Testing Procedure
- Test Section Construction
- LWD Limitations



LWD Setup



Boussinesq Half Space Equation

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

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

- (1)Grip
- (2)Top fix and release mechanism
- (3)Guide rod
- (4)10 Kg –falling weight
- (5)Lock pin
- (6)Set of steel springs
- (7)Loading plate diameter

Three Major Elements:

- (a)Weight to induce the pulse
- (b)The loading plate
- (c)Accelerometer
(To determine the deflection)



Motive behind change

- Density testing has been useful, but is not time efficient, does not verify design properties, and should be replaced
- Density test does not simulate the roadway deformation under traffic



Light Weight Deflectometer

INDOT permits LWD testing on the following materials:

- Aggregate No.53, No.73, structural backfill size 1, 1.5 and 2 in
- Chemically Modified soils



Maximum Allowable Deflection

The maximum allowable deflection for #53 aggregate will be in accordance with the following:

Material Type	Maximum Allowable Deflection (mm)
Lime Modified Soil	0.30
Cement Modified Soil	0.27
Aggregates over Lime Modified Soil	0.30
Aggregates over Cement Modified Soil	0.27

Materials not included in the table need a test pad.



ITM 508, LWD Testing Procedure

- Select site and set up LWD connection to its computational unit.
- The test section should be **level and smooth**.
- Set the plate on a prepared surface and seat it by turning it **left and right 45 degrees**. Do not drop the loading plate on the prepared surface.
- LWD plate **should not translate laterally** with each successive drop.



Con't.

- Perform **3 seating drops** before collecting the data. If noticing **excessive deflection**.
- **Material needs additional compaction.**
- **Following seating drops, perform three drops from a fixed height.**
- **Record the average of 4th, 5th and 6th drops**



Test Pad Construction

Test section requirements:

- AASHTO T-11, T-27, and T-99.
- Subgrade shall be proof-rolled.
- Test Pad area is 100 ft. by 20 ft. (part of the roadway).
- One moisture test is based on AASHTO T-255. Moisture shall be between -3 and OMC. Perform moisture on aggregates before placing on grade.



Con't.

- Shall be 4 roller passes in vibratory mode and one with static on the aggregates.
- 10 randomly selected LWD Tests (Deflection) based on ITM-802 and take average of 10 tests.
- Perform an additional passes in vibratory and static mode each.
- Retest the previous test locations (10) and take the average.
- Subtract the average deflection of step 8 from step 6.
- If difference is 0.02 mm or below, test section is complete.



- The average deflection of step 8 is the maximum allowable deflection and would be used for the remaining project.
- If the difference is greater than .02 mm, additional roller passes in vibratory and static are required prior to LWD test.

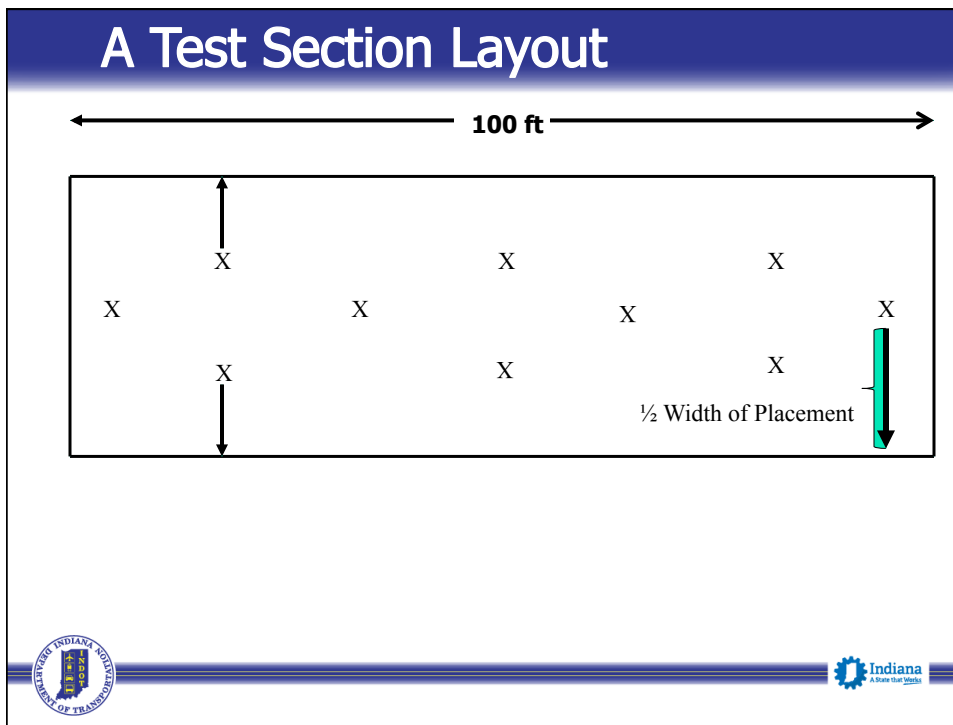


Proof Rolling of Chemically Modified Subgrade



A fully legally loaded tri-axle dump truck. (About 70,000 lbs.)





INDIANA DEPARTMENT OF TRANSPORTATION
LWD TEST SECTION FOR AGGREGATE OVER SOILS

INDIANASOURCE SAMPLE ID NO. (R-12 #) _____

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST INFO		TEST DATA										
Test Section Data	Site No.	Section No.	Average									
	Ref. to Certificate	Stationing (S.P. No.)	1	2	3	4	5	6	7	8	9	10
Subgrade LWD Info		Type	Cohesive or Granular (Fill or Cut)									
LWD Test Section Data	Passes	LWD Assignment Test Number										
	Fail	Deflection (0.1 in)										
	Passes	LWD Assignment Test Number										
	Fail	Deflection (0.1 in)										
	Passes	LWD Assignment Test Number										
	Fail	Deflection (0.1 in)										
	Passes	LWD Assignment Test Number										
	Fail	Deflection (0.1 in)										
	Passes	LWD Assignment Test Number										
	Fail	Deflection (0.1 in)										
Test Site		Reference Material Deflection Limit										
Laboratory Report Data		Material Name and Type	Test Number									
Test Site Method		Reference Material (N ₁)	Deflection									
Comments		Comments 1										
		Comments 2										

REMARKS: This record is to be filled out by the engineer of the project or the LWD test section contractor after passing a work on the test site.

V - VIBRATORY S - STATIC

LWD Serial Number: _____ RECORDED IN SITE-MANAGER: _____ Qualified Technician: _____

INDIANA DEPARTMENT OF TRANSPORTATION
LWD TEST SECTION FOR AGGREGATE OVER SOILS

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO. _____

SYNTHESIZED TEST NO. _____

TEST SITE DATA

Subgrade LWD Info

Cohesive or Granular (Fill or Cut)

Passes LWD Assigned Test Number	4V+1S											
Avg. Test Deflection (S.) (mm)	0.379	0.387	0.375	0.388	0.375	0.392	0.389	0.394	0.372	0.354	0.365	

LABORATORY REPORT DATA

TEST SITE MEASUREMENTS

COMMENTS

REMARKS: V - VIBRATORY S - STATIC

INDIANA DEPARTMENT OF TRANSPORTATION

INDIANA DEPARTMENT OF TRANSPORTATION
LWD TEST SECTION FOR AGGREGATE OVER SOILS

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO. _____

SYNTHESIZED TEST NO. _____

TEST SITE DATA

Subgrade LWD Info

Cohesive or Granular (Fill or Cut)

Passes LWD Assigned Test Number	4V+1S										
Avg. Test Deflection (S.) (mm)	0.379	0.387	0.375	0.388	0.375	0.392	0.389	0.394	0.372	0.354	0.365
Passes LWD Assigned Test Number	5V+2S										
Avg. Test Deflection (S.) (mm)	0.273	0.269	0.278	0.278	0.273	0.269	0.275	0.265	0.279	0.270	0.274

LABORATORY REPORT DATA

TEST SITE MEASUREMENTS

COMMENTS

REMARKS: V - VIBRATORY S - STATIC

INDIANA DEPARTMENT OF TRANSPORTATION

INDIANA DEPARTMENT OF TRANSPORTATION
LWD TEST SECTION FOR AGGREGATE OVER SOILS

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO. _____

SYSTEMS TEST NO. _____

TEST SECTION DATA

Test Section Data	Station	Ref. to Construction	Number of LWDs	Completed Depth (ft. or m)	Test Section Division Number	Average	1	2	3	4	5	6	7	8	9	10
Subgrade LWD Info	Type	LWD Assigned Test Number	Cohesive or Granular (Fill or Cut)													
LWD Test Section Data	Passes	LWD Assigned Test Number	4V+1S													
	Avg.	Test Deflection (S.) (mm)	0.379	0.387	0.375	0.388	0.375	0.392	0.389	0.394	0.372	0.354	0.365			
	Passes	LWD Assigned Test Number	5V+2S													
	Avg.	Test Deflection (S.) (mm)	0.273	0.269	0.278	0.278	0.273	0.269	0.275	0.265	0.279	0.270	0.274			
	Passes	LWD Assigned Test Number	6V+3S													
	Avg.	Test Deflection (S.) (mm)	0.267	0.266	0.267	0.275	0.298	0.268	0.272	0.269	0.256	0.244	0.255			
	Passes	LWD Assigned Test Number														
	Avg.	Test Deflection (S.) (mm)														
	Passes	LWD Assigned Test Number														
	Avg.	Test Deflection (S.) (mm)														
Test Site	Maximum Allowable Deflection (mm)	0.267	TEST DATA													
Laboratory Report Data	Material Name and Date	Test Number														
Test Site Moisture	Moisture (Std. Pass. - 3% to 5%)	0														
Comments	Comments 1															
	Comments 2															



REMARKS: The procedure will continue until the difference of the average of the 10 LWD test between consecutive cells passes a visual test per Page 3.02.02.

V - VIBRATORY S - STATIC

LWD 50 Count _____

Contractor: _____

RECORDED BY SITE MANAGER _____ QUALIFIED TECHNICIAN _____

INDIANA DEPARTMENT OF TRANSPORTATION
LWD TEST SECTION FOR AGGREGATE OVER SOILS

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO. _____

SYSTEMS TEST NO. _____

TEST SECTION DATA

Test Section Data	Station	Ref. to Construction	Number of LWDs	Completed Depth (ft. or m)	Test Section Division Number	Average	1	2	3	4	5	6	7	8	9	10
Subgrade LWD Info	Type	LWD Assigned Test Number	Cohesive or Granular (Fill or Cut)													
LWD Test Section Data	Passes	LWD Assigned Test Number	4V+1S													
	Avg.	Test Deflection (S.) (mm)	0.379	0.387	0.375	0.388	0.375	0.392	0.389	0.394	0.372	0.354	0.365			
	Passes	LWD Assigned Test Number	5V+2S													
	Avg.	Test Deflection (S.) (mm)	0.273	0.269	0.278	0.278	0.273	0.269	0.275	0.265	0.279	0.270	0.274			
	Passes	LWD Assigned Test Number	6V+3S													
	Avg.	Test Deflection (S.) (mm)	0.267	0.266	0.267	0.275	0.298	0.268	0.272	0.269	0.256	0.244	0.255			
	Passes	LWD Assigned Test Number														
	Avg.	Test Deflection (S.) (mm)														
	Passes	LWD Assigned Test Number														
	Avg.	Test Deflection (S.) (mm)														
Test Site	Maximum Allowable Deflection (mm)	0.267	TEST DATA													
Laboratory Report Data	Material Name and Date	Test Number	111													
	Station	112+05														
	Tested on Material Passing (No. 4 or 3/4" Sieve)	3/4														
	1. Wt. of Pan & Wet Material (W1)(b) or (g)	2370.0														
	2. Wt. of Pan & Dry Material (W2)(b) or (g)	2188.7														
	3. Wt. of Moisture (b) Line 1 - Line 2	181.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	4. Wt. of Pan (W3)(b) or (g)	100.0														
	5. Wt. of Dry Material Line 2 - Line 4	2088.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	% Moisture (0.1%) (Line 3 / Line 5) x 100	8.7														
Comments	Comments 1															
	Comments 2															



REMARKS: The procedure will continue until the difference of the average of the 10 LWD test between consecutive cells passes a visual test per Page 3.02.02.

V - VIBRATORY S - STATIC

LWD 50 Count _____

Contractor: _____

RECORDED BY SITE MANAGER _____ QUALIFIED TECHNICIAN _____

LWD Accepting Data Sheet

TD409 LWD Rev 12 INDIANA DEPARTMENT OF TRANSPORTATION ORIGINAL: PROJECT FILE
 6/10/2014 LWD AND MOISTURE ACCEPTANCE TESTS COPY TO: OFFICE OF GEOTECHNICAL ENGINEERING, Indianapolis

AGGREGATES OVER CHEMICALLY MODIFIED SOILS

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO.			
SITEMANAGER TEST NO.			
SITEMANAGER SAMPLE I.D. NO. (R+12 digits)			
Test Site	Station		
	Line No.		
	Ref. To Centerline		
	Elevation or Lift No.		
	Compacted Depth of Lift (inches)		
Comp. App.	LWD Assigned Test Number		
	Test Deflection (S _L) (mm)		
	Average Deflection (mm)		
Laboratory Data	Maximum Allowable Deflection (mm)		
	Material Name and Type		
	Lab. SM ID (R+12 digits)		
Test Site	Optimum Moisture Content (OMC) (%)		
	Determined Moisture (%)		
Comments	Comments 1		
	Comments 2		

REQUIREMENTS:		ITEM 506 DATA	
Maximum Allowable Deflections (mm)	Aggregates over Cement Modified Soil - 0.30 (mm)	Test Number	
REMARKS:		Station	
CS = Crushed Stone, G = Gravel, S = Slag		Tested on Material Passing (No. 4 or 3/4" Sieve)	
		1. Wt. of Pan & Wet Material (W1)(lb) or (g)	
		2. Wt. of Pan & Dry Material (W2)(lb) or (g)	
		3. Wt. of Moisture (M) Line 1 - Line 2	0.0 0.0 0.0
		4. Wt. of Pan (W3)(lb) or (g)	
		5. Wt. of Dry Material Line 2 - Line 4	0.0 0.0 0.0
		6. Moisture (0.1%) (Line 3 / Line 5) x 100	

LWD Serial Number _____ RECORDED IN SITE-MANAGER _____ Qualified Technician: _____




TD409 LWD Rev 12 INDIANA DEPARTMENT OF TRANSPORTATION ORIGINAL: PROJECT FILE
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FOR CHEMICALLY MODIFIED SOILS

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO.			
SITEMANAGER TEST NO.			
SITEMANAGER SAMPLE I.D. NO. (R+12 digits)			
Test Site	Station		
	Line No.		
	Ref. To Centerline		
	Elevation or Lift No.		
	Compacted Depth of Lift (inches)		
Chem. Modif.	LWD Assigned Test Number	1	
	Test Deflection (S _L) (mm)	0.263	
	Average Deflection (mm)		
Target	Maximum Allowable Deflection (mm)	0.267	
* From test section	Maximum Allowable Deflection (mm)		
Laboratory Data	Lab. SM ID (R+12 digits)		
	Optimum Moisture Content (OMC) (%)		
Test Site	Determined Moisture (%)		
	Sec. #15, @ OMC or above	0	0
Comments	Comments 1		
	Comments 2		

REQUIREMENTS:		ITEM 506 DATA	
Maximum Allowable Deflections	Lime	Test Number	
Modified Soil 0.30 (mm)	Cement	Station	
Modified Soil 0.27 (mm)		Tested on Material Passing (No. 4 or 3/4" Sieve)	
REMARKS:		1. Wt. of Pan & Wet Material (W1)(lb) or (g)	
* From test section (Determined by test section)		2. Wt. of Pan & Dry Material (W2)(lb) or (g)	
		3. Wt. of Moisture (M) Line 1 - Line 2	0.0 0.0 0.0
		4. Wt. of Pan (W3)(lb) or (g)	
		5. Wt. of Dry Material Line 2 - Line 4	0.0 0.0 0.0
		6. Moisture (0.1%) (Line 3 / Line 5) x 100	

LWD Serial Number _____ RECORDED IN SITE-MANAGER _____ Qualified Technician: _____

TD409 LWD Rev 12 INDIANA DEPARTMENT OF TRANSPORTATION ORIGINAL: PROJECT FILE
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CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO.					
SITEMANAGER TEST NO.					
SITEMANAGER SAMPLE I.D. NO. (R+12 digits)					
Test Site Data	Station				
	Line No.				
	Ref. To Centerline				
	Elevation or Lift No.				
Compacted Depth of Lift (inches)					
Number of Passes with Compactor					
Chem. Modif.	LWD Assigned Test Number	1	2		
	Test Deflection (S _u) (mm)	0.223	0.243		
	Average Deflection (mm)				
Target	Maximum Allowable Deflection (mm)		0.267		
* From test section	Maximum Allowable Deflection (mm)				
Laboratory Data	ASTM D1557 (R+12 digits)				
	Optimum Moisture Content (OMC) (%)				
Test Site Moisture	Determined Moisture (%)				
	Sec. 215, @ OMC or above	0	0	0	
Comments	Comments 1				
	Comments 2				
PASS OR FAIL OR INFORMATION					
REQUIREMENTS:		Lime Cement	ITEM 506 DATA		
Maximum Allowable Deflections		Test Number			
Modified Soil 0.30 (mm)		Station			
Modified Soil 0.27 (mm)					
REMARKS:					
* From test section (Determined by test section)					
LWD SUI Carrot		Tested on Material Passing (No. 4 or 3/4" Sieve)			
Compactor:		1. Wt. of Pan & Wet Material (W1)(b) or (g)			
		2. Wt. of Pan & Dry Material (W2)(b) or (g)			
		3. Wt. of Moisture (b) Line 1 - Line 2	0.0	0.0	0.0
		4. Wt. of Pan (W3)(b) or (g)			
		5. Wt. of Dry Material Line 2 - Line 4	0.0	0.0	0.0
		% Moisture (0.1%) (Line 3 / Line 5) x 100			

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CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO.					
SITEMANAGER TEST NO.					
SITEMANAGER SAMPLE I.D. NO. (R+12 digits)					
Test Site Data	Station				
	Line No.				
	Ref. To Centerline				
	Elevation or Lift No.				
Compacted Depth of Lift (inches)					
Number of Passes with Compactor					
Chem. Modif.	LWD Assigned Test Number	1	2	3	
	Test Deflection (S _u) (mm)	0.223	0.243	0.219	
	Average Deflection (mm)				
Target	Maximum Allowable Deflection (mm)		0.267		
* From test section	Maximum Allowable Deflection (mm)				
Laboratory Data	ASTM D1557 (R+12 digits)				
	Optimum Moisture Content (OMC) (%)				
Test Site Moisture	Determined Moisture (%)				
	Sec. 215, @ OMC or above	0	0	0	
Comments	Comments 1				
	Comments 2				
PASS OR FAIL OR INFORMATION					
REQUIREMENTS:		Lime Cement	ITEM 506 DATA		
Maximum Allowable Deflections		Test Number			
Modified Soil 0.30 (mm)		Station			
Modified Soil 0.27 (mm)					
REMARKS:					
* From test section (Determined by test section)					
LWD SUI Carrot		Tested on Material Passing (No. 4 or 3/4" Sieve)			
Compactor:		1. Wt. of Pan & Wet Material (W1)(b) or (g)			
		2. Wt. of Pan & Dry Material (W2)(b) or (g)			
		3. Wt. of Moisture (b) Line 1 - Line 2	0.0	0.0	0.0
		4. Wt. of Pan (W3)(b) or (g)			
		5. Wt. of Dry Material Line 2 - Line 4	0.0	0.0	0.0
		% Moisture (0.1%) (Line 3 / Line 5) x 100			

TD409 LWD Rev 12
6/10/2014

INDIANA DEPARTMENT OF TRANSPORTATION
**LWD AND MOISTURE ACCEPTANCE TESTS
FOR CHEMICALLY MODIFIED SOILS**

ORIGINAL: PROJECT FILE
OFFICE OF GEOTECHNICAL ENGINEERING,
Indianapolis

COPY TO:

CONTRACT NO. _____ PROJECT NO. _____ ROAD NO. _____ DATE _____ WEATHER _____

FIELD TEST NO.			
SITEMANAGER TEST NO.			
SITEMANAGER SAMPLE I.D NO. (R+12 digits)			
Test Site Data	Station		
	Line No.		
	Ref. To Centerline		
	Elevation or Lift No.		
Penetrated Depth of Lift (inches)			
Number of Passes with Compactor			
Chem. Modif.	LWD Assigned Test Number	1	2
	Test Deflection (S _u) (mm)	0.223	0.243
	Average Deflection (mm)	0.210	
Target	Maximum Allowable Deflection (mm)	0.267	
* From test section	Maximum Allowable Deflection (mm)		
Laboratory Data	Lab. S _u (R+12 digits)		
	Optimum Moisture Content (OMC) (%)		
Test Site Moisture	Determined Moisture (%)		
	Sec. 215, @ OMC or above	0	0
Comments	Comments 1		
	Comments 2		
PASS OR FAIL OR INFORMATION			

REQUIREMENTS:
Maximum Allowable Deflections
Modified Soil 0.30 (mm)
Modified Soil 0.27 (mm)

ITEM 506 DATA

Test Number	Station	1. Wt. of Pan & Wet Material (W1)(b) or (c)	2. Wt. of Pan & Dry Material (W2)(b) or (c)	3. Wt. of Moisture (b) Line 1 - Line 2	4. Wt. of Pan (W3)(b) or (c)	5. Wt. of Dry Material Line 2 - Line 4	% Moisture (0.1%) (Line 3 / Line 5) x 100
				0.0	0.0	0.0	0.0

REMARKS:
* From test section (Determined by test section)

LWD SU Card
Inspector: _____

INDIANA DEPARTMENT OF TRANSPORTATION

Indiana
A Smart Way to Live

LWD Test

Acceptance Testing

Chemically modified soils ...**Three test per 1400 cyd** for two lane road.

Chemically modified soils shall be**proofrolled**

Aggregates over chemically modified soils**Three Test for 800 tons**

Moisture Test**One Moisture Test /day**



LWD Availability

LIGHT WEIGHT DEFLECTOMETER, LWD (ZORN)	
District	Total No's of LWD available
Crawfordsville	8
Fort Wayne	8
Greenfield	11
La Porte	10
Seymour	8
Vincennes	13
Office of Geotechnical Services	2
Total	60



Limitations:

- The aggregates larger than 1.5 in. shall not be over 15% in testing location.
- The testing location shall not exceed 5% inclination.
- The testing location shall not be frozen.
- Test shall not be executed when deflection measurements are less than 0.2 mm.
- LWD test is questionable in case of shallow ground water (2 feet) or soil with high moisture content.



Conclusions:

- Quick and easy.
- Inspector remains on grade at the test site.
- Roller operator see the results. Contactor more aware of final test results.
- Better understanding of water content.
- Easily transfer the data electronically .
- Modulus relates reliably with design parameters such as CBR, shear strength and Resilient Modulus.
- Test takes about three minutes.



Indiana Test Methods, (ITM)

Link for ITM -508-12T

ITM No. 508-12T

Field Determination of Deflection Using Light Weight Deflectometer

http://www.in.gov/indot/div/mt/itm/pubs/508_testing.pdf

LWD Field Testing Procedures

<http://intranet.indot.state.in.us/materialtests/pdfs/LWDFieldTestingProcedures.pdf>



Modulus-Based Construction Specification for Compaction of Earthwork and Unbound Aggregate: Appendices

DRAFT FINAL REPORT

Prepared for

**National Cooperative Highway Research Program
NCHRP Project 10-84**

**Transportation Research Board of
The National Academies**

Submitted by:

**The University of Texas at El Paso
Center for Transportation Infrastructure Systems
500 West University Avenue El Paso,
TX 79968-0516**

August 2014

TRANSPORTATION RESEARCH BOARD NATIONAL RESEARCH COUNCIL
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Selected Test Section in North Vernon

US-50

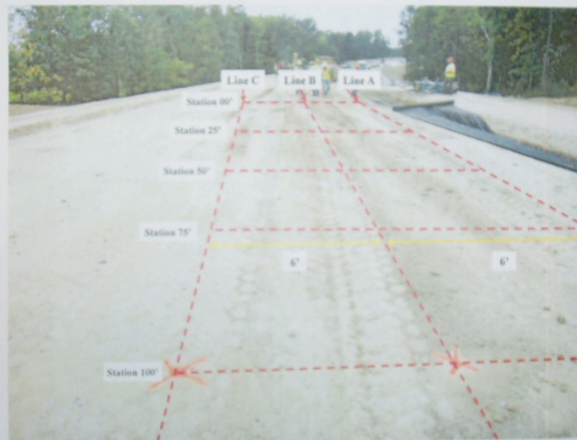


Figure L.1.2 – Location of Testing Spots on Selected Test Section in North Vernon, Indiana



Evaluation of Modulus-Based Devices

Subgrade Design Modulus 6500 psi

Subgrade Layer:

LWD modulus- 13810 psi.

DCP modulus- 29500 psi for the top 6-in. layer

LWD Accepting Data Sheet

DCP modulus-14900 psi for the 12 in. penetration
(Composite modulus of the layer)

Subbase Layer:

LWD modulus – 14000 psi

The standard deviation of the LWD replicate tests was 500 psi



Construction Projects

Construction Projects completed
in 2014 with LWD:

118 No's

LWD Test Performed in 2014:

2011 No's



Cost Comparison Among NDG, DCP, and LWD

Device	Estimated Tests Per 8-hr Day	Daily Employee Rate	Daily Equipment Rate	Daily Charge	Cost Per Test (Approx.)	Est. Device Price
NDG including 1-Point Proctor	18	\$336.00	\$35.00	\$371.00	\$20.60	\$ 8,000.00- \$12,000.00
DCP	32	\$336.00	\$ 3.00	\$339.00	\$10.00	\$ 1,000.00- \$ 1,300.00
LWD	72	\$336.00	\$14.00	\$350.00	\$ 5.00	\$ 10,000.00- \$ 1,2000.00

Other Costs:

NDG - Training: Safety and Maintenance

DCP - None

LWD- Calibration and Verification



Questions

?

