FLORIDA DEPARTMENT OF TRANSPORTATION
State Materials Office
5007 NE 39th Avenue
Gainesville, Florida 32609

June 21, 2023

Florida Method of Test for Lime Rock Bearing Ratio (LBR)

Designation: FM 5-515

1. SCOPE

This test method is intended for the determination of the bearing value of soils when they are compacted in the laboratory at moistures varying from the dry to wet side of optimum moisture per FM 1-T 180. The test is useful for evaluating lime rock and other soils used for base, stabilized subgrade, and subgrade or embankment material encountered in Florida.

Note 1: This procedure is a continuation of FM 1-T 180.

2. REFERENCED DOCUMENTS

FSTM Standards:

FM 1-T 180 – Moisture Density Relations of Soils Using a 10-lb. (4.54kg) Rammer and an 18-in. (457mm) Drop.

3. APPARATUS

3.1 Surcharge Weights One annular disc weighing 5 ± 0.10 pounds, (2.27 ± 0.04 kg), and additional slotted weights weighing 5 ± 0.10 pounds (2.27 ± 0.04 kg), as shown in **Appendix A**, each are used when surcharge is required (**See Section 6.1**).

3.2 Penetration Piston **–** The penetration piston is 1.954 ± 0.005 inches (49.63 ± 0.13 mm) in diameter and has a minimum length of 5 inches as shown in **Appendix C, D, E**, and **F**.

3.3 Loading Device **–** A compression loading device capable of being operated manually or electrically at a constant rate of 0.05 ± 0.005 inches (1.27 ± 0.13 mm) per minute can be used to force the penetration piston into the specimen as shown in **Appendix E** and **F**. If the loading device cannot maintain the allowable rate stated in this subsection, then the test result may be invalid.

Note 2: It is recommended to have a device that provides a Process Control check on the consistency of the entire load frame system. The device should achieve an LBR value of 100 at the correct penetration.

3.4 Swell Plate – A perforated plate weighing 2.5 ± 0.5 pounds (1.13 ± .23 kg),

similar to that shown in **Appendix B**, is used.

3.5 Soak Tank – A tank that shall have raised ridges, or other devices, in the bottom, placed in such a manner to allow free access of water to the bottom of the mold. The tank shall have an overflow placed so that the height of water in the tank remains within 0.25 inch (6.35 mm) of the same elevation as the top of the soil sample in the mold.

3.6 Electronic Data Acquisition System – A device such as a strip chart recorder or computer capable of producing the load-deflection curve for each test.

3.7 Documentation shall be maintained showing equipment verification at a frequency not to exceed 12 months. Verification documentation shall be maintained for the following equipment: surcharge weights, penetration pistons, loading devices, swell plates, and jaw crushers.

4. PROCEDURE

Immediately following the compaction per **FM 1-T 180**, the specimen shall be inverted so that the spacer disc is now on top and a base plate on the bottom. The spacer disc shall be removed. If the filter paper is damaged, or was not inserted prior to compaction, a new piece of filter paper shall be inserted at this time.

5. SOAKED OR UNSOAKED

5.1 Soaking Requirement **–** Following **Section 4**, the compacted specimens shall be placed in a soaking tank so that the height of water remains within 0.25 inch (6.35 mm) of the same elevation as the top of the soil sample in the mold. The soak time shall be 48 hours ± 4 hours. A swell plate shall be placed on top of each sample before it is placed in the soak tank and left in place during the entire soaking and draining period.

5.2 Draining – The specimen shall be removed from the soaking tank after the soak period and allowed to drain on a visibly level surface for 15 ± 2 minutes immediately before penetration testing. The drain surface shall be such that will allow free access for water to drain from the bottom of the mold. After draining, the swell plate shall be removed, and the specimen tested immediately.

5.3 Unsoaked – When permitted by specification, the soaked steps of **Section 5.1** can be eliminated.

6. PENETRATION TEST

6.1 Application of Surcharge – A surcharge of 15 pounds (6.8 kg) for stabilized subgrade and 20 pounds for embankment (9.1 kg) shall be applied to the specimen (**See Section 3.4**). No surcharge weight is used on base materials.

6.2 Application of Load – Before any reading is taken, a seating load of 10 pounds (4.54 kg) is applied to the specimen with the required surcharge weights as described in **Section 8.1** (Application of Surcharge), when using a manually operated machine as shown in **Appendix E.** The deflection and load gauges are then zeroed, and the load applied through the piston at a constant rate of 0.05 inches (1.3mm) ± 0.005 inch (0.13 mm) per minute. When automatic recording equipment, as shown in **Appendix F**, is used, the seating load is not required. When a strip chart recorder is used, the recording pen is zeroed on the chart paper before the load is applied.

6.3 Load Readings – Load readings shall be obtained for each 0.010 inch (0.25 mm) penetration up to 0.200 inches (5.08 mm), after which the load reading shall be taken at 0.225, 0.250, 0.275, 0.300, 0.325, 0.350, 0.375, 0.400, 0.450, and 0.500 inches (5.72, 6.35, 6.98, 7.62, 8.26, 8.89, 9.52, 10.16, 11.43, and 12.7 millimeters) of penetration. For those cases where the LBR value can obviously be obtained very early in the penetration testing, the higher penetration readings may be waived. **Appendix H** is a suggested form sheet for recording the necessary data obtained from a test specimen when using a manual loading device as shown in **Appendix E.** Each recorded unit load (pressure), in pounds per square inch (megapascals), shall be calculated by dividing the incremental load by 3 square inches (1935 mm^2). This unit load shall then be plotted as the ordinate (Y-axis) of a graph whereon the penetration, in inches (mm), is plotted as the abscissa (X-axis). A smooth curve shall be drawn through the plotted points. For those machines which perform the test automatically but are not equipped with recording devices, the technique is the same as for manually operated machines.

6.4 For machines equipped with load-deflection recorders, the curve is plotted automatically. It is well to note that most machines with attached recorders show the load in pounds (newton) rather than the unit load (pressure) in pounds per square inch (megapascals, MPa). Since the cross-sectional area of the piston is a constant, the load scale may easily be converted to a pressure scale simply be dividing the load in pounds (newton) by 3 square inches (1935 mm^2).

7. CALCULATIONS

7.1 Load-Penetration Relationship – The curve will usually be convex upwards although the initial portion of the curve may be concave upwards: the concavity is assumed to be due to surface irregularities as shown in **Appendix J.** A

correction is applied by drawing a tangent to the curve at the point of greatest slope. The corrected curve then becomes the tangent plus the convex portion of the original curve with the origin moved to the point where the tangent intersects the horizontal axis. Methods of correcting typical curves are illustrated in **Appendix J** and **K**.

7.2 Establishing Lime rock Bearing Ratio of Material – The corrected unit load obtained at 0.1 inch (2.54mm) penetration shall be divided by 800 psi (5.516 MPa), which is the standard strength of lime rock. This ratio is then multiplied by 100, and the resulting value is the LBR in percent.

$$\boldsymbol{LBR = \frac{Corrected\ Unit\ Load\ (psi)}{800\ psi} \times 100} \qquad \boldsymbol{(U.S.)}$$

or

$$\boldsymbol{LBR = \frac{Corrected\ Unit\ Load\ (MPa)}{5.516\ MPa} \times 100} \qquad \boldsymbol{(S.I.)}$$

The collection of LBR values for each compacted sample should provide sufficient data to plot an LBR vs. moisture content curve such as shown in the upper half of **Appendix G**. The peak or maximum LBR value can then be determined in the same way the maximum density is obtained from a moisture-density curve (lower half of **Appendix G**). This procedure shall be used whenever it is required to establish an LBR value for a material. A reported passing LBR shall not be extrapolated from a plot unless at least two points are above 90 percent of the minimum required specification value for the intended material use. If necessary, perform at least one additional LBR penetration test at a moisture content between the two highest data points.

Note 3: For those cases where a material is being tested to check for compliance to a specified minimum LBR value only, the two samples nearest optimum moisture may be tested. If both samples satisfy the minimum LBR requirements, the material may be reported as satisfying the specification, and the remainder of the samples may be discarded. If, however, either sample failed to meet the minimum specified LBR value, then the full LBR curve should be determined as previously described.

8. REPORT

The test results should be reported as shown on the sample page in **Appendix G** consisting of:

8.1 Moisture Density Plot – A plot of the moisture-density curve giving the maximum dry density to the nearest $\boldsymbol{0.1\ ^{lb}/_{ft^3}}$ (1 $^{kg}/_{m^3}$) and optimum

moisture content to the nearest 0.1 percent.

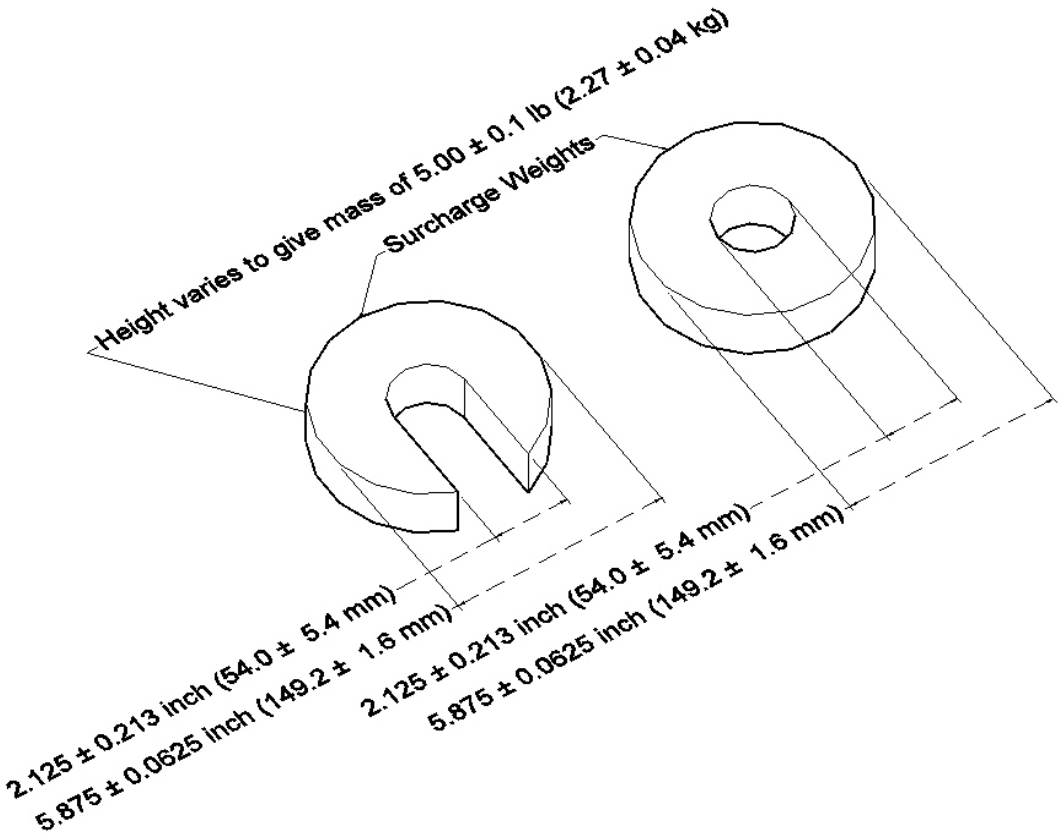
8.2 LBR Moisture Curve – A semi-log plot of the LBR-moisture curve giving the maximum LBR value.

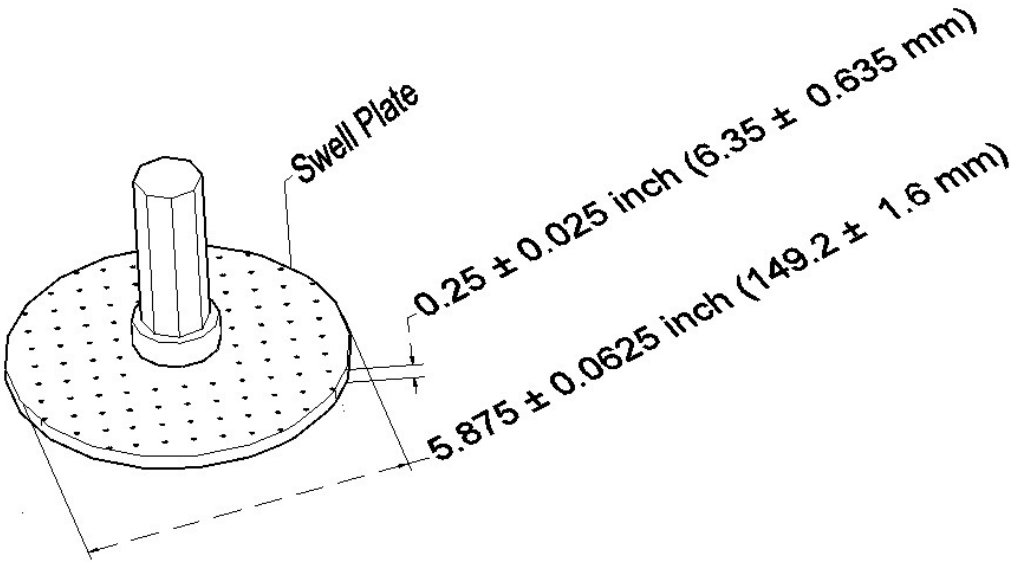
Metric Equivalents	
0.0001 in.	0.0025 mm
0.001 in.	0.025 mm
0.0625 + 0.03125 in	1.60 + 0.80 mm
0.25 in.	6.35 mm
2.00 ± 0.010 in.	50.80 ± 0.25 mm
1.41 + 0.026 in.	35.80 + 0.70 mm
1.954 + 0.005 in	49.63 + 0.13 mm
2.0625 in	52.39 mm
2.5 in.	63.00 mm
2.90 ± 0.02 in.	73.7 ± 0.51 mm
3.75 in.	95.25 mm
5.875 in.	149.23 mm
5.9375 + 0.031 in	150.81 + 0.79 mm
5.9375 in	151.0 mm
6.00 + 0.026 in.	152.40 + 0.70 mm
6.00 in.	152.40 mm
6.50 in.	165.10 mm
3.0 in^2.	1935.48 mm^2
5.00 ± 0.01 lb	2.27 ± 0.005 kg
10.0 lb	4.53 kg

The values above apply to **Appendix A – F.**

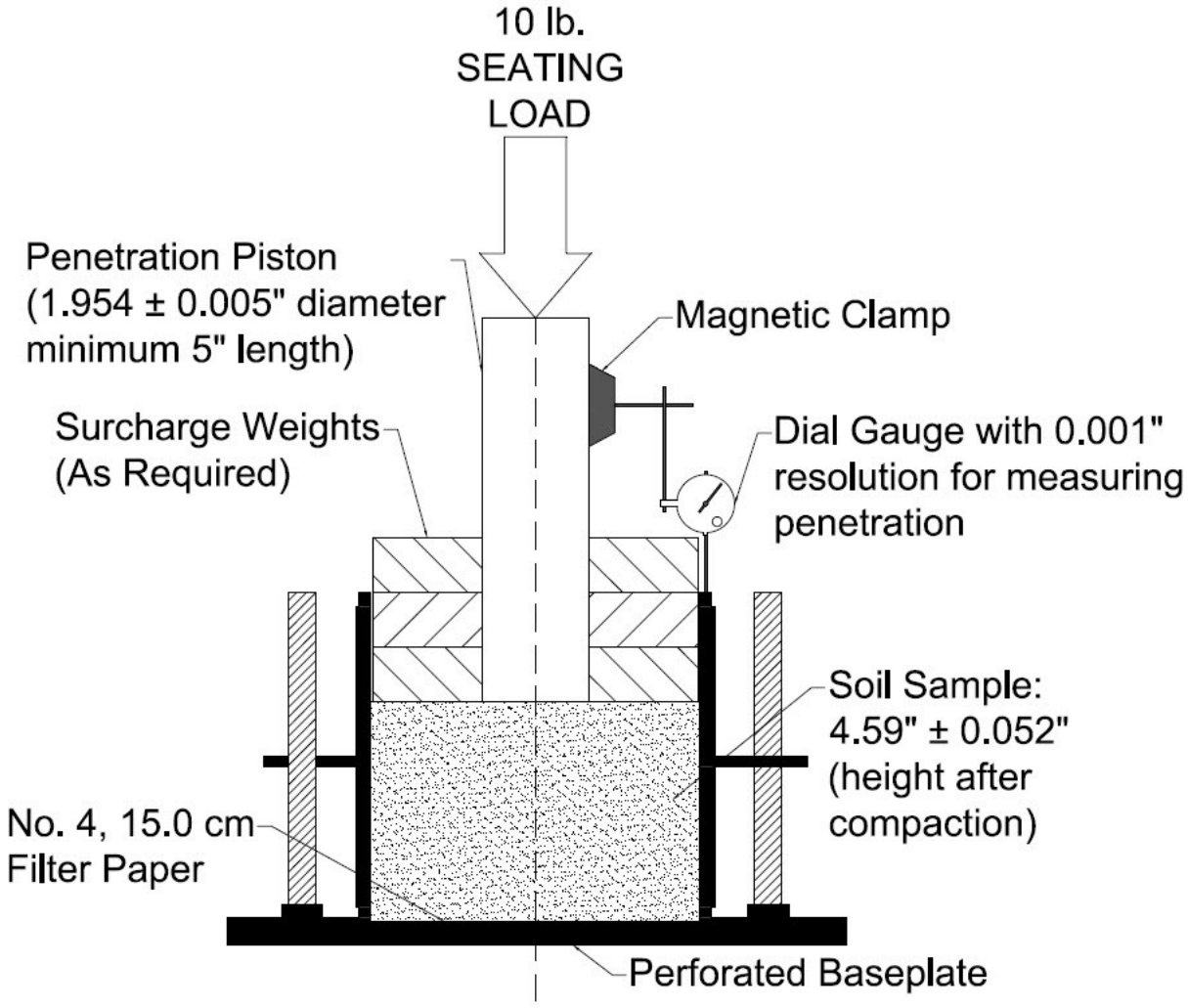
APPENDIX

APPENDIX A: LBR TESTING APPARATUS – PART I

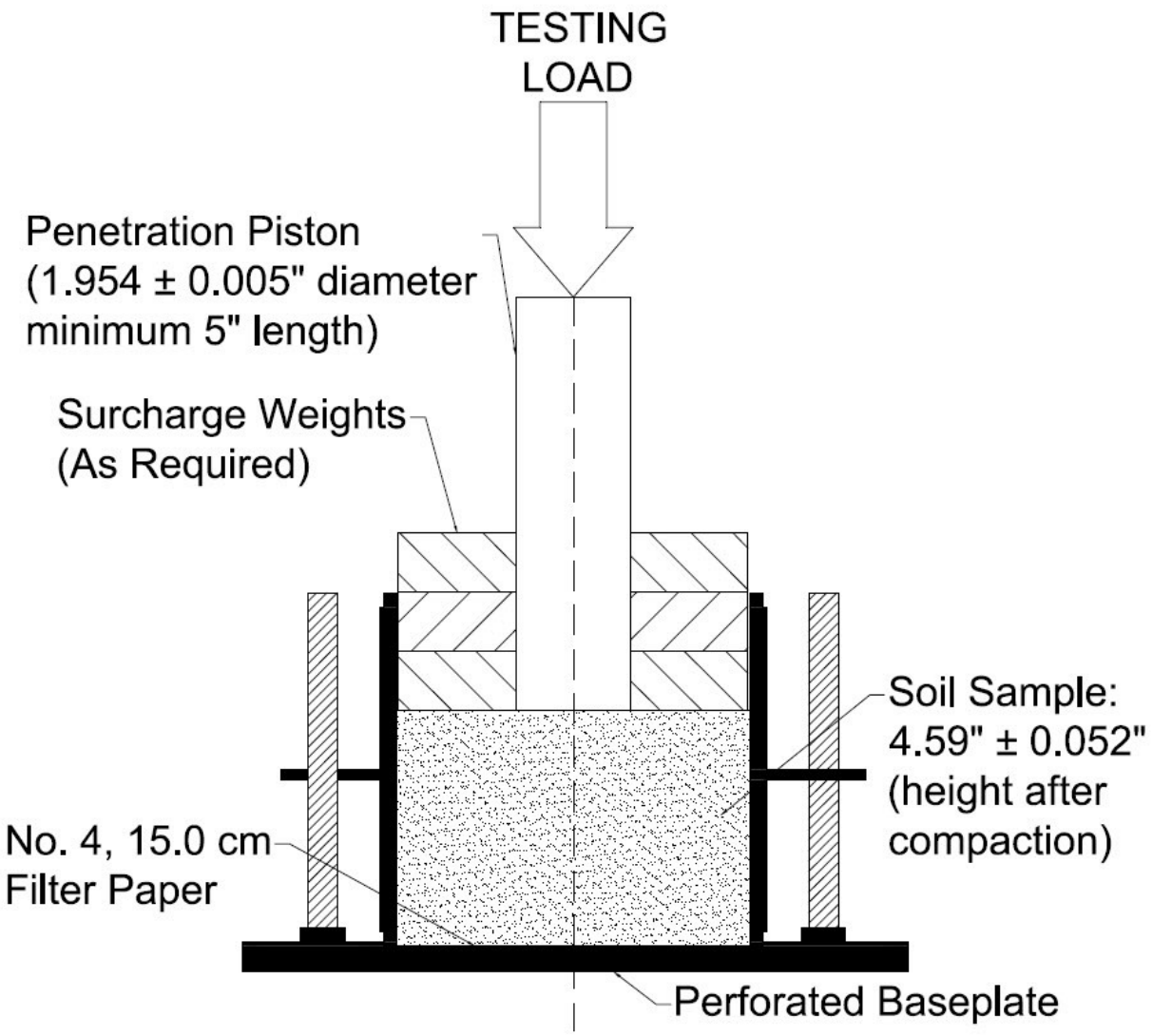




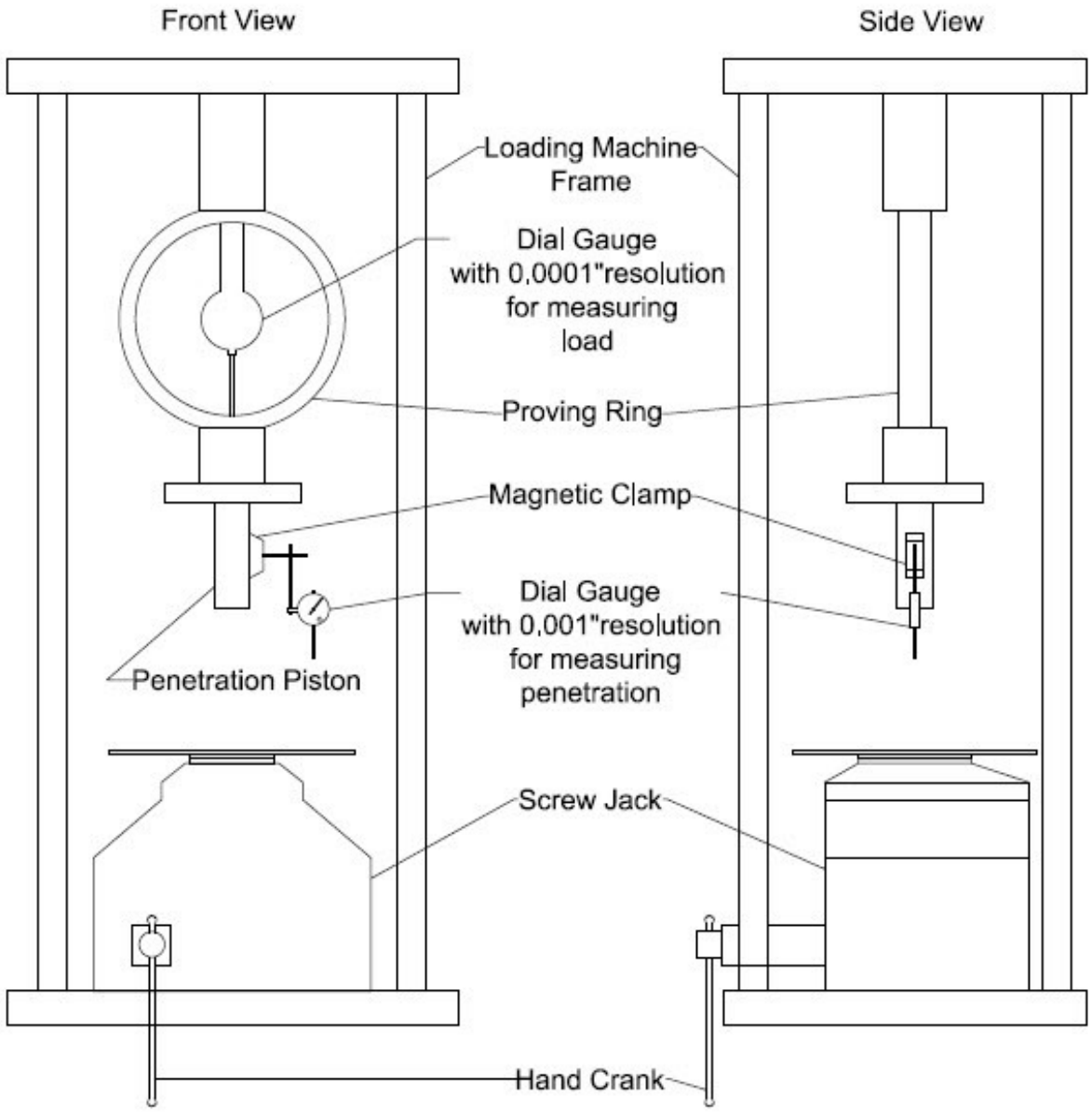
APPENDIX B: LBR TESTING APPARATUS – PART II



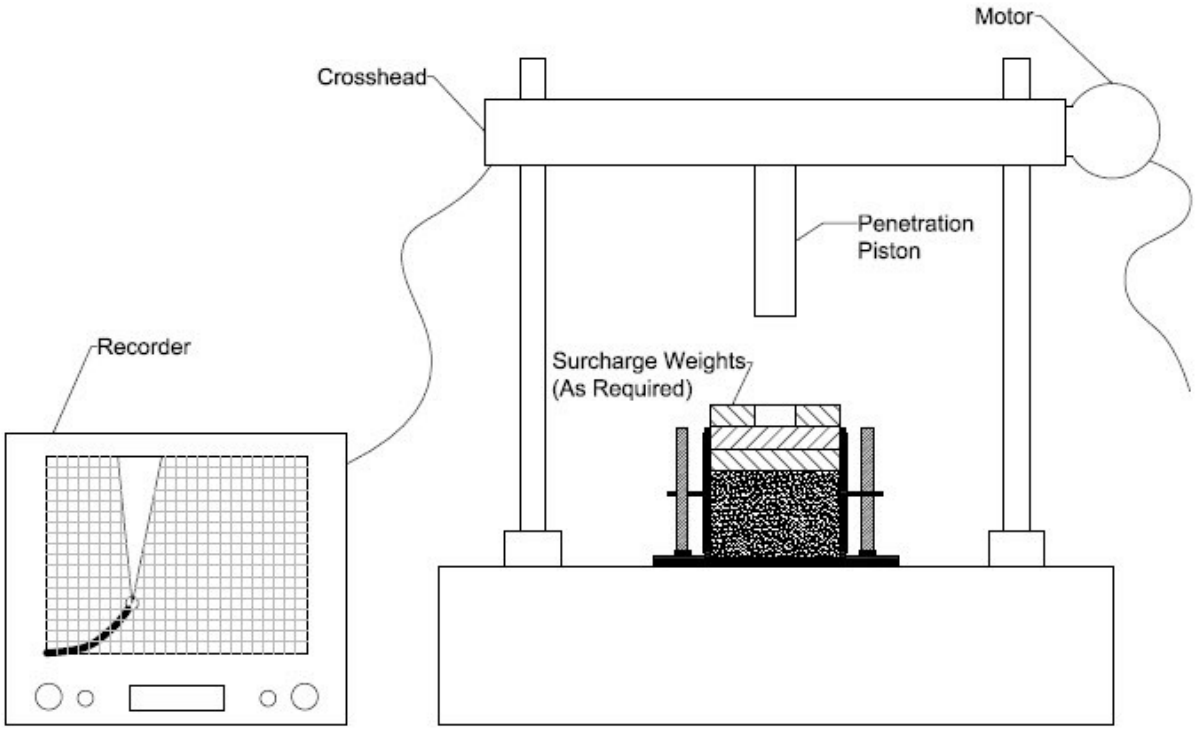
APPENDIX C: CROSS SECTION OF SEATED PENETRATION PISTON USING MANUAL LOADING DEVICE



APPENDIX D: CROSS SECTION OF PENETRATION PISTON USING AUTOMATIC RECORDING MACHINE



APPENDIX E: MANUAL LOADING DEVICE



APPENDIX f: AUTOMATIC TESTER AND RECORDER

State Materials Office Soils and Foundations Lab Analytical Testing Worksheet	FM 5-515 Limerock Bearing Ratio	Effective / Revised Date: Sept. 5, 2013 By: B. Greenwood — Pg. 1 of 1

Project Information		*Sample Information*		*Testing Results*	
Project Number	1910661B101	Sample Number	LBR Test #1	Dry Density (lbs/ft^3)	128.3
Testing Type	IR - Int. Research	LIMS Number		Optimum Moisture (%)	7.9
District	District 2	Sample Location		LBR	198
County	Alachua County	Notes			
Source	SMO Pit Stockpile Bin 1			Tested By	
Date Received	07162014	Date Tested	7/23/2014	Reviewed By	

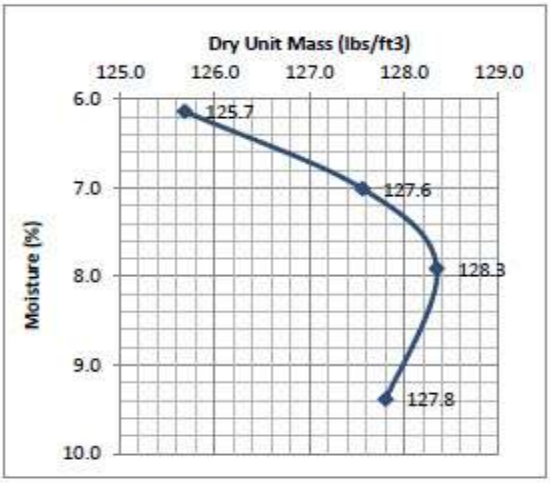
Material Description: White Limerock — Material ID: 405L

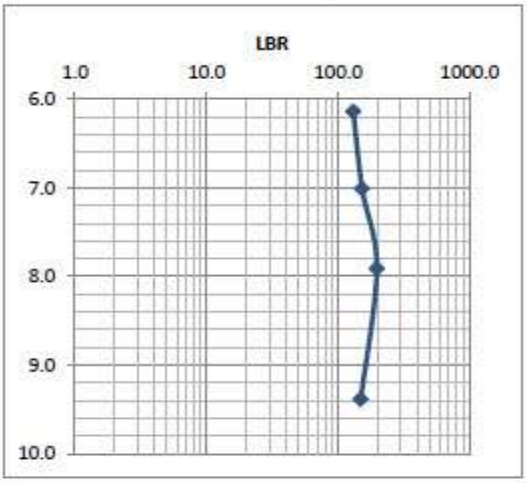
Compaction	✓	✓	✓	✓			Passing	%
Mold Number	238	224	54	90			3.5"	
Water Added (%)	6	7	8	9			1.5"	
Wet Mass & Mold (lbs.)	25.37	25.79	26.08	26			1"	
Mold Mass (lbs.)	15.36	15.55	15.69	15.51			3/4"	50
Wet Mass (lbs.)	10.01	10.24	10.39	10.49			#4	50
Wet Unit Mass (lbs/ft3)	133.4	136.5	138.5	139.8			#200	
Dry Unit Mass (lbs/ft3)	125.7	127.6	128.3	127.8				

L.B.R.	131	153	198	149		
Record Number	4	4	3	1		

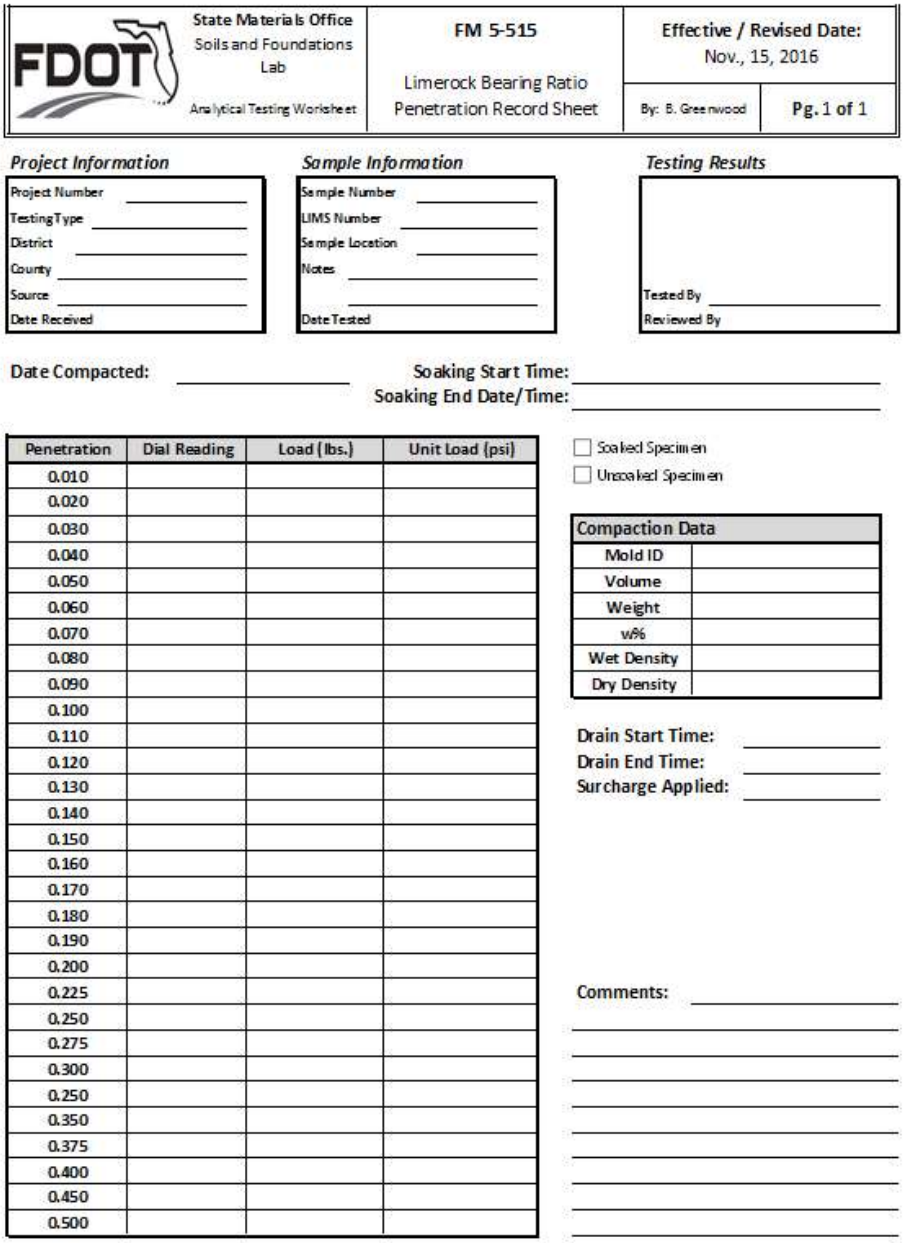
Notes

Moisture Determination						
Can Number	60	92	45	98		
Wet Soil & Can (g)	689.7	680.3	640.1	650.4		
Dry Soil & Can (g)	654.2	640.7	598.7	601.1		
Water Mass (g)	35.5	39.6	41.4	49.3		
Can Mass (g)	75.9	75.7	75.3	75.7		
Dry Soil Mass (g)	578.3	565	523.4	525.4		
Moisture Content (%)	6.1	7.0	7.9	9.4		





APPENDIX G: COMPACTION TEST AND LBR WORKSHEET EXAMPLE



State Materials Office
Soils and Foundations Lab
Analytical Testing Worksheet

FM 5-515
Limerock Bearing Ratio Penetration Record Sheet

Effective / Revised Date: Nov., 15, 2016
By: B. Greenwood
Pg. 1 of 1

Project Information

Project Number
Testing Type
District
County
Source
Date Received

Sample Information

Sample Number
LIMS Number
Sample Location
Notes
Date Tested

Testing Results

Tested By
Reviewed By

Date Compacted:
Soaking Start Time:
Soaking End Date/Time:

Penetration	Dial Reading	Load (lbs.)	Unit Load (psi)
0.010			
0.020			
0.030			
0.040			
0.050			
0.060			
0.070			
0.080			
0.090			
0.100			
0.110			
0.120			
0.130			
0.140			
0.150			
0.160			
0.170			
0.180			
0.190			
0.200			
0.225			
0.250			
0.275			
0.300			
0.250			
0.350			
0.375			
0.400			
0.450			
0.500			

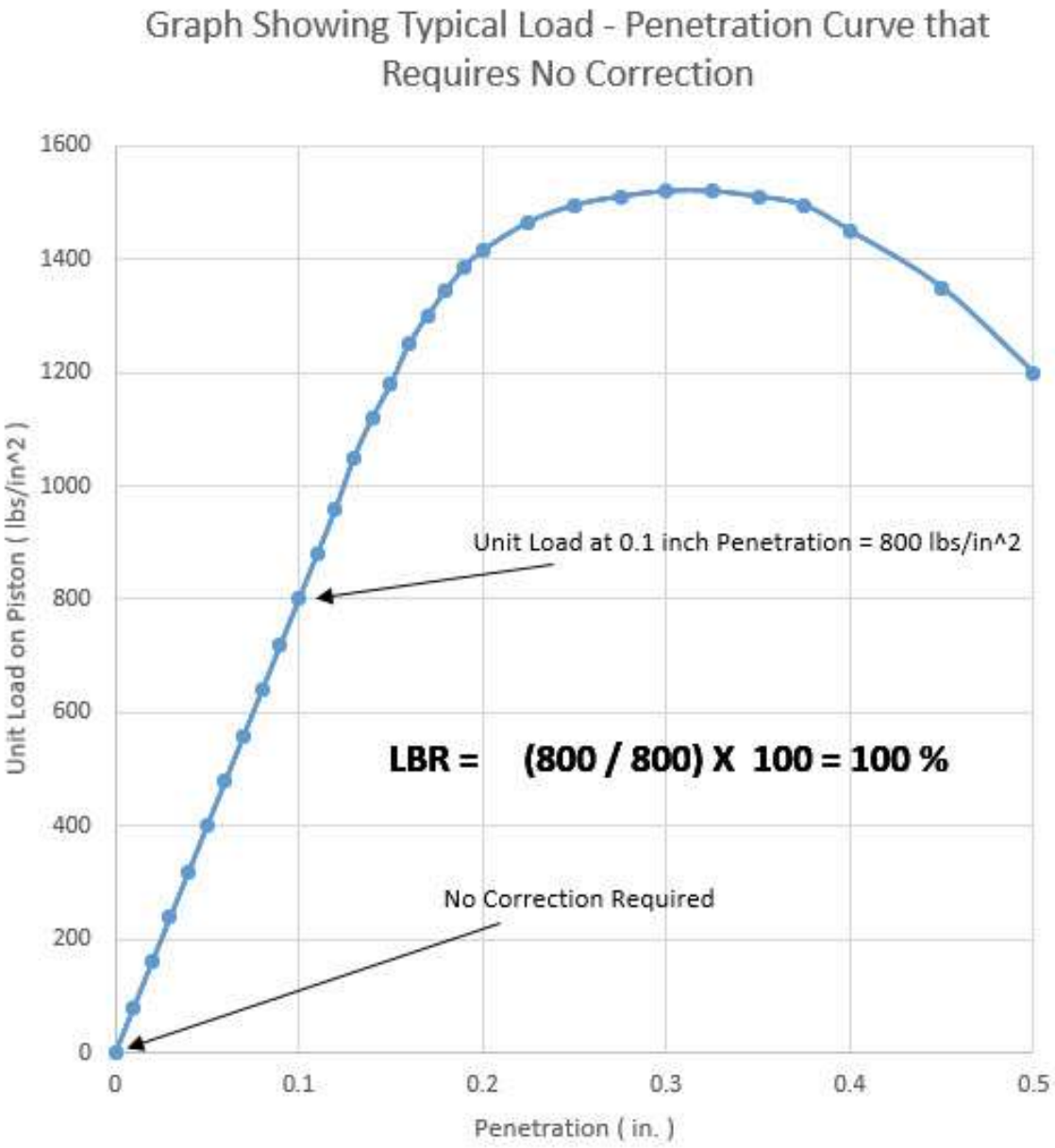
☐ Soaked Specimen
☐ Unsoaked Specimen

Compaction Data	
Mold ID	
Volume	
Weight	
w%	
Wet Density	
Dry Density	

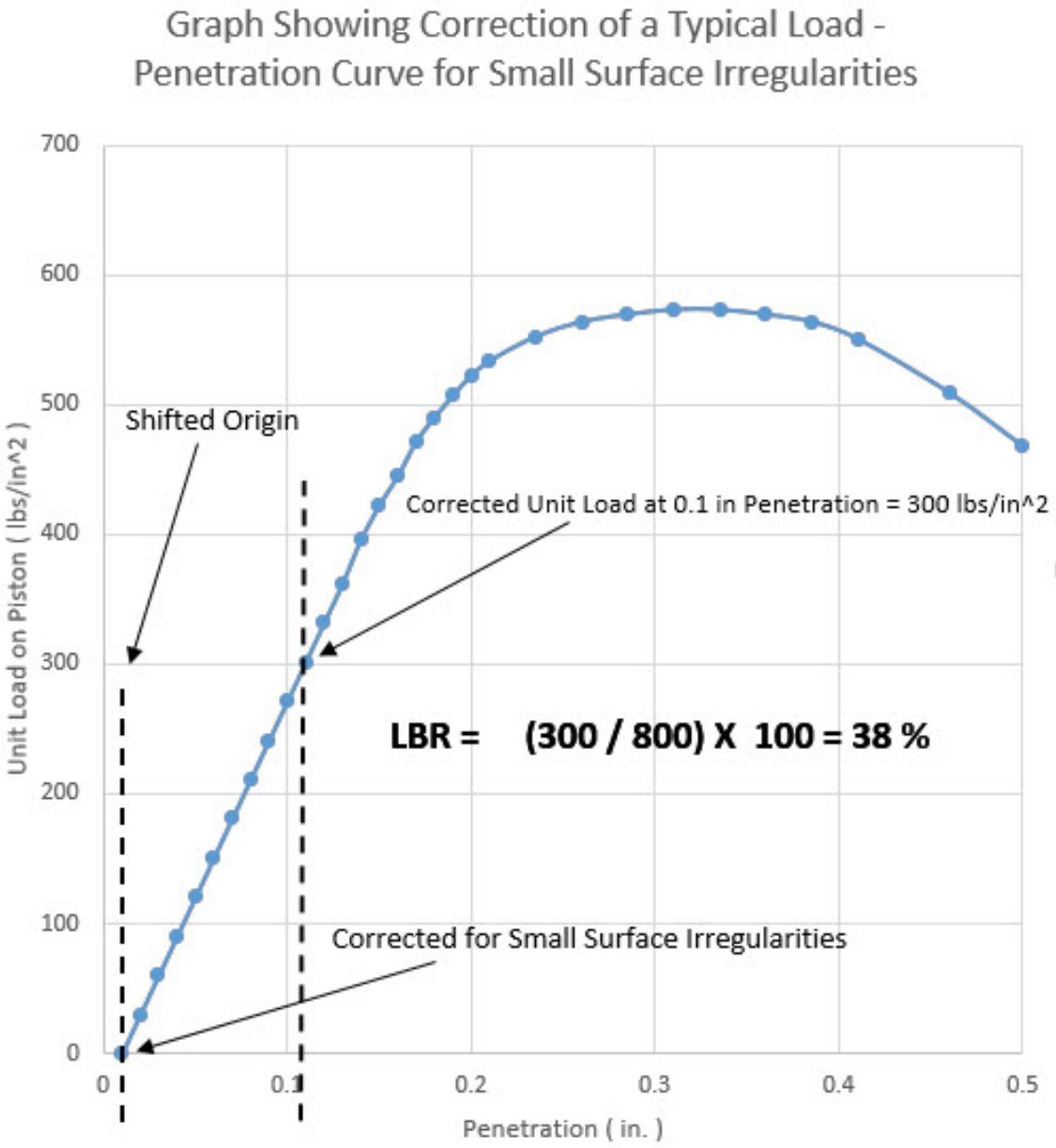
Drain Start Time:
Drain End Time:
Surcharge Applied:

Comments:

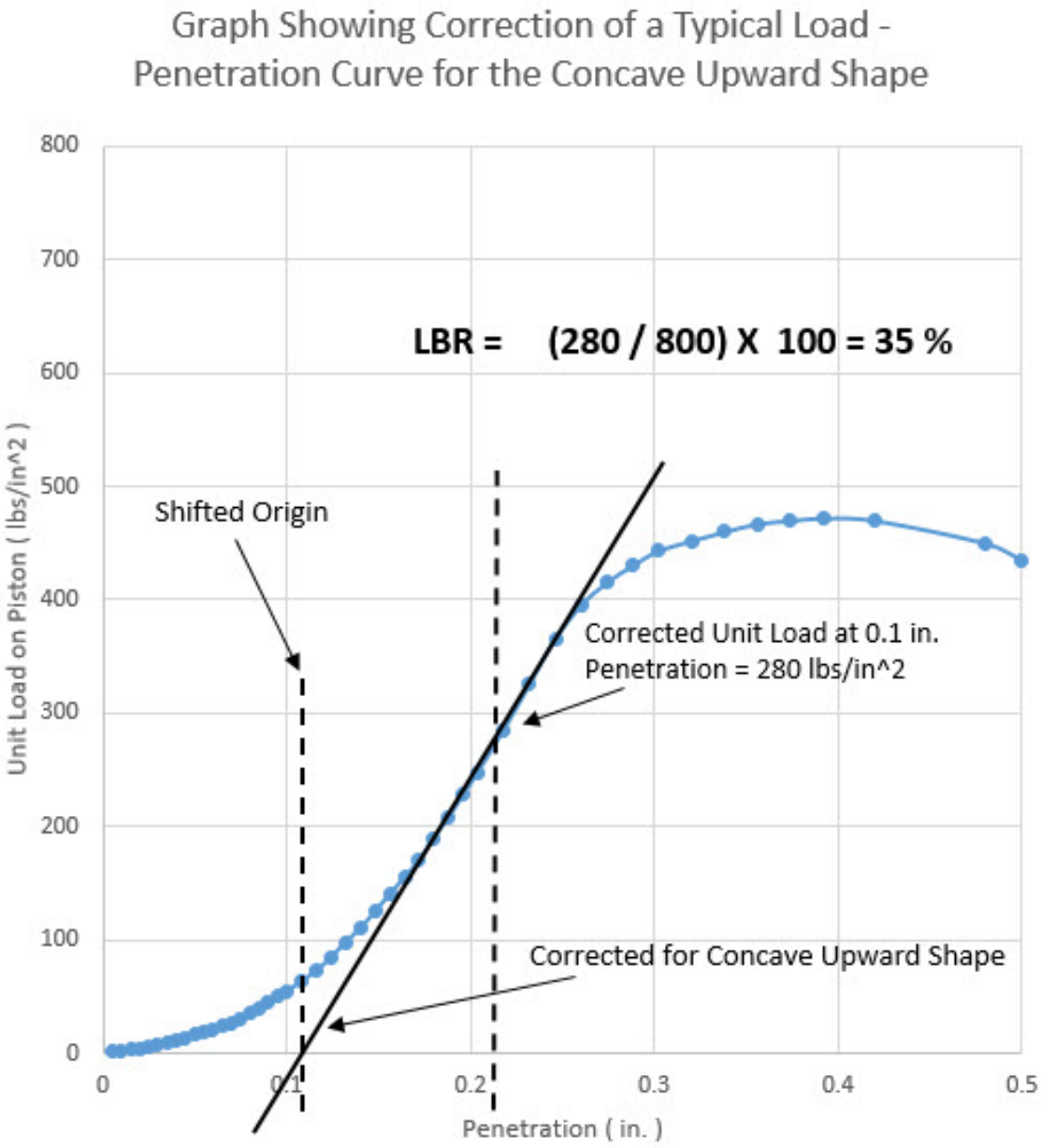
APPENDIX H: LBR TEST DATA SHEET EXAMPLE



APPENDIX i: PLOT OF UNIT LOAD VS. DEFORMATION REQUIRING NO CORRECTION



APPENDIX J: PLOT OF UNIT LOAD VS. DEFORMATION REQUIRING CORRECTION FOR SMALL SURFACE IRREGULARITIES



APPENDIX K: PLOT OF UNIT LOAD VS. DEFORMATION REQUIRING CORRECTION FOR THE CONCAVE UPWARD SHAPE CURVE