ALDOT – 427
PROCEDURE FOR LIMEROCK BEARING RATIO

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Date: 2019.10.22 08:19:48 -05'00'

1.0 Scope

1.1 This test method is intended for the determination of the limerock bearing ratio (LBR) of crushed limerock when it is compacted in the laboratory at moistures varying from the dry to wet side of optimum using a 10-lb. rammer dropped from a height of 18 in. The test is useful for evaluating limerock used for base.

2.0 Referenced Documents

2.1 AASHTO Standards

- M 92, Wire-Cloth Sieves for Testing Purposes
- M 231, Weighing Devices Used in the Testing of Materials
- T 2, Sampling of Aggregates
- T 180, Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in) Drop
- T 248, Reducing Samples of Aggregate to Testing Size
- T 265, Laboratory Determination of Moisture Content of Soils

3.0 Apparatus

3.1 The equipment shall consist of the following:

3.1.1 **A cylindrical mold** - made of metal, with an internal diameter of 6-in and a height of 6-in. It shall have a detachable collar assembly approximately 2.5-in. in height to permit preparation of compacted samples. The mold and collar assembly shall be so constructed that it can be fastened firmly to a detachable perforated base plate.

3.1.2 **Spacer Disc -** A metal disc 5 15/16-in in diameter and 1.41-in. in height that can be inserted as a false bottom in the cylinder mold during compaction.

3.1.3 **Mechanical Rammer -** The rammer shall be equipped with a suitable arrangement to control the height of drop to a free fall of 18 ± 0.06 in. above the elevation of the soil. The mechanical rammer shall operate in such a manner as to provide uniform and complete coverage of the specimen surface (8 to 10 blows per revolution of rammer). The rammer weight shall be 10 ± 0.02 lbs.

3.1.4 **Penetration piston** - the piston is 1.954 ± 0.005 in. in diameter and a minimum length of 5 in. with an end area of 3 in^2.

3.1.5 **Loading Device -** a compression loading device capable of being operated manually with 60,000 lbs. minimum capacity and capable of a constant rate of 0.05± 0.005 in. per minute.

3.1.6 **Scale -** with 70 lb. (30,000 g) capacity sensitive to one hundredths of a pound for weighing the specimen.

3.1.7 **Scale** – with a 2 lb. (1,000 g) capacity, sensitive to one tenth of a gram for weighing moisture samples.

3.1.8 **Perforated Plate (Swell Plate)** – weighing 2.5 ± 0.5 lbs.

3.1.9 **Water Tank** – with a depth sufficient enough to submerse the mold with sample to a depth so that the height of the water remains within 0.25 in. of the same elevation of the soil sample in the mold.

3.1.10 **Drying Oven –** Capable of maintaining a temperature of 110° C ± 0.5°.

3.1.11 **Coarse filter paper** 150-mm diameter (No. 4)

3.1.12 **Miscellaneous equipment** - including mixing pans, graduates, moisture cans, etc.

4.0 Sample Preparation

4.1 If the soil is damp when received from the field, it shall be dried until it becomes friable under the trowel. It may be dried in air or by use of drying apparatus such that the temperature does not exceed 140°F (60°C) .

4.2 Initial Preparation:

4.2.1 120 lbs. of material (approximately) is required for performing the LBR testing.

4.2.2 40 lbs. (approximately) of material is required for the PD, 4.2.3 2 lbs. of materials passing the No. 40 sieve is required for the atterburg limits.

4.2.4 For materials used for base or stabilizers with particle sizes greater than 3/4 in., the material shall be crushed so that the entire sample passes the 3/4-in. sieve by use of a mechanical jaw crusher having a minimum jaw plate dimension of 2.5 x 3.5 mm. Those pieces not reduced by mechanically crushing shall be manually broken up to pass the 3/4-in. sieve. The material is then passed through a No. 4 sieve, the percentage retained is recorded and the procedure is continued to Section 4.3.

4.3 The material shall then be separated into five portions weighing approximately 20 lbs. (9100 g), each of which shall be representative of the total.

4.4 Each of the separate portions shall be thoroughly mixed with amounts of water sufficient to cause each of the moisture contents of the samples to vary by approximately one percent with the lowest moisture content being approximately three percentage points below the optimum moisture content. The moisture contents selected shall bracket the optimum moisture content, thus providing samples which, when compacted, will increase in weight to the maximum density and then decrease in weight. The samples of soil-water mixtures shall be placed in covered containers and allowed to stand prior to compaction in accordance with Table 1. For selecting a standing time, it is not required to perform the actual classification procedure described in AASHTO M-145 (except in the case of referee testing), if previous data exist which provide a basis for classifying the sample.

TABLE 1 Dry Preparation Method Soaking Times

Classification M 145	Minimum Soaking Times-hours
A-3	No Requirement
A-2-4 (Non-Plastic)	3
A-1, A-2-4 (Plastic), A-2-5, A-2-6, A-2-7, A-4, A-5, A-6, A-7	12

5.0. COMPACTION PROCEDURE

5.1 Immediately prior to compacting the material, it shall be remixed, and a representative sample shall be taken for moisture content determination. The moisture content sample shall be weighed immediately, and the weight recorded. The sample shall be dried in an oven at 230 ± 9°F (110 ± □°C) for at least 12 hours, or to constant weight to determine the moisture content. The moisture content sample shall weigh not less than 1.125 lbs. (510g).

5.2 Each mold and base plate set shall be weighed empty without a spacer disk or extension collar. The weight shall be recorded and used later to determine the weight of soil in the mold after compaction.

5.3 The spacer disc shall be inserted into the bottom of the 6-inch mold and then a specimen formed by compacting the prepared soil in the mold (with collar attached) in five equal layers to give a total compacted depth of about 5 in. Each layer shall be compacted with 56 uniformly distributed blows from the rammer, dropping free from a height of 18 in. ± 1/16 inch above the approximate elevation of each finally compacted layer when a stationary mounted type rammer is used. During compaction, the mold shall rest on a uniform rigid foundation, such as is provided by a cube of concrete weighing not less than 200 lbs.

5.4 Following the compaction, the extension collar shall be removed, and the compacted soil carefully trimmed even with the top of the mold by means of the straight edge. Holes developed in the surface by removal of coarse material shall be patched with smaller size material passing a No. 4 sieve.

5.5 A coarse filter paper (No. 4) shall be placed over the top surface, and a perforated base plate clamped to the top of the mold. The mold shall be inverted and the base plate, formerly on the bottom, removed. The spacer disc shall be removed, and a filter paper inserted. The mold and moist soil shall then be weighed. Record the weight on the form. Multiply the weight of the compacted specimen (and mold), less the weight of the mold, by 13.33 and record the result as the wet weight in lbs. per cubic foot of the compacted soil.

5.6 Repeat the above procedure for each increment of moisture content using the samples prepared as described in Section 3. A minimum of four specimens shall be compacted at varying moisture contents beginning approximately two percentage points below the optimum moisture content and increasing the moisture until the optimum moisture content is exceeded.

6.0 MOISTURE-DENSITY RELATIONSHIP

6.1 Calculate the moisture content to the nearest 0.1 percent and the dry unit weight of the soil to the nearest 0.1 lb./ft^3 as compacted for each trial as follows:

$$w = \frac{\mathrm{A} - \mathrm{B}}{\mathrm{B} - \mathrm{C}} x100$$

and

$$\mathrm{Wd} = \frac{\mathrm{Ww}}{w + 100} x100$$

where:

w = percentage of moisture in the specimen based on oven dry mass of soil,
A = mass of container and wet soil,
B = mass of container and dry soil,
C = mass of container,
W_d = dry density in lb./ft^3 of compacted soil, and
W_w = wet density in lb./ft^3 of compacted soil.

The oven-dry unit weights in lbs. per cubic foot (densities) of the soil shall be plotted as ordinates and corresponding moisture contents as abscissas. Fitting the best smooth curve through these points, a convex curve is generally obtained. The coordinates of the peak of the curve shall be termed the optimum moisture content and the maximum dry density of the soil, respectively.

7.0 SOAKING

Following Section 4, the compacted specimens shall be placed in a soaking tank so that the height of water remains within 1/4 inch of the same elevation as the top of the soil sample in the mold. The soak time shall be 48 hours ± 4 hours. A surcharge of approximately 2.5 lbs. (weight of 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. Spacers shall be used under the base of each mold so that the perforations are elevated from the floor of the soaking tank.

7.1 Draining - Before the actual penetration test is run, the specimen shall be removed from the soaking tank and allowed to drain on a visibly level surface for 15 ± 2 minutes. 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.

8.0 PENETRATION TEST

8.1 No surcharge weight is used on base materials.

8.2 Application of Load - The deflection and load gauges are zeroed, and the load applied through the piston at a constant rate of approximately 0.05 in. per minute. When automatic recording equipment is used, the 10-pound seating load is not required. The recording pen is zeroed on the chart paper before the load is applied. Load readings shall be obtained for each 0.01-inch penetration up to 0.2 in., 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 in. 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. Each recorded unit load, in lbs. per square inch, shall be calculated by dividing the incremental load by 3 square in. This unit load shall then be plotted as the ordinate (vertical axis) of a graph whereon the penetration, in in., is plotted as the abscissa (horizontal 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.

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 lbs. rather than in lbs. per square inch. 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 lbs. by 3 square in.

9.0 CALCULATIONS

9.1 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. 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. See Appendix A for examples of corrected Graphs.

9.2 Establishing Limerock Bearing Ratio of Material - The corrected unit load obtained at 0.1-inch penetration shall be divided by 800 psi, which is the standard strength of limerock. This ratio is then multiplied by 100, and the resulting value is the LBR in percent.

$$\text{LBR} = \frac{\text{Corrected Unit Load}}{800\text{psi}} \text{x}100$$

The collection of LBR values for each compacted sample should provide sufficient data to plot an LBR vs. moisture content curve (semi-log). The peak or maximum LBR value can then be determined in the same way the maximum density is obtained from a moisture-density curve. This procedure shall be used whenever it is required to establish an LBR value for a material.

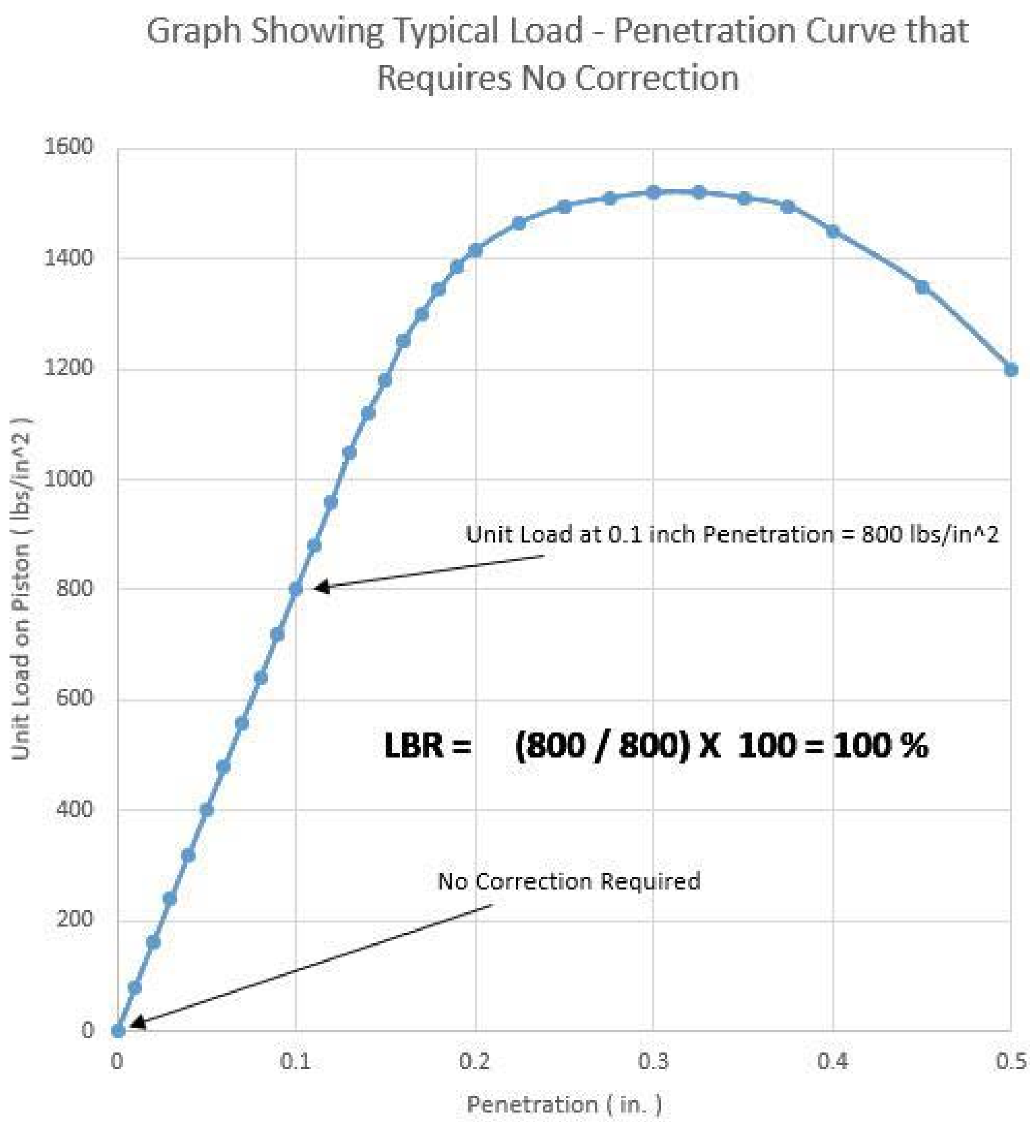
Note: (For those cases where a material is being tested to check for compliance to a specified minimum LBR value only, the two samples nearest optimum moisture may be tested. If both samples satisfy the minimum LBR requirements, the material may be reported as satisfying the specification, and the remainder 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.)

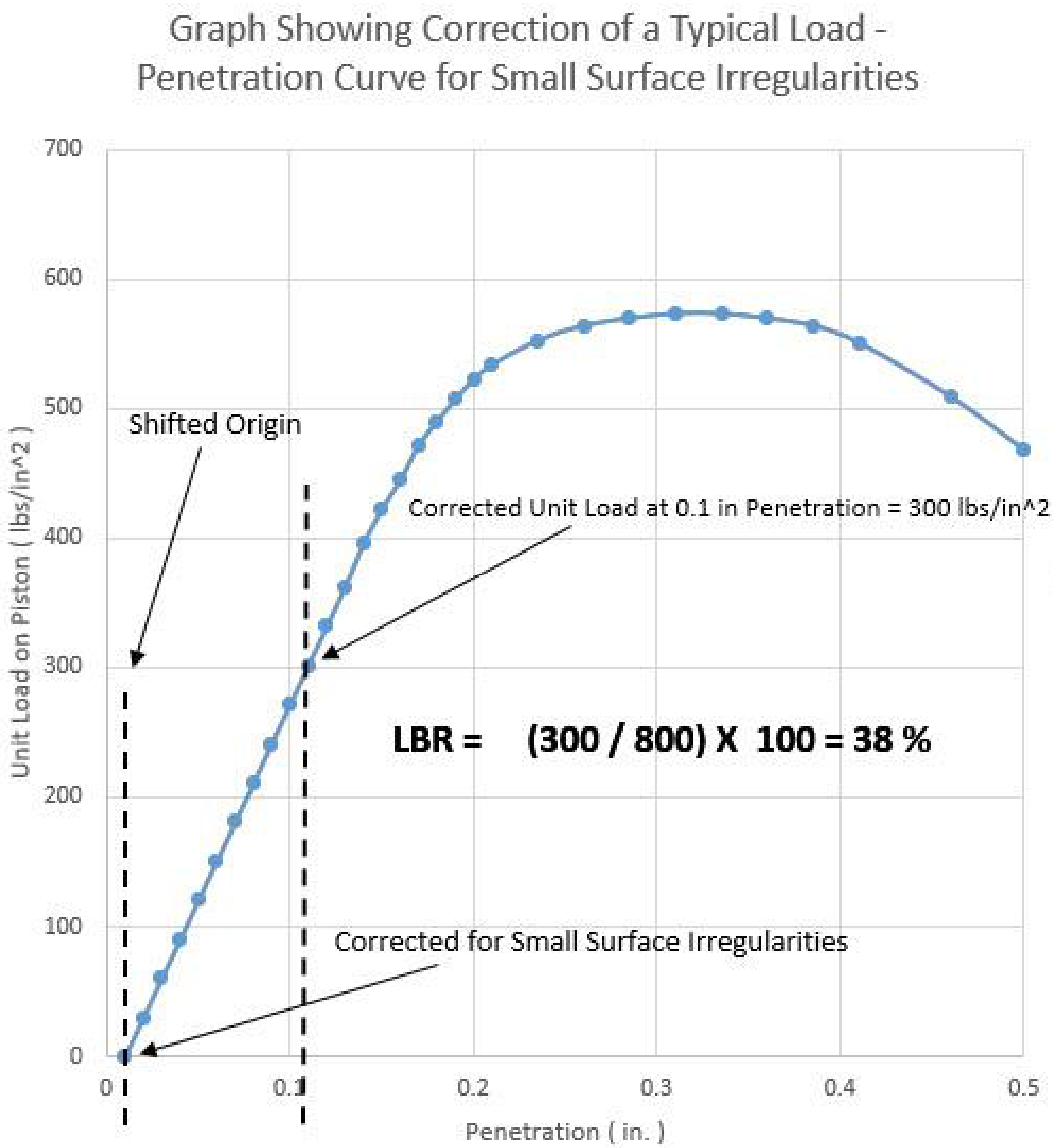
10.0 REPORT

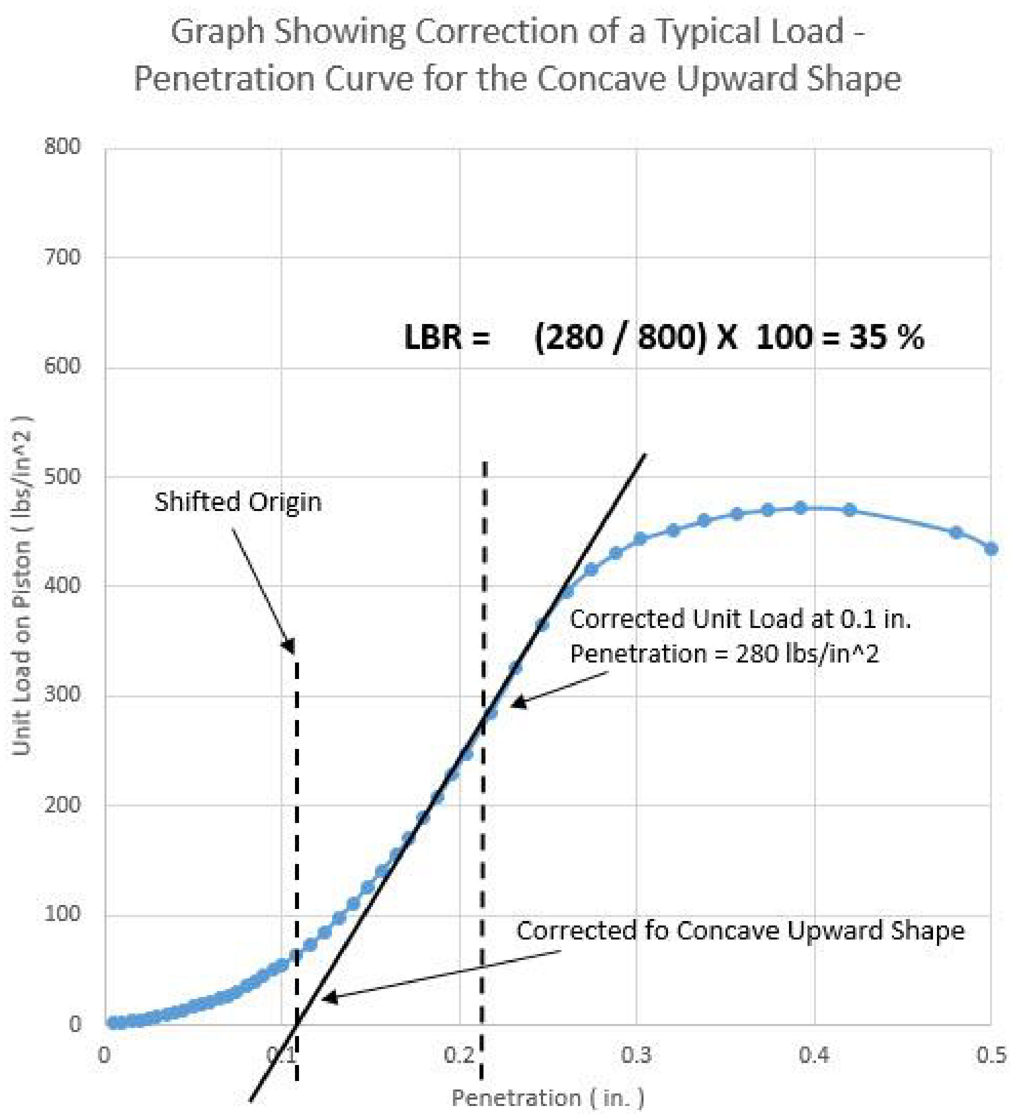
10.1 The following data shall be recorded and reported for each sample tested:

- 10.1.1 Gradation analyses for the sample as received.
- 10.1.2 Liquid limit and Plasticity Index.
- 10.1.3 Optimum Moisture and Maximum Density.
- 10.1.4 Bearing Ratio in percentage of the standard load for each sample for 0.1-inch penetration for the soaked specimens.
- 10.1.7 Design LBR Value.

APPENDIX A: Example Graph Corrections




Graph Showing Correction of a Typical Load - Penetration Curve for Small Surface Irregularities
700
600
500
400
300
200
100
0
Unit Load on Piston (lbs/in^2)
Shifted Origin
Corrected Unit Load at 0.1 in Penetration = 300 lbs/in^2
LBR = (300 / 800) X 100 = 38 %
Corrected for Small Surface Irregularities
0
0.1
0.2
0.3
0.4
0.5
Penetration (in.)


Graph Showing Correction of a Typical Load - Penetration Curve for the Concave Upward Shape
LBR = (280 / 800) X 100 = 35 %
Shifted Origin
Corrected Unit Load at 0.1 in. Penetration = 280 lbs/in^2
Corrected fo Concave Upward Shape
Unit Load on Piston (lbs/in^2)
Penetration (in.)
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5