Method of Test for
MOISTURE - DENSITY RELATIONSHIPS
DOTD Designation: TR 418M-98
METRIC VERSION

INTRODUCTION

These methods of test are designed to determine the relationship between the moisture content of the materials listed below and the resulting maximum dry density when the material is compacted in the laboratory as specified in this procedure.

These procedures are also applicable to previously stabilized or treated materials and existing materials, including materials containing asphaltic particles or particles of other surfacing, which are to be treated or stabilized.

Record and calculate values in these procedures to the same degree of accuracy shown in the example on the Laboratory Moisture-Density Relationship Worksheet for the applicable procedure.

All materials, except for shell, sand-shell, sand for use in sand-shell, and those containing reclaimed asphaltic concrete or previously stabilized or treated base course, shall be prepared in accordance with DOTD TR 411 and the appropriate method of test. Sand and shell shall be prepared in accordance with DOTD TR 418, Methods C or D. Materials containing reclaimed asphaltic concrete or previously stabilized or treated base course shall be prepared in accordance with DOTD TR 418, Methods H or I. Prior to the determination of maximum dry density and optimum moisture content, all materials shall be classified in accordance with DOTD TR 423, except for shell, sand-shell, materials containing reclaimed asphaltic concrete, recycled portland cement concrete, or previously stabilized or treated base course.

TABLE OF METHODS

1. **Method A** - Soils or soil-aggregate mixtures with less than 5% by dry mass of aggregate retained on a 4.75 mm sieve into which no additives are to be incorporated.
2. **Method B** - Soils or soil-aggregate mixtures with less than 5% by dry mass of aggregate retained on a 4.75 mm sieve into which cement, lime or other approved dry additives are to be incorporated.
3. **Method C** - Shell or sand-shell into which no additives are to be incorporated.
4. **Method D** - Shell or sand-shell into which cement is to be incorporated.
5. **Method E** - Soil-aggregate mixtures with 5% or more by dry mass of aggregate retained on a 4.75 mm sieve into which no additives are to be incorporated.
6. **Method F** - Soil-aggregate mixtures, all having 5% or more by dry mass of aggregate retained on a 4.75 mm sieve into which cement, lime or other approved dry additives are to be incorporated.
7. **Method G** - Designated materials, including stone, slag, or recycled portland cement concrete.
8. **Method H** - Recycled in-place material - specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.
9. **Method I** - Recycled in-place material to be cement stabilized or treated, or lime treated or conditioned - specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.

REFERENCE PROCEDURES

1. *DOTD TR 108,* Splitting and Quartering Samples.
2. *DOTD TR 112,* Amount of Material Finer than 75 μm sieve in Aggregate.
3. *DOTD TR 113,* Sieve Analysis of Fine and Coarse Aggregates.
4. *DOTD TR 403,* Determination of Moisture Content.
5. *DOTD TR 407,* Mechanical Analysis of Soils.
6. *DOTD TR 411,* Dry Preparation of Disturbed Samples for Test.
7. *DOTD TR 415,* Field Moisture - Density Relationships.
8. *DOTD TR 416,* Determination of the Percentage of Lime for Treatment of Soils or Soil-Aggregate Mixtures
9. *DOTD TR 417,* The Mixing Loss of Aggregate Material.
10. *DOTD TR 423,* Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes.
11. *DOTD TR 428,* Determining the Atterberg Limits of Soils.
12. *DOTD TR 432,* Determining the Minimum Cement Content for Soil Cement Stabilization.

DEFINITIONS

For the purposes of this test procedure, the following definitions will apply:

1. **Aggregate** - a naturally occurring or manufactured material, retained on a 2.00 mm sieve allowed for incorporation into the soil fraction. For testing purposes, previously stabilized or treated materials and existing materials, including materials containing asphaltic particles or particles of other surfacing which are retained on the 2.00 mm sieve shall be considered as aggregate.
2. **Additive** - an approved cement, lime or other approved additive incorporated dry into the soil, soil-aggregate mixture, shell or sand-shell mixture for stabilization or treatment. When approved liquid additives or slurries are to be incorporated, the testing method shall be determined by the DOTD Materials Engineer Administrator.
3. **Composite** - a blend of two or more samples representing materials with closely similar characteristics.
4. **Gravel** - naturally rounded, siliceous aggregate.
5. **Recycled In-place Materials** - soil or soil-aggregate mixtures which are not naturally occurring, containing asphaltic material, hydraulic cement, lime, or other stabilizers or surfacings excluding portland cement concrete, which exist in-place and are to be reprocessed.
6. **Recycled PCC** - a crushed, graded portland cement concrete prequalified in accordance with DOTD specifications.
7. **Sand** - a material approved for use as sand.
8. **Shell** - approved clam or reef shell.
9. **Siliceous** - a material composed of silica dioxide.
10. **Slag** - a material approved for use as slag.
11. **Stone** - a material approved for use as stone.
12. **Soil** - naturally occurring sand, silt or clay which passes the 2.00 mm sieve.
13. **Soil-Aggregate** - a mixture of soil and aggregate.

MATERIAL COMPOSITES

When a number of similar samples are submitted from a specific area, instead of developing an individual curve for each sample, a composite may be created and a single curve developed. A composite may consist only of soil or soil-aggregate mixtures which exhibit similar characteristics of geological formation, color, uniformity, weathering, origin, and engineering properties.

To be grouped into a composite, all individual samples must meet all of the following conditions.

1. The aggregate or aggregate-mixture must be the same type(s).
2. The total percentage of material retained on the 2.00 mm sieve must not vary more than ±5%. The percentage of material retained on the 2.00 mm and any individual sieve larger than the 2.00 mm sieve must not vary more than ±5%.
3. The soil types, based on the material passing the 2.00 mm sieve in accordance with DOTD TR 423, of individual samples to be incorporated into a composite must be identical.
4. The A-Groups, determined in accordance with DOTD TR 423, of individual samples to be incorporated into a composite must be identical.

Materials which meet these criteria may be composited. Composites shall be thoroughly blended. A representative portion will be obtained from the composite for testing purposes.

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD A

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry density of soils or soil-aggregates with less than 5% aggregate by dry mass retained on a 4.75 mm sieve, into which no additives are to be incorporated, when the material is compacted in the laboratory in accordance with this procedure. For soils or soil-aggregates with 5% or more aggregate retained on the 4.75 mm sieve, refer to DOTD TR 418, Method E.

Note A-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415.*

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 0.000944 m^3, manufactured with an internal diameter of 101.60 ± 0.41 mm and a height of 116.43 ± 0.13 mm, and with a detachable collar approximately 64 mm in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 102.21 mm or the height is less than 115.57 mm at any point.

Note A-2: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive device**
1. Automatic Rammer
   a. A metal 2.495 ± 0.023 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 101.6 mm inside diameter mold and arranged to control the height of drop to 305 ± 2 mm.
   b. Alternate - a metal 2.495 ± 0.023 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 101.6 mm inside diameter mold and arranged to control the height of drop to 457 ± 2 mm.
2. Manual Rammer - a metal 2.495 ± 0.023 kg rammer with a circular striking face with a diameter of 50.80 ± 0.25 mm and arranged to control the height of drop to 305 ± 2 mm.

C. **Compaction block** - a stable block or pedestal composed of portland cement concrete with a mass of 90 kg.

D. **Straightedge** - steel straightedge, approximately 300 mm long.

E. **Scale** - a scale of 10 kg or more capacity, sensitive to 5 g or less.

F. **Sieve** - a 4.75 mm sieve conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing the soil with water.
5. Large screwdriver to remove material from mold.
6. Ruler or Height Gauge - accurate to 1 mm.

H. **Graduated cylinder** - incremented in mL.

I. **Wax paper.**

J. **Engineer's Curve** - Alvin 1010-21 or equivalent.

K. **Laboratory Moisture-Density Worksheet, Methods A & B** - DOTD Form No. 03-22-4194. (Figure A-1)

L. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure A-2)

M. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure A-3)

Note A-3: *It is convenient, but not essential, to have a mechanical device for removing the compacted soil from the mold. Such a device may consist of a closed cylindrical sleeve slightly less than 102 mm in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

Obtain a representative portion, with a mass of 5 kg, of the dried prepared material passing the 4.75 mm sieve from a minimum 15 kg sample (1 full sample sack).

IV. Procedure

A. Record the mass of the representative portion as **D** on the worksheet.

B. Add a quantity of water, measured in mL, sufficient to make the soil slightly damp. Mix thoroughly. Record the quantity of water as **G** for the first point on the worksheet.

Note A-4: *Check the mixture by squeezing it in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

C. Pass the damp representative portion through a 4.75 mm sieve.

D. Cover the representative portion to which water has been added, protect it so that the moisture content remains constant, then allow it to slake for a minimum of thirty minutes. Remix thoroughly at the end of the slaking period. Recover the representative portion.

E. Compact the test specimen using an approved rammer.

1. If mold requires an attachable base plate, attach base plate. Determine the mass of the mold and base plate and record as **I** on the worksheet.
2. When using a mold without an attachable base plate, place wax paper on the compactor base. Determine the mass of mold and record the mass as **I** on the worksheet. Place the mold over the wax paper and secure the mold to the compactor base.
3. Attach collar to mold.
4. Uncover the representative portion and remix.
5. Place a quantity of the representative portion into the mold in an even layer that will yield slightly more than 1/3 the volume of the mold after compaction. Recover the representative portion.
6. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material, to a uniform lift thickness.
7. Rest the rammer on top of the layer to be compacted. Compact the layer using 25 blows with the 2.495 kg rammer from a 305 mm drop (alternate - 17 blows from a 457 mm drop).
8. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
9. Repeat Steps IV.E.4 - 8 for two more layers.
10. After the third layer has been compacted, remove the mold, base plate (if applicable), and compacted specimen from the automatic rammer and place in a pan.
11. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
12. Note the height of the compacted test specimen.
    a. If the compacted material is greater than 5 mm above the height of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
    b. If the compacted material is below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
13. Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the straightedge. Fill any depressions with the trimmed material. After the depressions are filled, smooth with the straightedge even with the top of the mold.
14. Brush material from all outside surfaces of mold, and exposed edges of base plate or wax paper.
15. Remove wax paper (if applicable) and brush fines from the wax paper onto top of test specimen. Take care not to lose any fines from test specimen.
16. Determine the mass of the mold, base plate (if applicable), and compacted test specimen and record the mass as **H** on the worksheet.
17. Remove the base plate, if applicable. Remove material from the mold. Obtain a representative test specimen of approximately 500 g from the center of the compacted material and determine the moisture content in accordance with DOTD TR 403, Method B.

18. Pass the remaining material from the mold through a 4.75 mm sieve and recombine it with the remaining representative portion.
19. Add water to the recombined representative portion to increase its moisture content by approximately 2% and mix thoroughly. (Refer to Step V.A. to determine the quantity of water to be added.) Record the quantity of water added in mL as **G** on the worksheet.
20. Repeat steps IV.E.1 - 19. Continue repeating the procedure until there is a substantial decrease in the wet mass of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the incremental quantity of water (G) in mL to equal an approximately 2% increase in the moisture content of the representative portion by using the following formula.

$$G = (D \times 0.02) - (10 \times N)$$

where:

D = dry mass of representative portion, g
N = the number of moisture content samples removed from the 5 kg representative portion
0.02 = decimal equivalent for a 2 % increment of water
10 = reduction of incremental water due to 500 g moisture content specimen

example:

D = 5145 g
N = 1

$$G = (5145 \times 0.02) - (10 \times 1)$$

$$= 102.9 - 10$$

$$G = 92.9 = 93$$

Note A-5: *1 g of water = 1 cc of water = 1 mL of water.*

B. Calculate wet mass of compacted soil (J) in grams in the mold for each moisture content by using the following formula.

$$J = H - I$$

where:

H = mass of mold, base plate (if applicable) and compacted wet soil, g
I = mass of mold and base plate (if applicable), g

example:

H = 5965 g
I = 4195 g

$$J = 5965 - 4195$$

$$J = 1770$$

C. Calculate wet density (WWD) in kg/m^3 for each moisture content by using the following formula.

$$WWD = \frac{J}{0.944}$$

where:

J = wet mass of compacted soil,g
0.944 = a constant including the volume of the mold and a conversion from g/m^3 to kg/m^3

example:

J = 1770 g

$$WWD = \frac{1770}{0.944}$$

$$WWD = 1875$$

D. Calculate the mass of water (WW) in grams and the mass of dry material (DW) in grams for each moisture content by using the following formulas.

$$WW = K - L \quad \text{and} \quad DW = L - M$$

where:

K = mass of cup and wet material, g
L = mass of cup and dry material, g
M = mass of cup, g

examples:

K = 586.0 g
L = 533.5 g
M = 47.5 g

$$WW = 586.0 - 533.5 \qquad DW = 533.5 - 47.5$$

and

$$WW = 52.5 \qquad DW = 486.0$$

E. For each increment of water added, calculate the moisture content (MC) in % of the material to the nearest 0.1 percent by using the following formula.

$$MC = (\frac{WW}{DW}) \times 100$$

where:

WW = mass of water, g
DW = mass of dry material, g

example:

WW = 52.5 g
DW = 486.0 g

$$MC = (\frac{52.5}{486.0}) \times 100$$

$$= 0.10802 \times 100$$

$$MC = 10.8$$

F. Calculate the dry density (DWD) in kg/m^3 for each moisture content using the following formula.

$$DWD = \frac{WWD}{100 + MC} \times 100$$

where:

WWD = wet density, kg/m^3
MC = moisture content, %

example:

WWD = 1875 kg/m^3
MC = 10.8 %

$$DWD = \frac{1875}{100 + 10.8} \times 100$$

$$= 16.9223 \times 100$$

$$DWD = 1692.23 = 1692\ kg/m^3$$

G. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet densities have been plotted. Repeat the process for each moisture content, substituting dry densities for wet densities.

H. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet Density vs. Moisture Content and Dry Density vs. Moisture Content. (Refer to the Laboratory Compaction Report.) As close as possible to the intersection, round the peak to form a smooth continuous line.

Note A-6: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

I. Determine the Optimum Moisture Content (%). The Optimum Moisture Content is the moisture content corresponding to the peak of the Dry Density Curve.

J. Determine the Maximum Dry density. The Maximum Dry Density is the dry density of the soil at the optimum moisture content.

VI. Report

A. Report the Maximum Dry density and Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. From DOTD TR 407 and TR 423, report the following on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
1. Grain Size Distribution
2. Atterberg Limits
3. Soil Group
4. Group Index
5. Classification

C. Report the DOTD TR 418 method used on the Soils/Soil-Aggregate Form and on the Laboratory Compaction Report.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4194
Metric
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods (A) & B
(Metric)

PROJECT NO: 999-99-9999 DATE: 12/12/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Clay Loam SAMPLE NO: S-1

TESTED BY: B.D., I.S. CHECKED BY: J.B.W.

*MAX. DRY DENSITY OF SOIL (___ TR 418-A, ___ TR 415-A), kg/m³	A		
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-A, ___ TR 432-B, ___ TR 416, ___ specified)	B		
*% MASS OF ADDITIVE (___ chart, ___ formula)	C		
DRY MASS OF SOIL (representative portion), g	D		5145
*MASS OF ADDITIVE TO BE ADDED, g	E	(C x D) ÷ 100	
*TOTAL DRY MASS OF SOIL AND ADDITIVE, g	F	D + E	

* *FOR USE WITH DOTD TR 418, METHOD B ONLY.*

CURVE POINT NO.	***		1	2	3	4	5	6
MOISTURE CUP NO.	***							
WATER ADDED, mL	G	See Calculations	520	93	83	73	63	
MASS MOLD, BASE (if appl.) & WET SOIL, g	H		5965	6025	6100	6110	6060	
MASS MOLD & BASE (if applicable), g	I		4195	4195	4195	4195	4195	
MASS WET COMPACTED SOIL, g	J	H - I	1770	1830	1905	1915	1865	
MASS OF CUP & WET SOIL, g	K		586.0	587.8	604.2	601.3	616.9	
MASS OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
MASS OF WATER, g	WW	K - L	52.5	61.3	73.4	79.6	90.1	
MASS OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
MASS OF CUP, g	M		47.5	47.5	47.6	47.6	47.5	
MASS OF DRY SOIL, g	DW	L - M	486.0	479.0	483.2	474.1	479.3	
WET DENSITY, kg/m³	WWD	$\frac{J}{0.944}$	1875	1939	2018	2029	1976	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	10.8	12.8	15.2	16.8	18.8	
DRY DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	1692	1718	1752	1737	1663	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4194)
Figure A-1 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD A

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. Lab No. 22-999999

COMPACTION REPORT

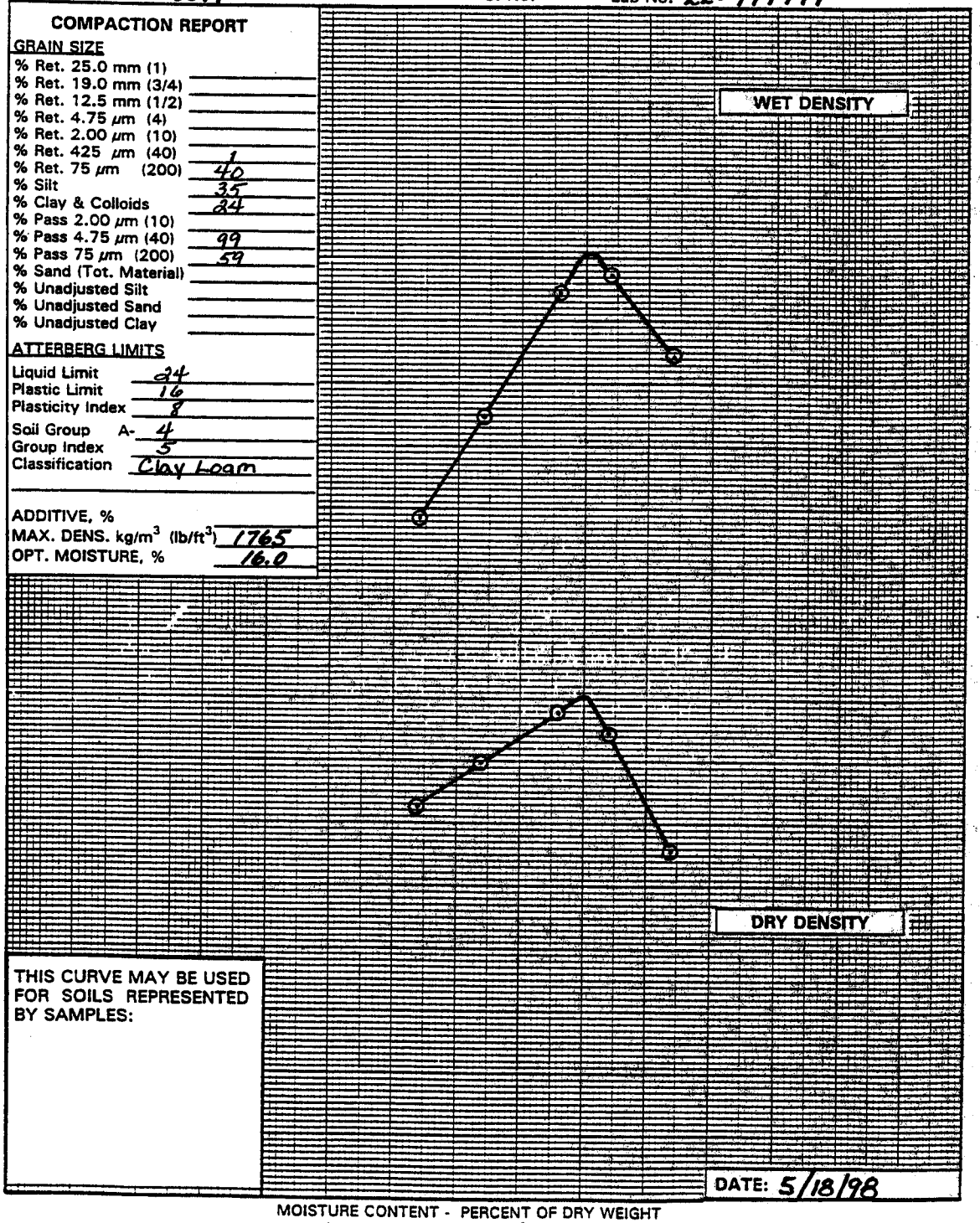
GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 μm (4)	
% Ret. 2.00 μm (10)	
% Ret. 425 μm (40)	
% Ret. 75 μm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 μm (10)	
% Pass 4.75 μm (40)	99
% Pass 75 μm (200)	59
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	24
Plastic Limit	16
Plasticity Index	8
Soil Group A-	4
Group Index	5
Classification	Clay Loam

ADDITIVE, %	
MAX. DENS. kg/m³ (lb/ft³)	1765
OPT. MOISTURE, %	16.0



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

Laboratory Compaction Report (03-22-4165)
Figure A-2 (Metric)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 5/98

Metric / English [M] *(M or E - Located on MATT Menu)*

Project No. 19191-1919-1010191919 **Material Code** 4011 **Lab. No.** 2421-191919191919

Date Sampled 12-15-1917 **Submitted By** 10101919 **Quantity**

Purp. Code 7 **Pit No.** **Spec Code** 3

Date Tested 12-12-1917 **Ident.** S1-111 **Parish No.** 17

From Station + **To Station** + **Location**

Hole No. **Depth, m (ft)** **Log Distance, km (mi)**

Item No. **Sampled by:**

Remarks 1

Hydrometer Analysis (DOTD TR 407)			Graduate No.	Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)			
Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	0
% Ret. 425 µm (40)	1
% Ret. 75 µm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 µm (#10)	100
% Pass 4.75 µm (40)	99
% Pass 75 µm (200)	59
% Sand (Tot. Material)	
% Unadjusted Silt	35
% Unadjusted Sand	41
% Unadjusted Clay	

LIQUID LIMIT
No. Blows
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Factor
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

PLASTIC LIMIT
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

% Organic Matter (TR 413)
Liquid Limit (TR 428) 24
Plasticity Index (TR 428) 8
Natural Moisture Content, % (TR 403)
Optimum Moisture Content, % (TR 418) 16.0
Maximum Density, kg/m^3 (lb/ft^3) (TR 418) 1761.5
Laboratory Compaction Method (TR 418) A
% Cement (TR 432 or Plans)
% Lime (TR 416)
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-4 (2)
Classification (TR 423) Clay Loam
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if +2.00 mm (No.10. g) material equals or exceeds 5%)

Remarks 2

Tested By: N.H. Checked By: G.C. APPROVED BY:
Date: 12/12/97 Date: 12/19/97 DATE:

Soils/Soil-Aggregate Form (03-22-0723)
Figure A-3 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD B

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry density of soil cement, lime treated or conditioned soil cement, cement treated or lime treated soils, all containing less than 5% aggregate by dry mass retained on a 4.75 mm sieve, when the material is compacted in the laboratory in accordance with this procedure. When these materials contain 5% or more aggregate by dry mass retained on a 4.75 mm sieve, refer to DOTD TR 418, Method F.

Note B-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415. For field conditioned material which requires the addition of additives, TR 415 Method B can be used in the laboratory to determine moisture-density relationships of the material and additive combination only if the required amount of additive is known; however, for field conditioned material brought into the laboratory for the purpose of determining the required amount of additive, it is not permissible to use Method B of TR 415.*

II. Apparatus

A. **Same as DOTD TR 418, Method A.**
B. **Cement or lime.**

Note B-2: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit mass of 1500 kg/m^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement, a unit mass of 1440 kg/m^3 shall be used. For Type II cement, a unit mass of 1500 kg/m^3 shall be used.

Lime shall meet DOTD specifications for hydrated lime. A unit mass of 560 kg/m^3 shall be used.

C. **Personal protective equipment**
   1. Respirator.
   2. Gloves.
   3. Apron.
   4. Goggles.
D. **Laboratory Moisture-Density Worksheet, Methods A & B** - DOTD Form No. 03-22-4194. (Figure B-1)
E. **Additive Conversion Chart.** (Figure B-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure B-3)
G. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure B-4)

III. Test Sample

Obtain a minimum representative sample of 15 kg (one full sample sack of material).

IV. Health Precautions

Care must be taken not to allow cement or lime to contact skin or to inhale its reaction fumes.

V. Procedure

A. Preparation
   1. Determine the maximum dry density of the soil using one of the following methods and record as **A** on the worksheet.
      a. DOTD TR 418, Method A.
      b. DOTD TR 415, Method A.
   2. Determine the percent by volume of cement in accordance with DOTD TR 432 or the percent of lime in accordance with DOTD TR 416 or use the percent specified. Record as **B** on the worksheet.
   3. Convert percent by volume to percent by mass and record as **C** on the worksheet. (Refer to Step VI.A or B for mass - volume conversion calculations.)
   4. Prepare a minimum of five 3 kg representative portions from the test sample.

B. Testing
   1. Calculate the mass of additive to be added to the representative portion in accordance with Step VI.C and record as **E** on the worksheet.
   2. Add the required mass of the additive, determined in Step V.B.1, to each representative portion.

3. Add a sufficient quantity of water, measured in mL, to make the 3 kg representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water as **G** for the first point on the worksheet.

Note B-3: *Check the mixture by squeezing it in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

4. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 3 kg representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. (Refer to Step VI.D) Record the quantity of water added to each representative portion as **G** on the worksheet.
5. Cover the representative portions to which water has been added, protect them so that the moisture content remains constant, and allow them to stand for a minimum of 30 min.
6. Remix the individual representative portions, protect them so that the moisture content remains constant, then allow them to slake as follows.
   a. Soil mixed with cement: The combined standing and slaking time plus the compaction time in the laboratory shall approximate the moist mixing time plus the compaction time in the field. This time shall be a minimum of 60 min and a maximum of 90 min.
   b. Soil mixed with lime: The combined standing and slaking time plus compaction time in the laboratory shall approximate the moist mixing time and mellowing time in the field, but shall not be less than 15 hours.
   c. When lime-conditioned soil is to be cement treated or stabilized, mix the soil with the lime and allow it to slake in accordance with Step V.B.6.b. Then add the required mass of cement (determined in accordance with Step V.B.1) to the soil-lime mixture and allow the soil-lime-cement mixture to slake in accordance with Step V.B.6.a.
7. Determine the maximum dry density of the soil and additive mixture.
   a. Remix the slaked mixture thoroughly.
   b. Pass the slaked mixture through a 4.75 mm sieve.
   c. Compact the slaked mixture in accordance with Method A, Steps IV.E. 1-17.
   d. Repeat Steps 7. a - c for each 3 kg representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet mass of the compacted material or the material becomes too wet to compact.

VI. Calculations

A. Determination of percent of additive by mass by using the Additive Conversion Chart (Figure B-2). This chart may be used for Type IB Portland cement and hydrated lime.
   1. Enter the chart on the left scale. Reading vertically, place a point at the appropriate maximum dry density of the soil-aggregate mixture obtained in Step V.A.1.
   2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of additive.
   3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
   4. Read the percent by mass directly from the additive scale on the chart at the point where the line drawn in Step 3 intersects the scale for the additive being used.
   5. Record this value as **C** on the worksheet.
   6. Example: Figure B-2
      a. Type IB Cement

         A = 1765 kg/m^3
         B = 8% Type IB cement by volume

      (1) Follow the left scale to the point represented by 1765 kg/m^3.
      (2) Follow the right scale to the point represented by 8% by volume.
      (3) Draw a straight line across the scale, connecting the two points.
      (4) The percent cement by mass, read directly from the middle scale, is 7.3%.

      b. Lime

         A = 1715 kg/m^3
         B = 6% hydrated lime, by volume

(1) Follow the left scale to the point represented by 1715 kg/m^3.
(2) Follow the right scale to the point represented by 6% by volume.
(3) Draw a straight line across the scale, connecting the two points.
(4) The percent lime by mass, read directly from the middle scale, is 2.0%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by mass of additive (C) using the following formula.

$$C = \frac{(UB/100)}{A - (UB/100)} \times 100$$

$$C = \frac{1}{(A/UB) - 0.01}$$

where:

A = maximum dry density of the soil, kg/m^3
B = % by volume of additive
U = unit mass of additive, kg/m^3
100 = constant
0.01 = constant

example: *(Type IP Cement)*

A = 1765 kg/m^3
B = 8 %
U = 1440 kg/m^3

$$C = \frac{1}{[1765/(1440 \times 8)] - 0.01}$$

$$= \frac{1}{[0.1532] - 0.01}$$

$$= \frac{1}{0.1432}$$

$$C = 7.0$$

Note B-4: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

C. Calculate the mass of additive (E) in grams to be incorporated into the representative portion of soil using the following formula and record on the worksheet.

$$E = \frac{C \times D}{100}$$

where:

C = % by mass of additive (from chart or formula)
D = dry mass of representative portion, g
100 = constant

example:

C = 7.3 %
D = 3000 g

$$E = \frac{7.3 \times 3000}{100}$$

$$= \frac{21900}{100}$$

$$E = 219 \text{ g}$$

D. Calculate the quantity of water to be added to each representative portion (G_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + (0.02 \times F)$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
F = total mass of material and additive, kg
0.02 = decimal equivalent for a 2% increment of moisture

example:

G_{n-1} = 207 mL
F = 3219 g

$$G_n = 207 + (0.02 \times 3219)$$

$$= 207 + 64.38$$

$$G_n = 271 \text{ mL}$$

Note B-5: *1 g of water = 1 cc of water = 1 mL of water.*

E. Perform all calculation steps for the soil-additive mixture in accordance with Method A, Step V.B - J.

VII. Report

A. Report the Maximum Dry Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 5 kg/m^3 and 0.1 percent, respectively.
B. Report the type and percent by volume of additive to the nearest percent on the Laboratory Compaction Report and the Soils/Soil-Aggregate Form.
C. From DOTD TR 407 and TR 423, report the following on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
    1. Grain Size Distribution
    2. Atterberg Limits
    3. Soil Group
    4. Group Index
    5. Classification

VIII. Normal Test Reporting Time

Normal test reporting time is 5 days.

Note B-6: *When percent cement is to be determined by DOTD TR 432, Method B or the percent lime by DOTD TR 416, normal testing and reporting time will be 3 weeks or 2 weeks, respectively.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4194
Metric
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods A & (B)
(Metric)

PROJECT NO: 999-99-0099 DATE: 12/12/97 LAB NO: 22-999999

*TYPE ADDITIVE: Type IB Cement TYPE SOIL: Clay Loam SAMPLE NO: S-1

TESTED BY: I.S., N.H. CHECKED BY: G.C.

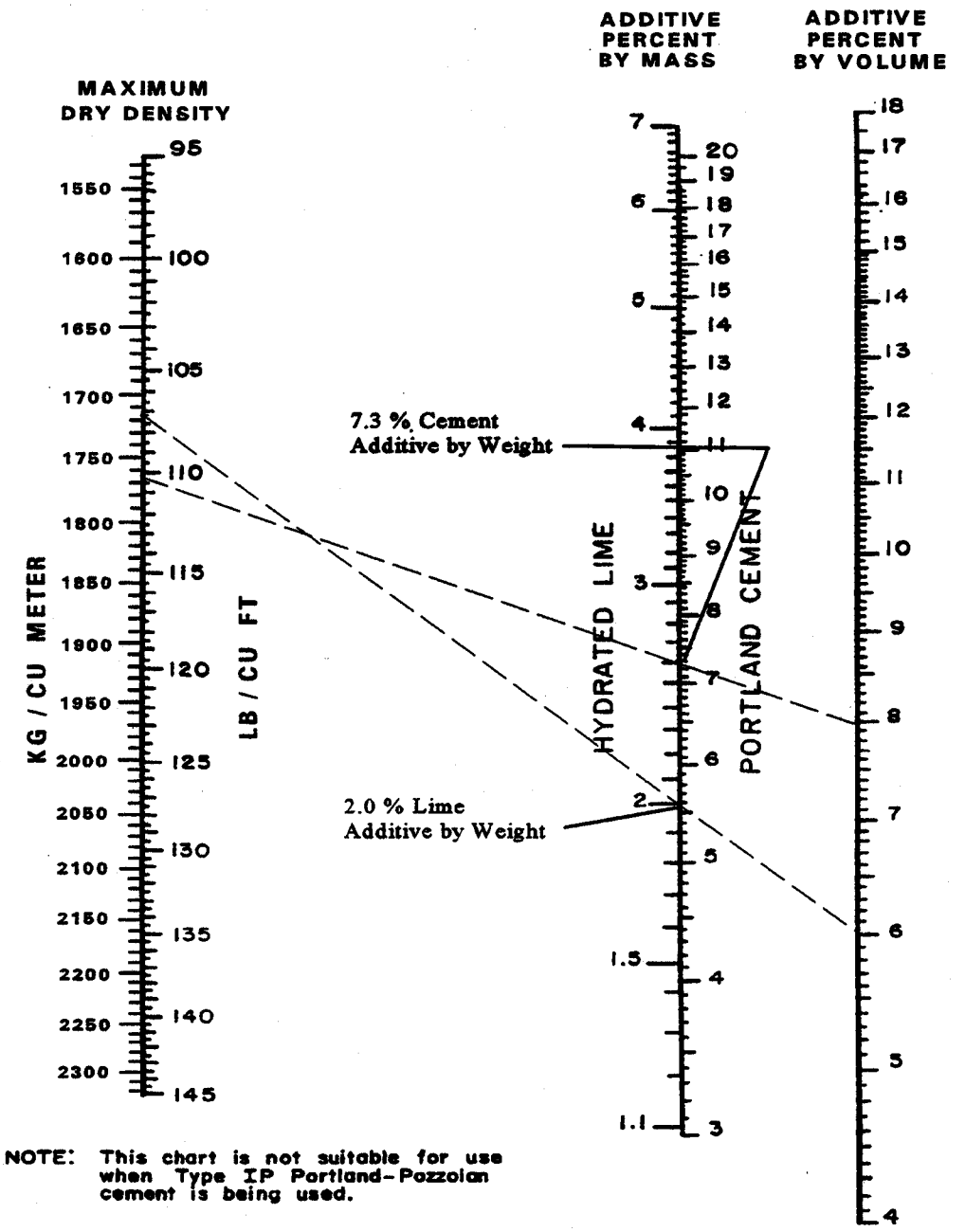
*MAX. DRY DENSITY OF SOIL (___ TR 418-A, ___ TR 415-A), kg/m³	A		176.5
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-A, ___ TR 432-B, ___ TR 416, ___ specified)	B		8
*% MASS OF ADDITIVE (___ chart, ___ formula)	C		7.3
DRY MASS OF SOIL (representative portion), g	D		3000
*MASS OF ADDITIVE TO BE ADDED, g	E	(C x D) ÷ 100	219
*TOTAL DRY MASS OF SOIL AND ADDITIVE, g	F	D + E	3219

* *FOR USE WITH DOTD TR 418, METHOD B ONLY.*

CURVE POINT NO.	***		1	2	3	4	5	6
MOISTURE CUP NO.	***		32	33	34	35	36	
WATER ADDED, mL	G	See Calculations	207	271	335	399	463	
MASS MOLD, BASE (if appl.) & WET SOIL, g	H		5933	5992	6060	6074	6019	
MASS MOLD & BASE (if applicable), g	I		4196	4196	4196	4196	4196	
MASS WET COMPACTED SOIL, g	J	H - I	1737	1796	1864	1878	1823	
MASS OF CUP & WET SOIL, g	K		568.0	569.6	584.0	581.4	592.5	
MASS OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
MASS OF WATER, g	WW	K - L	34.5	43.1	53.2	59.7	65.7	
MASS OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
MASS OF CUP, g	M		47.5	47.5	47.6	47.6	47.5	
MASS OF DRY SOIL, g	DW	L - M	486.0	479.0	483.2	474.1	479.3	
WET DENSITY, kg/m³	WWD	J / 0.944	1840	1903	1975	1989	1931	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	7.1	9.0	11.0	12.6	13.7	
DRY DENSITY, kg/m³	DWD	WWD / (100 + MC) x 100	1718	1746	1779	1766	1698	

REMARKS: O → Mass

Laboratory Moisture - Density Relationship Worksheet (03-22-4194)
Figure B-1 (Metric)



ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY MASS OF OVEN-DRY SOIL, SOIL-AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure B-2 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD B

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 1 Lab No. 22-9999

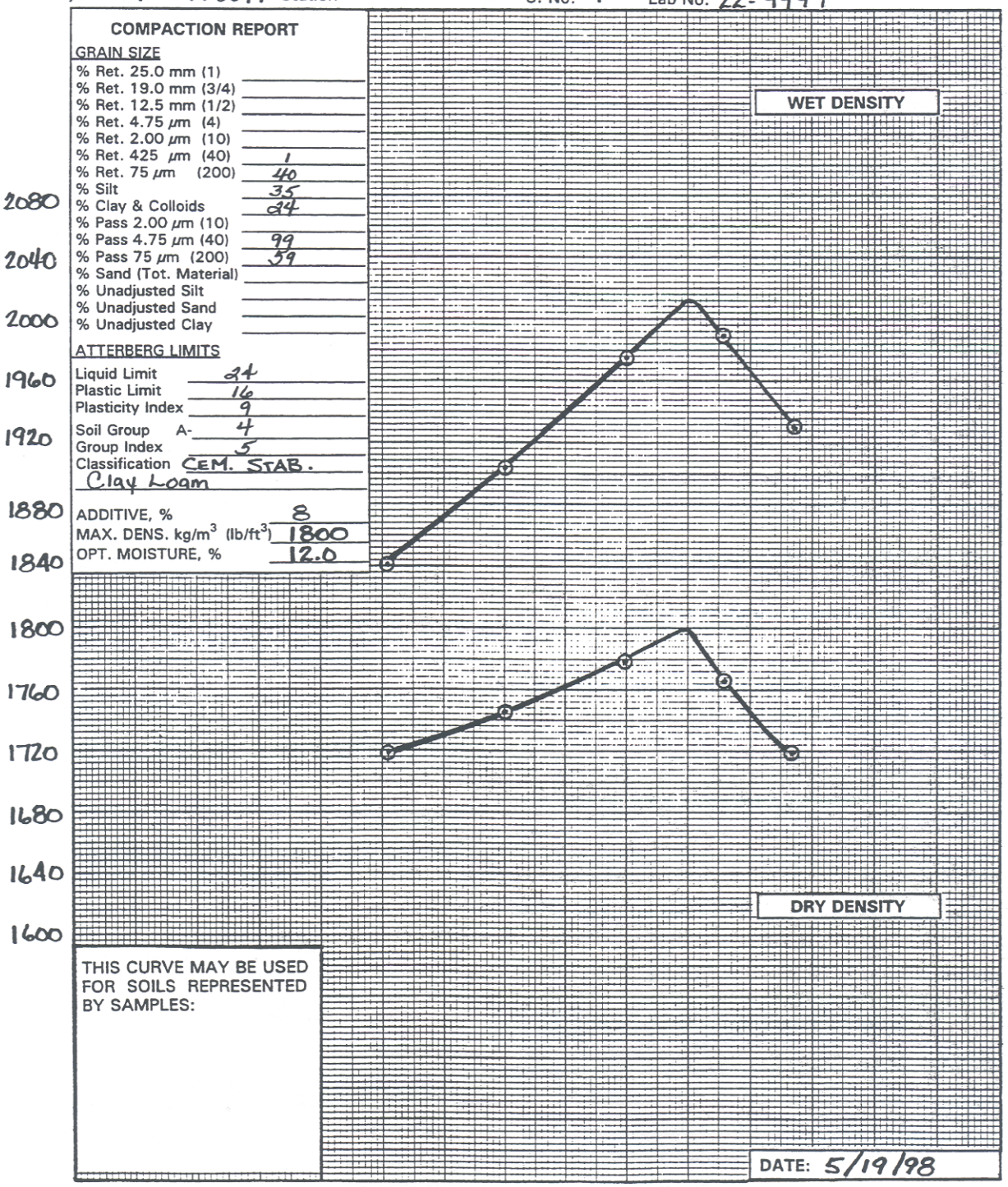
COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 μm (4)	
% Ret. 2.00 μm (10)	
% Ret. 425 μm (40)	1
% Ret. 75 μm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 μm (10)	
% Pass 4.75 μm (40)	99
% Pass 75 μm (200)	59
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	24
Plastic Limit	16
Plasticity Index	9
Soil Group A-	4
Group Index	5
Classification	CEM. STAB. Clay Loam
ADDITIVE, %	8
MAX. DENS. kg/m³ (lb/ft³)	1800
OPT. MOISTURE, %	12.0



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

Laboratory Compaction Report (03-22-4165)
Figure B-3 (Metric)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 5/98

Metric / English [M] *(M or E - Located on MATT Menu)*

Project No. 999999-999-010199 | Material Code 4211 | Lab. No. 22-9999999
Date Sampled 12-01-97 | Submitted By 010199 | Quantity
Purp. Code 7 | Pit No. | Spec Code 3
Date Tested 12-12-97 | Ident. S1- | Parish No. 17
From Station + | To Station + | Location
Hole No. | Depth, m (ft) | Log Distance, km (mi)
Item No. 310111(01)1 | Sampled by: N.H.
Remarks 1

Hydrometer Analysis (DOTD TR 407) | Graduate No. | **Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)**

Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	0
% Ret. 425 µm (40)	1
% Ret. 75 µm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 µm (#10)	100
% Pass 4.75 µm (40)	99
% Pass 75 µm (200)	59
% Sand (Tot. Material)	
% Unadjusted Silt	35
% Unadjusted Sand	41
% Unadjusted Clay	

LIQUID LIMIT
No. Blows
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Factor
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

PLASTIC LIMIT
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

% Organic Matter (TR 413)
Liquid Limit (TR 428) 24
Plasticity Index (TR 428) 8
Natural Moisture Content, %(TR 403)
Optimum Moisture Content, % (TR 418) 12.0
Maximum Density, kg/m^3 (lb/ft^3) (TR 418) 1810
Laboratory Compaction Method (TR 418) B
% Cement (TR 432 or Plans) 8.0
% Lime (TR 416)
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-4(2)
Classification (TR 423) Cement Stab. Clay Loam
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if + 2.00 mm (No.10, g) material equals or exceeds 5%)

Remarks 2

Tested By: Date:
Checked By: Date:
APPROVED BY: DATE:

Soils/Soil-Aggregate Report (03-22-0723)
Figure B-4 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD C

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry density of shell or sand-shell when compacted in the laboratory in accordance with this procedure.

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 0.002832 m^3, manufactured with an internal diameter of 152.46 ± 0.66 mm and a height of 154.90 ± 0.41 mm, and with a detachable collar approximately 90 mm in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 153.39 mm or the height is less than 152.40 mm at any point.

Note C-1: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive device** - automatic rammer with a 4.536 ± 0.045 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 152 mm inside diameter mold and arranged to control the height of drop to 457 ± 2 mm
C. **Compaction block** - a stable block or pedestal composed of portland cement concrete with a mass of 90 kg.
D. **Straightedge** - steel straightedge, approximately 300 mm long.
E. **Scale** - a scale of 10 kg or more capacity, sensitive to 5 g or less.
F. **Sieve** - a 19.0 mm sieve, conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation M 92).
G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screwdriver to remove material from mold.
6. Finishing tool.
7. Height gauge - dial micrometer incremented in 0.025 mm, accurate to 0.025 mm, mounted on a stand.

H. **Graduated cylinders** - incremented in mL.
I. **Wax paper.**
J. **Engineer's Curve** - Alvin 1010-21, or equivalent.
K. **Power driven wedge crusher.**
L. **Laboratory Moisture - Density Worksheet, Methods C & D** - DOTD Form No. 03-22-4195. (Figure C-1)
M. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure C-2)
N. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure C-3)

Note C-2: *It is convenient, but not essential, to have a mechanical device for removing the compacted material from the mold. Such a device may consist of a closed, cylindrical sleeve slightly less than 152 mm in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

A. Obtain a representative sample, having a mass of 55 kg each (4 full sample sacks each) of shell and sand.
B. Dry entire sample of each component in accordance with DOTD TR 411.

IV. Procedure

A. Preparation
1. Set crusher to produce 19.0 mm maximum size material.
2. Crush entire dried shell sample, sieve and recrush, until 95-100 percent of the material passes a 19.0 mm sieve.

Note C-3: *If sand is not to be mixed with the shell, proceed to Step 5.*

3. If the material to be tested is a sand-shell mixture, determine the "unit mass at point of delivery" of each component (sand and crushed shell) in accordance with DOTD TR 417.

4. If the material to be tested is a sand-shell mixture, determine the percent by mass of each component by using the specified percent by volume. Refer to Step V.A.
5. Prepare a minimum of five 7 kg representative portions. If the material is a sand-shell mixture, combine the sand and shell in the proportions by mass determined in Step 4, and mix thoroughly.

B. Testing

1. Add a sufficient quantity of water, measured in mL, to make the 7 kg representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **G** for the first point on the worksheet.
2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 7 kg representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary. (Refer to Step V.B) Record the quantity of water added as **G** for the remaining points on the Moisture-Density Relationship Worksheet, Methods C and D.
3. Cover the representative portions to which water has been added, protect them so that the moisture content remains constant, then allow them to stand for a minimum of 30 min. Remix and recover the individual representative portions.
4. Compact test specimen.
   a. If mold requires an attachable base plate, attach base plate. Determine the mass of the mold and base plate and record as **I** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on compactor base. Determine the mass of the mold and record as **I** on the worksheet. Place the mold over the wax paper and secure to the compactor base.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield approximately 1/3 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material, to a uniform lift thickness.
   g. Rest the automatic rammer on top of the layer to be compacted. Compact the layer using 150 blows with the rammer.
   h. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.4.d- h for two more layers.
   j. After the third layer has been compacted, remove the mold, base plate, if applicable, and compacted specimen from the automatic rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
   l. Note the height of the compacted test specimen.
      (1) If the compacted material is less than 145 mm in height or is more than 15 mm above the height of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
      (2) If the compacted material is above the top of the mold, but not more than 15 mm above, proceed as follows:
          Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
      (3) If the compacted material is below the top of the mold, but greater than 145 mm in height, proceed as follows:
          (a) Place the finishing tool on the compacted surface and rotate it while tapping very lightly to smooth and level the surface. Do not impart additional compactive effort to the specimen.
          (b) Determine the height of the specimen by measuring to the nearest 1 mm at three locations spaced equally around the circumference, and averaging.
          (c) Calculate the volume of the specimen in accordance with Step V.C and record as **K** on the worksheet.
   m. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.

n. Remove wax paper (if applicable) and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.

o. Determine the mass of the mold, base plate (if applicable), and compacted test specimen and record as **H** on the worksheet.

p. Remove the base plate (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.

q. Repeat Steps IV.B.4.a-p for each 7 kg representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet mass of the compacted material or the material becomes too wet to compact.

V. Calculations

A. If the material tested is a sand-shell mixture, calculate the Percent by mass for each component (sand (W_1) and shell (W_2)) using the following formulas, and record on the Moisture-Density Relationship Worksheet, Methods C and D.

$$W_1 = \frac{S_1 \times V_1 \times 100}{(S_1 \times V_1) + (S_2 \times V_2)}$$

$$W_2 = \frac{S_2 \times V_2 \times 100}{(S_1 \times V_1) + (S_2 \times V_2)}$$

where:

S_1 = unit mass of sand at point of delivery, kg/m^3 (from DOTD TR 417)
S_2 = unit mass of shell at point of delivery , kg/m^3 (from DOTD TR 417)
V_1 = % by volume of sand (as specified)
V_2 = % by volume of shell (as specified)

examples:

S_1 = 1441 kg/m^3 V_1 = 35 %
S_2 = 961 kg/m^3 V_2 = 65 %

$$W_1 = \frac{1441 \times 35 \times 100}{(1441 \times 35) + (961 \times 65)}$$

$$= \frac{5043500}{(50435) + (62465)}$$

$$= 44.672$$

$$W_1 = 44.7$$

$$W_2 = \frac{961 \times 65 \times 100}{(1441 \times 35) + (961 \times 65)}$$

$$= \frac{6246500}{(50435) + (62465)}$$

$$= 55.327$$

$$W_2 = 55.3$$

B. Calculate the quantity of water to be added to each representative portion (G_n) to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + 136$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
136 = a constant representing the volume of water in mL required for a two percent moisture content for a 7 kg representative portion

example:

G_{n-1} = 306 mL

$$G_n = 306 + 136$$

$$G_n = 442$$

Note C-4: *1 g of water = 1 cc of water = 1 mL of water*

C. Calculate the volume of the test specimen (K) in m^3 by using the following formula.

$$K = \frac{h}{1000} \times 0.01858$$

where:

h = average height of test specimen, mm
1000 = constant to convert mm to m
0.01858 = constant equal to the area of the specimen in m^2

example:

h = 155 mm

$$K = \frac{155}{1000} \times 0.01858$$

$$= 0.0028799$$

$$K = 0.002880 \text{ m}^3$$

D. Calculate wet mass of compacted material in mold (J) in grams for each representative portion by using the following formula and record on the worksheet.

$$J = H - I$$

where:

H = mass of mold & compacted wet material, g
I = mass of mold, g

example:

H = 12120 g
I = 6428 g

$$J = 12120 - 6428$$

$$J = 5692$$

E. Calculate wet density (WWD) in kg/m^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{J}{1000 \times K}$$

where:

J = wet mass of compacted material, g
1000 = constant to convert g to kg
K = (0.002832) a constant representing the volume of the mold or the volume of the specimen (if applicable) as calculated in Step C, m^3

example:

J = 5692 g
K = 0.002832 m^3

$$WWD = \frac{5692}{1000 \times 0.002832}$$

$$WWD = 2010 \text{ kg/m}^3$$

F. Calculate the mass of dry material (DW) and the mass of water (WW) in grams for each moisture content by using the following formulas.

$$DW = L - M \quad \text{and} \quad WW = J - DW$$

where:

L = mass of pan and dry material, g
M = mass of pan, g
J = wet mass of compacted material, g

examples:

L = 7775 g
M = 2327 g
J = 5692 g

$$DW = 7775 - 2327 \qquad WW = 5692 - 5448$$

and

$$DW = 5448 \qquad WW = 244$$

G. For each increment of water added, calculate the moisture content (MC) in % of the material to the nearest 0.1 percent by using the following formula.

$$MC = \left(\frac{WW}{DW}\right) \times 100$$

where:

WW = mass of water, g
DW = mass of dry material, g

example:

WW = 244 g
DW = 5448 g

$$MC = \left(\frac{244}{5448}\right) \times 100$$

$$= 0.04478 \times 100$$

$$MC = 4.5$$

H. Calculate the dry density (DWD) for each representative portion in kg/m^3 using the following formula and record on the worksheet.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet density, kg/m^3
MC = % moisture content
100 = constant

example:

WWD = 2010 kg/m^3
MC = 4.5 %

$$DWD = \frac{2010}{(100 + 4.5)} \times 100$$

$$= 19.2344 \times 100$$

$$DWD = 1923 \text{ kg/m}^3$$

I. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet densities have been plotted. Repeat the process for each moisture content, substituting dry densities for wet densities.

J. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet density Vs. Moisture Content and Dry Density Vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note C-5: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

K. Determine the Optimum Moisture Content (%) of the total material, which is the moisture content corresponding to the peak of the dry density curve.

L. Determine the maximum dry density of the total material, which is the mass corresponding to the peak of the Dry Density Curve.

VI. Report

A. Report the Maximum Dry Density and Optimum Moisture Content on the Laboratory Compaction Report and the Aggregate Test Report to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. Report the material type (shell or sand-shell) on the Laboratory Compaction Report.

C. Report the DOTD TR 418 method used on the Aggregate Test Report and on the Laboratory Compaction Report.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4195
Metric
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP

DOTD TR 418 - Methods (C) & D (Metric)

PROJECT NO: 999-99-9999 DATE: 12/19/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Sand/Shell SAMPLE NO: SS-6

TESTED BY: P.B. CHECKED BY: G.C.

	SAND	SHELL	TOTAL
PERCENT BY VOLUME	V_1 = 35	V_2 = 65	$V_1 + V_2 = 100$
UNIT MASS, kg/m³	S_1 = 1441	S_2 = 961	
THEORET. UNIT MASS OF MIX, kg/m³	S_1V_1 = 504.35	S_2V_2 = 624.65	$S_1V_1 + S_2V_2$ = 1129.00
PERCENT BY MASS SAND-SHELL	W_1 = 44.7	W_2 = 55.3	$W_1 + W_2$ = 100
MIX MASS OF SAND-SHELL, g	(W_1 x 7000) ÷ 100 = 3129	(W_2 x 7000) ÷ 100 = 3871	D =7000

*MAX. DRY DENSITY OF MATERIAL *(From TR 418, Method C)*, kg/m³	A		
*REQUIRED % BY VOL. OF ADDITIVE (____ TR 432-B, ____ specified)	B		
*% MASS OF ADDITIVE (____ chart, ____ formula)	C		
DRY MASS OF MATERIAL (Rep. portion) (____ Shell, ____ Sand-Shell), g	D		7000
*MASS OF ADDITIVE TO BE ADDED, g	E	(C x D) ÷ 100	
*TOTAL DRY MASS OF MATERIAL AND ADDITIVE, g	F	D + E	

* ***FOR USE WITH DOTD TR 418, METHOD D ONLY.***

CURVE POINT NO.	***		1	2	3	4	5	6
PAN NO. (if applicable)	***		31	27	61	101	70	
WATER ADDED, mL	G	See Calculations	306	442	578	714	850	
MASS MOLD, BASE (if appl.) & WET MATL, g	H		12120	12329	12474	12465	12352	
MASS MOLD & BASE (if applicable), g	I		6428	6428	6428	6428	6428	
MASS WET COMPACTED MATERIAL, g	J	H - I	5692	5901	6046	6037	5924	
VOLUME OF MOLD (or specimen), m³	K		0.002832					
MASS OF PAN & DRY MATERIAL, g	L		7775	7965	7997	7847	7666	
MASS OF PAN, g	M		2327	2431	2390	2341	2359	
MASS OF DRY MATERIAL, g	DW	L - M	5448	5534	5607	5506	5307	
MASS OF WATER, g	WW	J - DW	244	367	439	531	617	
WET DENSITY, kg/m³	WWD	$\frac{J}{(1000)\,K}$	2010	2084	2135	2132	2092	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.5	6.6	7.8	9.6	11.6	
DRY DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	1923	1955	1981	1945	1875	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4195)
Figure C-1 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD C

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. SS-6 Lab No. 22-999999

COMPACTION REPORT

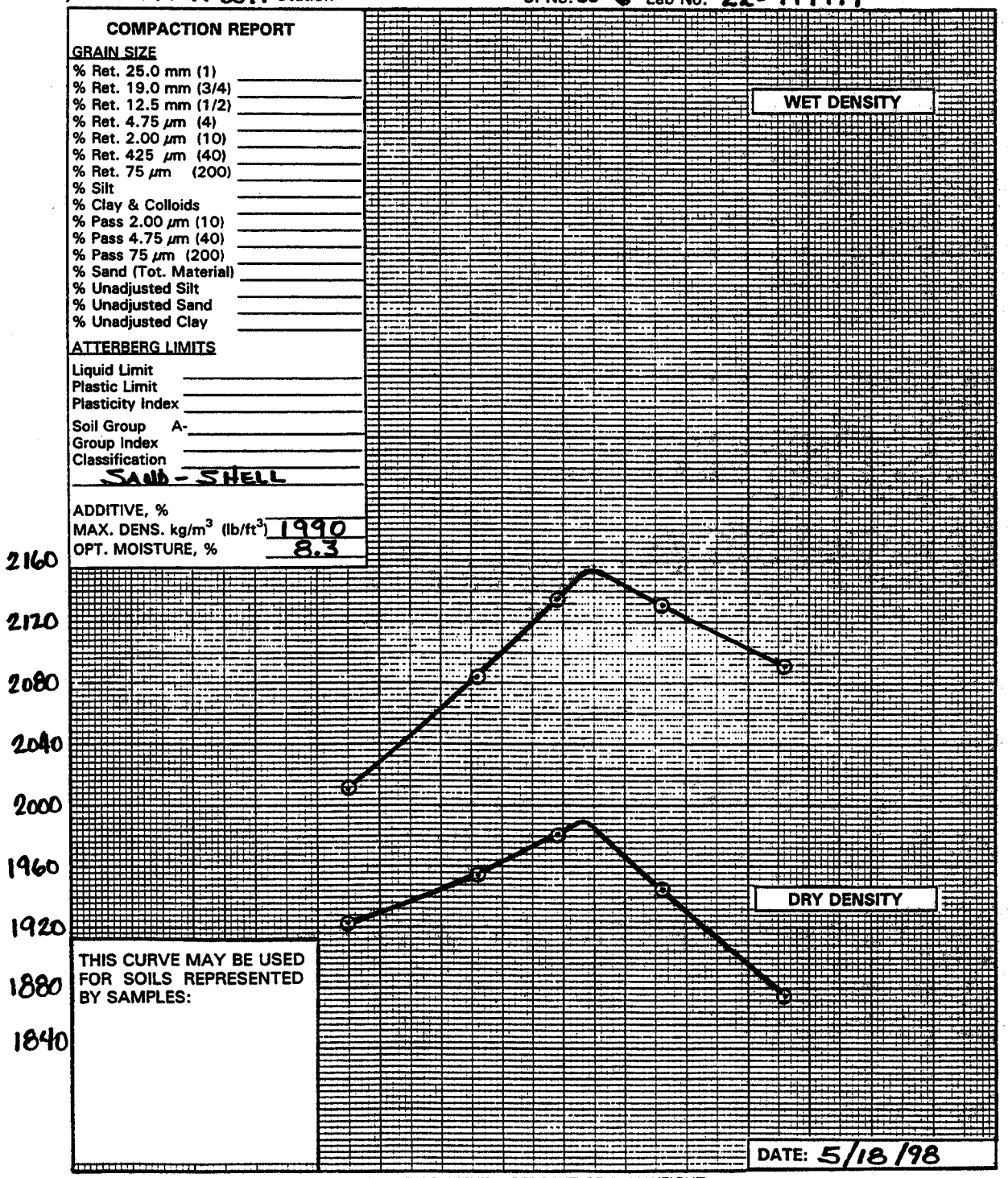
GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 μm (4)	
% Ret. 2.00 μm (10)	
% Ret. 425 μm (40)	
% Ret. 75 μm (200)	
% Silt	
% Clay & Colloids	
% Pass 2.00 μm (10)	
% Pass 4.75 μm (40)	
% Pass 75 μm (200)	
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	
Plastic Limit	
Plasticity Index	
Soil Group A-	
Group Index	
Classification	SAND - SHELL

ADDITIVE, %	
MAX. DENS. kg/m³ (lb/ft³)	1990
OPT. MOISTURE, %	8.3



Laboratory Compaction Report (03-22-4165)
Figure C-2 (Metric)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 9499-99-1010999 | Material Code 4014 | Lab No. 22-9999999
Date Sampled 12-07-97 | Submitted By 01099 | Quantity
Purp Code 7 | Source Code 4A999 | Spec Code 3 | P.O. No.
Date Tested 12-12-97 | Ident 5S-16 | Plant Code | Frict.Rating (1-4)
Item No. 31024 | Date Rec'd (lab) 12/6/97 | Sampled By: S.C.
Remarks 1

Tested By P.B. | Date 12/12/97 | Checked By G.C. | Date 12/19/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2				
9.5	3/8				
4.75	No. 4				
Mass Matl.in Pan					
Acc. Total					
Initial Dry Total Mass			% Diff:		

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10				
1.18	16				
600	30				
425	40				
300	50				
180	80				
150	100				
75	200				
53	270				
Mass Matl.in Pan					
Decant Loss					
Acc. Total					
Initial Dry Total Mass			% Diff:		
Dry Mass After Wash					

Remarks 2:

DOTD TR 428

Liquid Limit | Plastic Limit

No. of Blows		Mass Cup + Wet Soil,g	
Mass Cup + Wet Soil,g		Mass Cup + Dry Soil,g	
Mass Cup + Dry Soil,g		Mass Water	
Mass Water		Cup No.	
Factor		Mass Cup, g	
Cup No.		Mass Dry Soil	
Mass Cup, g		% Moisture	
Mass Dry Soil			
% Moisture		Plasticity Index	

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content,% (TR 418)	8.3
Maximum Density (TR 418) kg/m³ (lb/ft³)	1910
Lab Comp Method (TR 418)	C
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part,% (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: | Date:

Aggregate Test Report (03-22-0745)
Figure C-3 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD D

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry density of shell or sand-shell with cement additive when compacted in the laboratory in accordance with this procedure.

II. Apparatus

A. **Same as DOTD TR 418, Method C.**
B. **Cement.**

Note D-1: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit mass of 1500 kg/m^3 shall be used. When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement a unit mass of 1440 kg/m^3 shall be used. For Type II cement, a unit mass of 1500 kg/m^3 shall be used.*

C. **Personal protective equipment.**
   1. Respirator.
   2. Gloves.
   3. Apron.
   4. Goggles.
D. **Laboratory Moisture-Density Worksheet, Methods C & D** - DOTD Form No. 03-22-4195. (Figure D-1)
E. **Additive Conversion Chart.** (Figure D-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure D-3)
G. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure D-4)

III. Test Sample

Same as DOTD TR 418, Method C.

IV. Health Precautions

Care must be taken not to allow cement to contact skin or to inhale the dust.

V. Procedure

A. Preparation
   1. Determine the maximum dry density of the raw material using DOTD TR 418, Method C, and record as **A** on the worksheet.
   2. Determine the percent by volume of cement in accordance with DOTD TR 432, Method B or use the percent specified. Refer to Step VI.A or B for mass-volume conversion calculations. Record the percent cement by volume as **B** and the percent by mass as **C** on the worksheet.
   3. Prepare a minimum of five 7 kg representative portions from the test sample. If the material is a sand-shell mixture, combine the sand and shell in the proportions by mass determined by DOTD TR 418, Method C.

B. Testing
   1. Calculate the mass of additive to be added to the representative portions in accordance with Step VI.C and record as **E** on the worksheet.
   2. Add the required mass of cement determined in Step V.B.1 to each representative portion.

Note D-2: *Coordinate the initial mixing of cement with the representative portion so that a continuous compaction operation will result without violating the 90 ± 5 minute standing and slaking times in the following steps.*

   3. Add a sufficient quantity of water measured in mL, to make the 7 kg representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **G** on the worksheet.
   4. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 7 kg representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary. (Refer to Step VI.D) Record the quantity of water added to each representative portion as **G** on the worksheet.
   5. Cover the representative portions and allow them to stand for approximately 30 minutes, then remix.

6. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for 60±5 minutes.
7. Compact test specimen in accordance with Method C, Steps IV.B.4.a-q.

VI. Calculations

A. Calculate percent by mass of cement by Additive Conversion Chart.
1. Enter the chart on the left scale. Reading vertically, place a point at appropriate maximum dry density of the shell or sand-shell mixture obtained in Method C.
2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of cement.
3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
4. Read the percent cement by mass directly from the chart at the point where the line drawn in Step 3 intersects the middle scale.
5. Record the percent by mass of additive as **C** on the worksheet.
6. Example: Figure D-2

A = 1990 kg/m^3
B = 5 % cement by volume
U = 1500 kg/m^3

a. Follow the left scale to the point represented by 1990 kg/m^3.
b. Follow the right scale to the point represented by 5% by volume.
c. Draw a straight line across the scale, connecting the two points.
d. The percent cement by mass, read directly from the middle scale, is 3.9%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by mass of cement (C) by using the following formula.

$$C = \frac{(UB/100)}{A - (UB/100)} \times 100$$

$$C = \frac{1}{(A/UB) - 0.01}$$

where:

A = maximum dry density of the shell or sand-shell, kg/m^3
B = % by volume of cement
U = unit mass of cement, kg/m^3
100 = constant
0.01 = constant

example:

A = 1990 kg/m^3
B = 5%
U = 1500 kg/m^3

$$C = \frac{1}{[1990/(1500 \times 5)] - 0.01}$$

$$= \frac{1}{(0.2653) - 0.01}$$

$$= \frac{1}{0.2553}$$

$$C = 3.9$$

Note D-3: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

C. Calculate the mass of additive (E) in grams to be incorporated into the representative portion of soil by using the following formula and record on the worksheet.

$$E = \frac{C \times D}{100}$$

where:

C = % by mass of additive (from chart or formula)
D = dry mass of representative portion, g
100 = constant

example:

C = 3.9 %
D = 7000 g

$$E = \frac{3.9 \times 7000}{100}$$

$$= \frac{27300}{100}$$

$$E = 273$$

D. Calculate the quantity of water to be added to each representative portion (G_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + (0.02 \times F)$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
F = total mass of material and cement, g
0.02 = decimal equivalent for a 2% increment of moisture

example:

G_{n-1} = 273 mL
F = 7273 g

$$G_n = 273 + (0.02 \times 7273)$$

$$= 273 + 145$$

$$G_n = 418$$

Note D-4: *1 g of water = 1 cc of water = 1 mL of water*

E. Perform all calculation steps for the material in accordance with Method C, Step V.C-L.

VII. Report

A. Report the Maximum Dry Density and Optimum Moisture Content on the Laboratory Compaction Report and the Aggregate Test Report to the nearest 5 kg/m^3 and 0.1 percent, respectively.
B. Report the type and percent by volume of cement to the nearest 0.1 percent and the material type (shell or sand-shell) on the Laboratory Compaction Report.

VIII. Normal Test Reporting Time

Normal test reporting time is 5 days.

Note D-5: *When percent cement is to be determined by DOTD TR 432, Method B, normal test reporting time will be 3 weeks.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4195
Metric
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP

DOTD TR 418 - Methods C & D (Metric)

PROJECT NO: 999-99-0099 DATE: 12/19/97 LAB NO: 22-999999

*TYPE ADDITIVE: Type IB Cement TYPE SOIL: Sand/Shell SAMPLE NO: 55-7

TESTED BY: P.B. CHECKED BY: G.C.

	SAND	SHELL	TOTAL
PERCENT BY VOLUME	V_1 = 35	V_2 = 65	$V_1 + V_2 = 100$
UNIT MASS, kg/m³	S_1 = 1441	S_2 = 961	
THEORET. UNIT MASS OF MIX, kg/m³	S_1V_1 = 504.35	S_2V_2 = 624.65	$S_1V_1 + S_2V_2$ = 1129.00
PERCENT BY MASS SAND-SHELL	W_1 = 44.7	W_2 = 55.3	$W_1 + W_2$ = 100
MIX MASS OF SAND-SHELL, g	(W_1 x 7000) ÷ 100 = 3129	(W_2 x 7000) ÷ 100 = 3871	D =7000

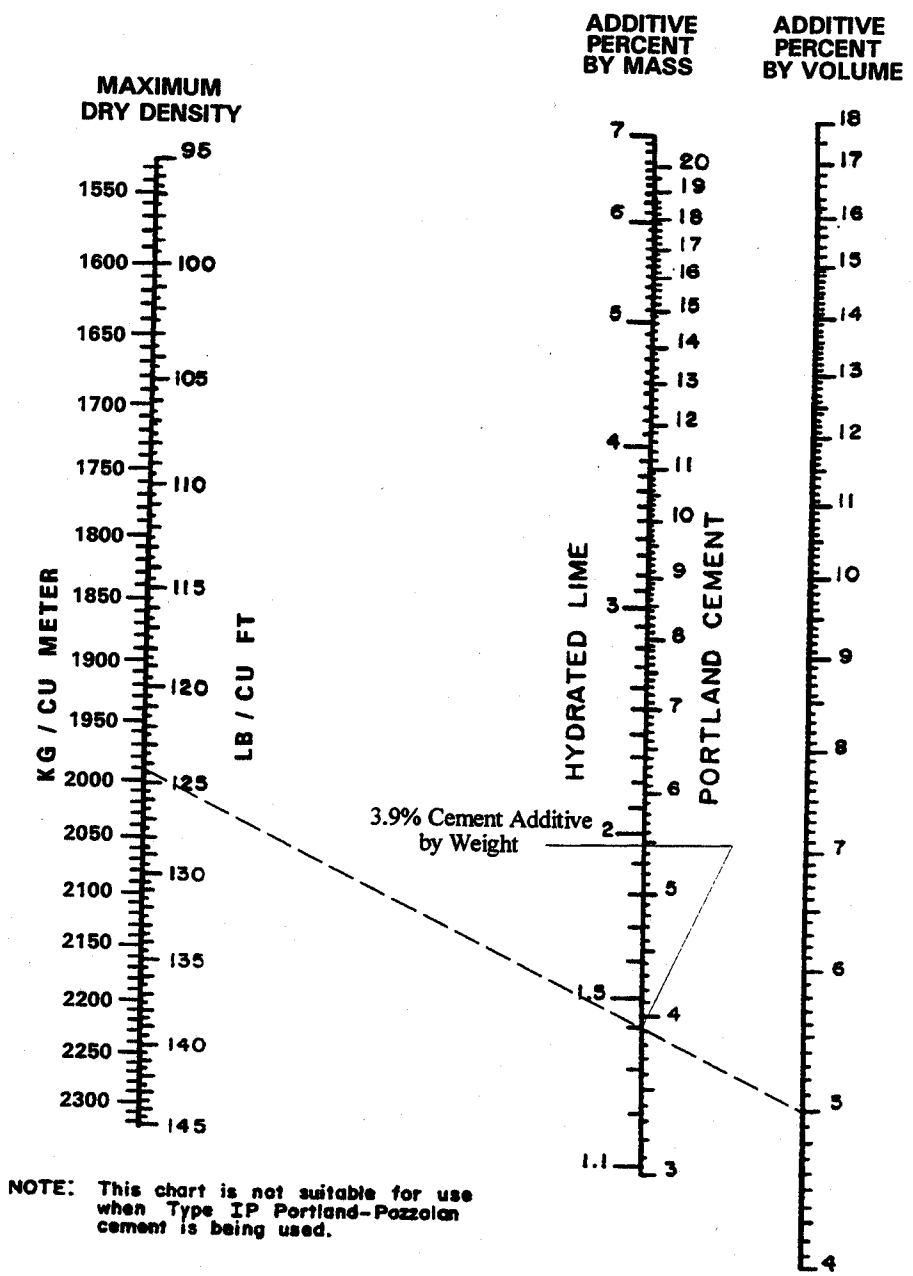
*MAX. DRY DENSITY OF MATERIAL *(From TR 418, Method C)*, kg/m³	A		1990
*REQUIRED % BY VOL. OF ADDITIVE (____ TR 432-B, ____ specified)	B		5.0
*% MASS OF ADDITIVE (____ chart, ____ formula)	C		3.9
DRY MASS OF MATERIAL (Rep. portion) (____ Shell, ____ Sand-Shell), g	D		7000
*MASS OF ADDITIVE TO BE ADDED, g	E	(C x D) ÷ 100	273
*TOTAL DRY MASS OF MATERIAL AND ADDITIVE, g	F	D + E	7273

* ***FOR USE WITH DOTD TR 418, METHOD D ONLY.***

CURVE POINT NO.	***		1	2	3	4	5	6
PAN NO. (if applicable)	***		31	67	61	101	27	
WATER ADDED, mL	G	See Calculations	273	418	563	708	853	
MASS MOLD, BASE (if appl.) & WET MATL, g	H		12066	12220	12442	12457	12429	
MASS MOLD & BASE (if applicable), g	I		6428	6428	6428	6428	6428	
MASS WET COMPACTED MATERIAL, g	J	H - I	5638	5792	6014	6023	6001	
VOLUME OF MOLD (or specimen), m³	K		0.002832					
MASS OF PAN & DRY MATERIAL, g	L		7747	7902	7970	7843	7743	
MASS OF PAN, g	M		2327	2431	2390	2340	2359	
MASS OF DRY MATERIAL, g	DW	L - M	5420	5471	5580	5503	5384	
MASS OF WATER, g	WW	J - DW	218	321	434	520	617	
WET DENSITY, kg/m³	WWD	$\frac{J}{(1000)\,K}$	1991	2045	2124	2127	2119	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.0	5.9	7.8	9.4	11.5	
DRY DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	1914	1931	1970	1944	1900	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4195)
Figure D-1 (Metric)



ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY MASS OF OVEN-DRY SOIL, SOIL-AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure D-2 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD D

DOTD 03-22-4165
Metric / English
Rev. 3/98

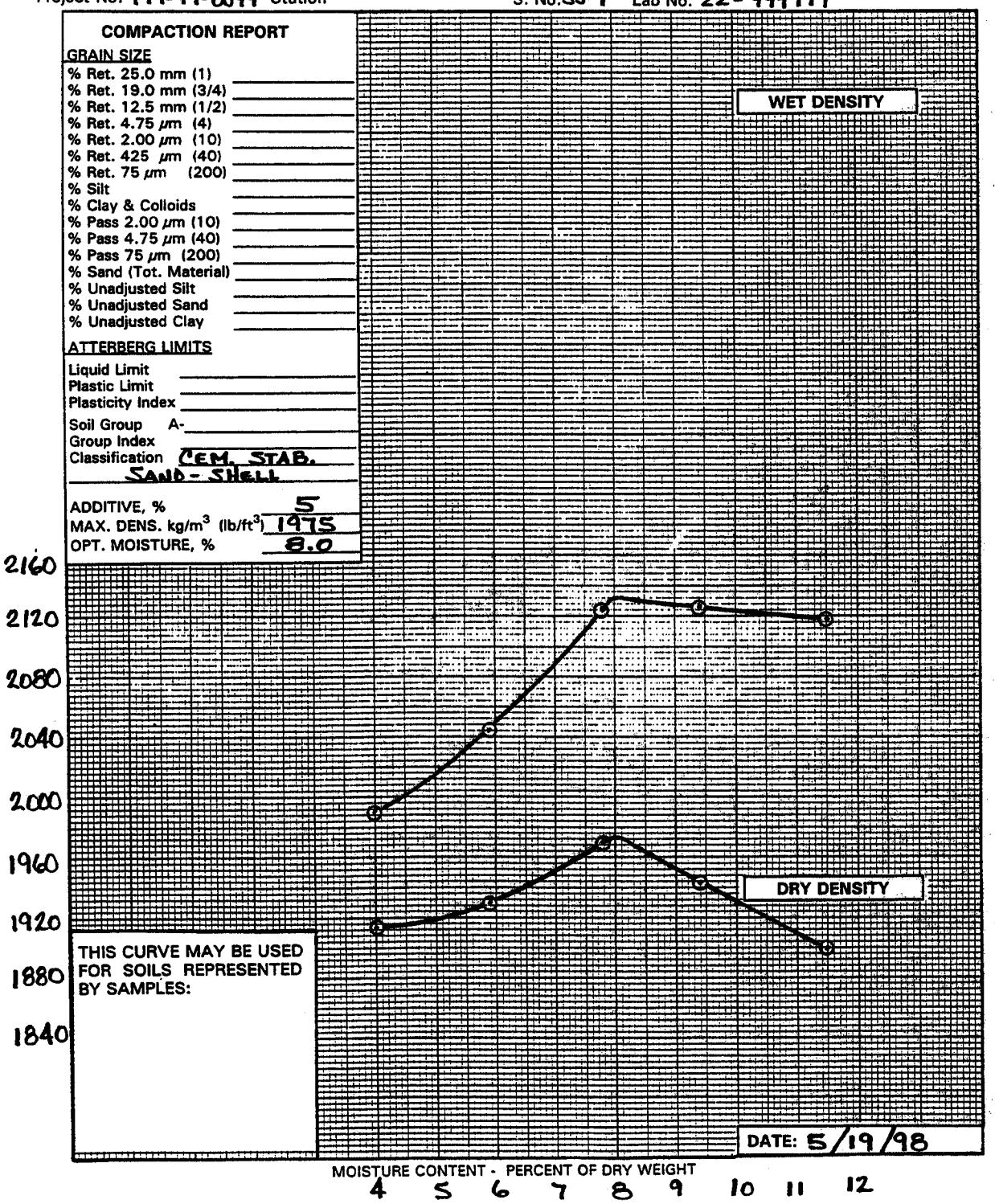
Project No. 999-99-0099 Station S. No. SS-7 Lab No. 22-999999

COMPACTION REPORT

GRAIN SIZE
- % Ret. 25.0 mm (1)
- % Ret. 19.0 mm (3/4)
- % Ret. 12.5 mm (1/2)
- % Ret. 4.75 μm (4)
- % Ret. 2.00 μm (10)
- % Ret. 425 μm (40)
- % Ret. 75 μm (200)
- % Silt
- % Clay & Colloids
- % Pass 2.00 μm (10)
- % Pass 4.75 μm (40)
- % Pass 75 μm (200)
- % Sand (Tot. Material)
- % Unadjusted Silt
- % Unadjusted Sand
- % Unadjusted Clay

ATTERBERG LIMITS
- Liquid Limit
- Plastic Limit
- Plasticity Index
- Soil Group A-
- Group Index
- Classification CEM. STAB. SAND - SHELL

- ADDITIVE, % 5
- MAX. DENS. kg/m³ (lb/ft³) 1975
- OPT. MOISTURE, % 8.0



Laboratory Compaction Report (03-22-4165)
Figure D-3 (Metric)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 9191-9191-101919 | Material Code 408 | Lab No. 22-191919191919
Date Sampled 1/21-1/21-97 | Submitted By 01919 | Quantity
Purp Code 7 | Source Code AA1919 | Spec Code 3 | P.O. No.
Date Tested - - | Ident | Plant Code | Frict.Rating (1-4)
Item No. 301 | Date Rec'd (lab) 12/6/97 | Sampled By: S.C.
Remarks 1

Tested By P.B. | Date 12/19/97 | Checked By G.C. | Date 12/13/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2				
9.5	3/8				
4.75	No. 4				
Mass Matl.in Pan					
Acc. Total					
Initial Dry Total Mass			% Diff:		

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10				
1.18	16				
600	30				
425	40				
300	50				
180	80				
150	100				
75	200				
53	270				
Mass Matl.in Pan					
Decant Loss					
Acc. Total					
Initial Dry Total Mass			% Diff:		
Dry Mass After Wash					

Remarks 2:

DOTD TR 428

Liquid Limit | Plastic Limit
No. of Blows | Mass Cup + Wet Soil,g
Mass Cup + Wet Soil,g | Mass Cup + Dry Soil,g
Mass Cup + Dry Soil,g | Mass Water
Mass Water | Cup No.
Factor | Mass Cup, g
Cup No. | Mass Dry Soil
Mass Cup, g | % Moisture
Mass Dry Soil
% Moisture | Plasticity Index

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content,%(TR 418)	8.0
Maximum Density (TR 418) kg/m³ (lb/ft³)	1975
Lab Comp Method (TR 418)	D
Cement, % (TR 432 or SPECIFIED)	5.0
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles %(TR 119)	
Flat or Elongated Part,%(TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part.,Iron Ore, Coal & Lignite, Wood),%(TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: _____ Date: _____

Aggregate Test Report (03-22-0745)
Figure D-4 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD E

I. Scope

This method of test is designed to determine the optimum moisture content of the total material and maximum dry density of raw soil-aggregate mixtures with 5% aggregate or more by dry mass retained on the 4.75 mm sieve when compacted in the laboratory in accordance with this procedure.

Note E-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415.*

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 0.002832 m^3, manufactured with an internal diameter of 152.46 ± 0.66 mm and a height of 154.90 ± 0.41 mm, and with a detachable collar approximately 90 mm in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 153.39 mm or the height is less than 152.40 mm at any point.

Note E-2: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive Device**
1. Automatic Rammer
   a. A 4.536 ± 0.045 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 152 mm inside diameter mold and arranged to control the height of drop to 457 ± 2 mm
   b. A 2.495 ± 0.023 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 152 mm inside diameter mold, and arranged to control the height of drop to 305 ± 2 mm
2. Manual Rammer
   a. A 4.536 ± 0.045 kg rammer, with a circular striking face with a diameter of 50.80 ± 0.25 mm and arranged to control the height of drop to 457 ± 2 mm
   b. A 2.495 ± 0.023 kg rammer, with a circular striking face with a diameter of 50.80 ± 0.25 mm and arranged to control the height of drop to 305 ± 2 mm

C. **Compaction block** - a stable block or pedestal composed of portland cement concrete and with a mass of 90 kg.

D. **Straightedge** - steel straightedge, approximately 300 mm in length.

E. **Scale** - a scale of 10 kg or more capacity sensitive to 5 grams or less.

F. **Sieves** - a set of the following sieves conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).
1. 25 mm
2. 19 mm
3. 12.5 mm
4. 4.75 mm
5. 2.00 mm

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screw driver to remove material from mold.
6. Finishing tool.
7. Height gauge - dial micrometer incremented in 0.025 mm, accurate to 0.025 mm, mounted on a stand.

H. **Graduated cylinders** - incremented in mL.

I. **Wax paper** - for molds without attached base plate.

J. **Engineer's Curve** - Alvin 1010-21 or equivalent.

K. **Laboratory Moisture - Density Worksheet, Methods E & F** - DOTD Form No. 03-22-4196. (Figure E-1).

L. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure E-2)

M. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure E-3)

Note E-3: *It is convenient, but not essential, to have a mechanical device for removing the compacted material from the mold. Such a device may consist of a closed, cylindrical sleeve slightly less than 152 mm in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

Obtain a representative sample of material with a mass of 82 kg (6 full sample sacks).

IV. Procedure

A. Preparation

1. Prepare the total sample in accordance with DOTD TR 411, using the 25 mm, 19 mm, 12.5 mm, 4.75 mm, and 2.00 mm sieves.

Note E-4: *If a gradation has been performed previously on this material, this gradation may be used in lieu of Step IV.A.1.*

2. Retain the separated material in separate containers.
3. Determine the mass of each fraction. Record the mass of material retained on the 25 mm screen as **A** on the worksheet. Record the mass of the fractions retained on the 19 mm, 12.5 mm, 4.75 mm, and 2.00 mm sieves as $\mathbf{B_n}$, corresponding to the appropriate sieve size. Record the material passing the 2.00 mm sieve as **D**.
4. Prepare a minimum of five 7 kg composited representative portions, with the same proportions of each size fraction as the original sample, except that for each representative portion remove the material retained on the 25 mm sieve and replace it with an equal mass of material based on the prorated percentages retained on the 19 mm, 12.5 mm, 4.75 mm and 2.00 mm sieves. Mix each representative portion thoroughly. (Refer to Step V.A for example.)

B. Testing

1. Add a quantity of water measured in mL to make the 7 kg representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **N** for the first point on the worksheet.

Note E-5: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 7 kg representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary for some materials. (Refer to Step V.B) Record the quantity added to each representative portion as **N** on the worksheet.
3. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for a minimum of 30 min.
4. Compact the test specimens using an approved rammer.
   a. If mold requires an attachable base plate, attach base plate. Determine the mass of the mold and base plate and record as **P** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on the compactor base. Determine the mass of mold and record the mass as **P** on the worksheet. Place the mold over the wax paper and secure the mold to the compactor base.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield approximately 1/3 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material.
   g. Rest the rammer on top of the layer to be compacted. Compact the layer using 28 blows with the 4.536 kg rammer or 75 blows with the 2.495 kg rammer.
   h. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.4.d-h for two more layers.
   j. After the third layer has been compacted, remove the mold, base plate, (if applicable) and compacted specimen from the automatic rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
   l. Note the height of the compacted test specimen.
      (1) If the compacted material is more than 15 mm above the height of the mold or more than 10 mm below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.

(2) If the compacted material is above the top of the mold, but not more than 15 mm above, proceed as follows:

Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.

(3) If the compacted material is below the top of the rim of the mold, but less than 10 mm below, proceed as follows:

(a) Place the finishing tool on the compacted surface and rotate it while tapping very lightly to smooth and level the surface. Do not impart additional compactive effort to the specimen.

(b) Determine the height of the specimen by measuring to the nearest 1 mm at three locations spaced equally around the circumference, and averaging.

(c) Calculate the volume of the specimen in accordance with Step V.C and record as **R** on the worksheet.

m. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.

n. Remove wax paper (if applicable) and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.

o. Determine the mass of the mold, base plate (if applicable), and compacted test specimen and record as **O** on the worksheet.

p. Remove the base plate, (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.

q. Repeat Steps IV.B.4.a-p for each 7 kg representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet mass of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the plus 25 mm replacement, the prorated mass retained, the percent retained, and the adjusted mass as shown on the worksheet. Calculate the accumulated mass in accordance with DOTD TR 113. Record these values where indicated.

B. Calculate the quantity of water to be added to each representative portion (N_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$N_n = N_{n-1} + 136$$

where:

N_{n-1} = volume of water added to the previous representative portion, mL

136 = a constant representing the approximate volume of water required for a 2% moisture content for a 7 kg representative portion, mL

example:

$N_{n-1} = 401$ mL

$$N_n = 401 + 136$$

$$N_n = 537$$

***Note E-6:** 1 g of water = 1 cc of water = 1 mL of water*

C. Calculate the volume of the test specimen (R) in m^3 by using the following formula.

$$R = \frac{h}{1000} \times 0.01858$$

where:

h = average height of test specimen, mm

0.01824 = constant equal to the volume of a 152.4 mm diameter mold, per m^3

1000 = constant to convert mm to m

example:

$h = 155$ mm

$$R = \frac{155}{1000} \times 0.01858$$

$$= 0.00287990$$

$$R = 0.002880$$

D. Calculate wet mass of compacted material in mold (Q) for each representative portion by using the following formula and record on the worksheet.

$$Q = O - P$$

where:

O = mass of mold, base plate (if used), and compacted wet material, g
P = mass of mold and base plate (if used), g

example:

O = 12134 g
P = 6387 g

$$Q = 12134 - 6387$$

$$Q = 5747$$

E. Calculate wet density (WWD) in kg/m^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{Q}{1000 \times R}$$

where:

Q = wet mass of compacted material, g
R = (0.002832) a constant representing the volume of the mold or the volume of the specimen (if applicable), as calculated in Step V.C, m^3

example:

Q = 5747 g
R = 0.002832 m^3

$$WWD = \frac{5747}{1000 \times 0.002832}$$

$$WWD = 2029$$

F. Calculate the mass of water (WW) and the mass of dry material (DW), using the formulas shown on the worksheet and record.

G. Calculate the moisture content (MC) in percent for each representative portion as shown on the worksheet and record.

H. Calculate the dry density (DWD) in kg/m^3 for each representative portion using the following formula.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet mass density, kg/m^3
MC = moisture content, %
100 = constant

example:

WWD = 2029 kg/m^3
MC = 5.9 %

$$DWD = \frac{2029}{100 + 5.9} \times 100$$

$$= \frac{2029}{105.9} \times 100$$

$$= 19.1595 \times 100$$

$$DWD = 1916$$

I. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet densities have been plotted. Repeat the process for each moisture content, substituting dry densities for wet densities.

J. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet Density Vs. Moisture Content and Dry Density Vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note E-7: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

K. Determine the Optimum Moisture Content (%) of the total material, which is the moisture content corresponding to the peak of the dry density curve.

L. Determine the maximum Dry Density of the total material, which is the density corresponding to the peak of the Dry Density Curve.

VI. Report

A. Report the Maximum Dry Density and the Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. From DOTD TR 407 and DOTD TR 423, report the following on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
   1. Grain Size Distribution.
   2. Atterberg Limits.
   3. Soil Group.
   4. Group Index.
   5. Classification.

Note E-8: *For sand clay gravel or other materials accepted by gradation determined in accordance with DOTD TR 112 and DOTD TR 113, the report of soil group index and classification will not be required.*

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4196
Metric
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods (E) & F
(Metric)

PROJECT NO: 999-99-9999 DATE: 12/27/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Clay Loam | Siliceous Agg. SAMPLE NO: S-2

TESTED BY: K.B. CHECKED BY: G.C.

SIEVE	*** ***		Wt. Retained, g	+25.0 mm Replacement $B_n/(1-(A/C))$	Prorated Wt. Ret., g (lb) (F)	% Retained (F/E) x 100 (G)	Adjusted Wt., g (G x 7000) ÷ 100	Accumulated Wt. g
25.0 mm	A		150					
19.0 mm	B_1		458	489 →	489	4.91	344	344
12.5 mm	B_2		322	344 →	344	3.46	242	586
4.75 µm	B_3		172	183 →	183	1.84	129	715
2.00 mm	B_4		1293	1379 →	1379	13.86	970	1685
Subtotal	C	$A+\Sigma B_{1..n}$	9395 →	9395				
-2.00 mm	D		7557 →	7557		75.93	5315	7000
Total	E	C + D	9952 →	9952		100	K = 7000	

*MAX. DRY DENSITY OF MATERIAL (___ TR 418-E, ___ TR 415-A), kg/m³	H		
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-A, ___ TR 432-B, ___ TR 416, ___ specified)	I		
*% WT. OF ADDITIVE (___ chart, ___ formula)	J		
DRY WT. OF MATERIAL (Representative Portion), g	K		7000
*WT. OF ADDITIVE TO BE ADDED, g	L	(J x K) ÷ 100	
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, g	M	K + L	

* *FOR USE WITH DOTD TR 418, METHOD F ONLY.*

CURVE POINT NO.	***		1	2	3	4	5	6
WATER ADDED, mL	N	See Calculations	401	537	673	809	945	
WT. MOLD, BASE (if applicable) & WET MATERIAL, g	O		12134	12329	12569	12592	12538	
WT. MOLD & BASE (if applicable), g	P		6387	6387	6387	6387	6387	
WT. WET COMPACTED MATERIAL, g	Q	O - P	5747	5942	6182	6205	6151	
VOLUME OF MOLD (or specimen), m³	R		0.002832					
WT. OF PAN & DRY MATERIAL, g	S		8042	8065	8287	7893	7961	
WT. OF PAN, g	T		2617	2549	2635	2313	2508	
WT. OF DRY MATERIAL, g	DW	S - T	5425	5516	5652	5580	5453	
WT. OF WATER, g	WW	Q - DW	322	426	530	625	698	
WET DENSITY, kg/m³	WWD	$\frac{Q}{(1000)\,R}$	2029	2098	2183	2191	2172	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	5.9	7.7	9.4	11.2	12.8	
DRY DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	1916	1948	1995	1970	1925	

REMARKS: _____

Laboratory Moisture - Density Relationship (03-22-4196)
Figure E-1 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD E

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 2 Lab No. 22-999999

COMPACTION REPORT

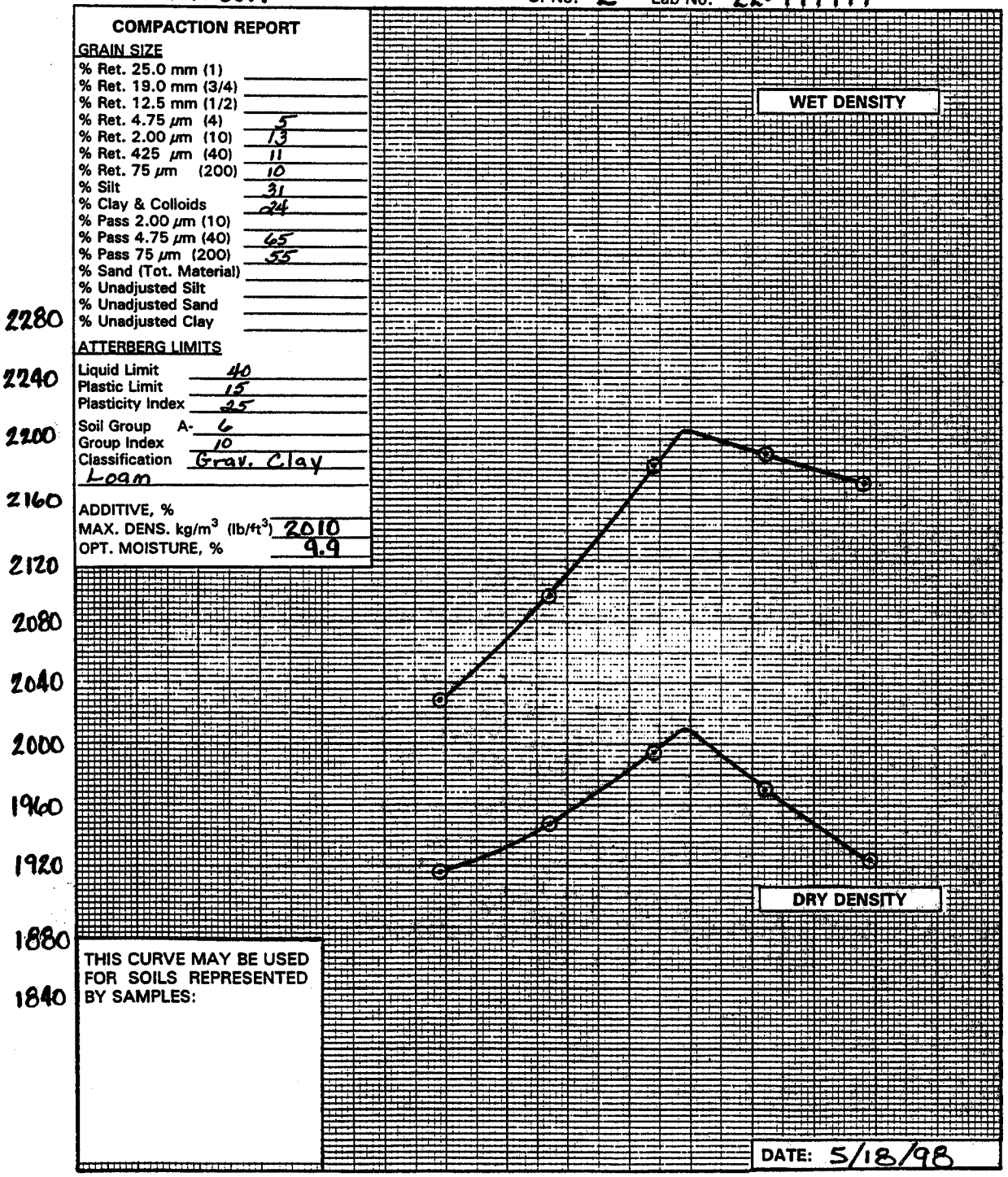
GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	40
Plastic Limit	15
Plasticity Index	25
Soil Group A-	6
Group Index	10
Classification	Grav. Clay Loam

ADDITIVE, %	
MAX. DENS. kg/m³ (lb/ft³)	2010
OPT. MOISTURE, %	9.9



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/18/98

Laboratory Compaction Report (03-22-4165)
Figure E-2 (Metric)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 5/98

Metric / English [M] *(M or E - Located on MATT Menu)*

Project No. [9191-1991-101919] Material Code [4015] Lab. No. [22-191919191919]

Date Sampled [12-201-1917] Submitted By [ ] Quantity [ ]

Purp. Code [7] Pit No. [ ] Spec Code [3]

Date Tested [12-217-1917] Ident. [51-121] Parish No. [ ]

From Station [ ] + [ ] To Station [ ] + [ ] Location [ ]

Hole No. _____ Depth, m (ft) [ ] [ ] Log Distance, km (mi) [ ]

Item No. [2103(104)] Sampled by: _____

Remarks 1 [ ]

Hydrometer Analysis (DOTD TR 407)			Graduate No.____	Dry Mass of Sample (W), g (1=50.0, 2=100.0) [ ]			
Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes	[ ]	[ ]	[ ]			
	120 Minutes	[ ]	[ ]	[ ]			

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g [ ]
Cup No. _____
Mass Cup, g [ ]
Mass Soil, g _____

RETAINED ON 425 µm (40)
Mass Cup + Soil, g [ ]
Cup No. _____
Mass Cup, g [ ]
Mass Soil, g _____

RETAINED ON 75 µm (200)
Mass Cup + Soil, g [ ]
Cup No _____
Mass Cup, g [ ]
Mass Soil, g _____

Size	Mass Retained (Wx) Gram	%
Total Mass, g	[ ]	
25.0 mm (1)	[ ]	
19.0 mm (3/4)	[ ]	
12.5 mm (1/2)	[ ]	
4.75 µm (4)	[ ]	
2.00 µm (10)	[ ]	
425 µm (40)	_____	_____
75 µm (200)	_____	_____
% Silt		_____
% Clay & Colloids		_____
Pass 4.75 µm (#4)	_____	_____
Pass 2.00 µm (#10)	_____	_____

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	6
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (#10)	76
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	40
% Unadjusted Sand	28
% Unadjusted Clay	

LIQUID LIMIT
No. Blows [ ]
Mass Cup + Wet Soil, g [ ]
Mass Cup + Dry Soil, g [ ]
Mass Water, g _____
Factor _____
Cup No. _____
Mass Cup, g [ ]
Mass Dry Soil, g _____
% Moisture _____

PLASTIC LIMIT
Mass Cup + Wet Soil, g [ ]
Mass Cup + Dry Soil, g [ ]
Mass Water, g _____
Cup No. _____
Mass Cup, g [ ]
Mass Dry Soil, g _____
% Moisture _____

% Organic Matter (TR 413) [ ]
Liquid Limit (TR 428) 40
Plasticity Index (TR 428) 25
Natural Moisture Content, % (TR 403) [9.9]
Optimum Moisture Content, % (TR 418) [ ]
Maximum Density, kg/m^3 (lb/ft^3) (TR 418) [2011.01]
Laboratory Compaction Method (TR 418) [E]
% Cement (TR 432 or Plans) [ ]
% Lime (TR 416) [ ]
% Fly Ash [ ]
% Other (Additive) Material Code [ ] Percent [ ]
Soil Group (TR 423) A-6(10)
Classification (TR 423) Clay Loam w/Siliceous Agg.
pH (TR 430) [ ]
Resistivity, ohm-cm (TR 429) [ ]
Classification Prefix (TR 423) (G=Siliceous Aggr. N=Non-Siliceous S=Shell) [ ]
(Required only if +2.00 mm (No.10, g) material equals or exceeds 5%)

Remarks 2 [ ]

Tested By: N.H. Checked By: G.C. APPROVED BY: _____
Date: 12/27/97 Date: 12/28/97 DATE: _____

Soils/Soil-Aggregate Worksheet (03-22-0723)
Figure E-3 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD F

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry density of soil cement, lime treated or conditioned soil cement, or cement treated or lime treated soil-aggregate mixtures, all containing 5% or more aggregate by dry mass retained on a 4.75 mm sieve, when the material is compacted in the laboratory in accordance with this procedure. When these materials contain less than 5% aggregate by dry mass retained on the 4.75 mm sieve, refer to Method B.

Note F-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415. For field conditioned material which requires the addition of additives, TR 415 Method B can be used in the laboratory to determine moisture-density relationships of the material and additive combination only if the required amount of additive is known; however, for field conditioned material brought into the laboratory for the purpose of determining the required amount of additive, it is not permissible to use Method B of TR 415.*

Note F-2: *It is not permissible to use DOTD TR 415, Method A when the sample contains aggregate other than siliceous gravel.*

II. Apparatus

A. **Same as DOTD TR 418, Method E.**
B. **Cement or lime.**

Note F-3: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit mass of 1500 kg/m^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement a unit mass of 1440 kg/m^3 shall be used. For Type II cement, a unit mass of 1500 kg/m^3 shall be used.

Lime shall meet DOTD specifications for hydrated lime. A unit mass of 560 kg/m^3 shall be used.

C. **Personal protective equipment**
   1. Respirator.
   2. Gloves.
   3. Apron.
   4. Goggles.
D. **Laboratory Moisture - Density Worksheet, Methods E & F** - DOTD Form No. 03-22-4196. (Figure F-1)
E. **Additive Conversion Chart.** (Figure F-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure F-3)
G. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure F-4)

III. Test Sample

Same as DOTD TR 418, Method E.

IV. Health Precautions

Care must be taken not to allow cement or lime to contact skin or to inhale reaction fumes.

V. Procedure

A. Preparation
   1. Determine the maximum dry density of the soil aggregate mixture using one of the following methods and record as **H** on the worksheet.
      a. DOTD TR 418, Method E.
      b. DOTD TR 415, Method A, if percent siliceous aggregate is within allowable range of 5 - 60 percent.
   2. Determine the percent by volume of cement in accordance with DOTD TR 432 or the percent of lime in accordance with DOTD TR 416 or use the percent specified. Record as **I** on the worksheet.
   3. Convert percent by volume to percent by mass and record as **J** on the worksheet. (Refer to Step VI.A or B for mass-volume conversion calculations).
   4. Prepare a minimum of five additional 7 kg composited representative portions, as described in Method E, Step IV.A.1-4.

Note F-4: *If DOTD TR 418, Method E was used to determine the maximum dry density of the soil-aggregate mixture, values for accumulated mass determined in DOTD TR 418, Method E are to be used to prepare the five additional representative portions.*

B. Testing

1. Calculate the mass of additive to be added to the representative portions in accordance with Step VI.C and record as **L** on the worksheet.
2. Add the required mass of the additive determined in Step V.B.1 to each composited representative portion.
3. Add a sufficient quantity of water, measured in mL, to make the 7 kg representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **N** for the first point on the worksheet.

Note F-5: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

4. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 7 kg representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary for some materials. (Refer to Step VI.D) Record the quantity of water added to each representative portion as **N** on the worksheet.
5. Cover the representative portions to which water and additive have been added and allow them to stand for a minimum of 30minutes, then remix.
6. Cover the representative portions again and protect them so that the moisture content remains constant, then allow them to slake as follows.
   a. Soil-aggregate mixed with cement: The combined standing and slaking time, plus the compaction time in the laboratory shall approximate the moist mixing time, plus the compaction time in the field. This time shall be a minimum of 60 min and a maximum of 90 min.
   b. Soil-aggregate mixed with lime: The combined standing and slaking time plus compaction time in the laboratory shall approximate the moist mixing time and mellowing time in the field, but shall not be less than 15 hours.
   c. When lime conditioned soil is to be cement treated or stabilized, mix the soil with the lime and allow it to slake in accordance with Step V.B.6.b. Then add the required mass of cement (determined in accordance with Step V.B.1) to the soil-aggregate-lime mixture. Then repeat Steps V.B.3-6.a.

Note F-6: *When during a project, the soil-aggregate mixture has been lime treated or conditioned in accordance with Section 304 of the specifications prior to sampling for cement treatment or stabilization, it shall be slaked in accordance with Step V.B.6.a.*

7. Compact the test specimen in accordance with Method E, Step IV.B.4.

VI. Calculations

A. Determine percent of additive by mass by using the Additive Conversion Chart (Figure F-2). This chart may be used for Type IB portland cement and hydrated lime.
   1. Enter the chart on the left scale. Reading vertically, place a point at the appropriate maximum dry density of the soil-aggregate mixture obtained in Step V.A.1.
   2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of additive.
   3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
   4. Read the percent by mass directly from the additive scale on the chart at the point where the line drawn in Step 3 intersects the scale for the additive being used.
   5. Record this value as **J** on the worksheet.
   6. Example: *(Figure F-2)*

      a. Type IB Cement

      H = 2010 kg/m^3
      I = 8% Type IB cement by volume

      (1) Follow the left scale to the point represented by 2010 kg/m^3 .
      (2) Follow the right scale to the point represented by 8% by volume.
      (3) Draw a straight line across the scale, connecting the two points.
      (4) The percent cement by mass, read directly from the middle scale is 6.3%.

b. Lime

H = 2010 kg/m^3
I = 6% hydrated lime, by volume

(1) Follow the left scale to the point represented by 2010 kg/m^3.
(2) Follow the right scale to the point represented by 6% by volume.
(3) Draw a straight line across the scale, connecting the two points.
(4) The percent lime by mass, read directly from the middle scale is 1.7%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by mass of additive (J) using the following formula.

$$J = \frac{(UI/100)}{H - (UI/100)} \times 100$$

$$J = \frac{1}{(H/UI) - 0.01}$$

where:

H = max. dry density of the soil-aggr. kg/m^3
I = % by volume of additive
U = unit mass of additive, kg/m^3
100 = constant
0.01 = constant

example: *(Type IP Cement)*

H = 2080 kg/m^3
I = 8%
U = 1440 kg/m^3

$$J = \frac{1}{[2080/(1440 \times 8)] - 0.01}$$

$$= \frac{1}{[0.1805] - 0.01}$$

$$= \frac{1}{0.1705}$$

$$J = 5.9$$

Note F-7: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

C. Calculate the mass of additive (L) in grams to be incorporated into the representative portion of soil using the following formula and record on the worksheet.

$$L = \frac{J \times K}{100}$$

where:

J = % by mass of additive (from chart or formula)
K = dry mass of representative portion, g
100 = constant

example:

J = 1.7 %
K = 7000 g

$$L = \frac{1.7 \times 7000}{100}$$

$$= \frac{11900}{100}$$

$$L = 119$$

D. Calculate the quantity of water to be added to each representative portion (N_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$N_n = N_{n-1} + (0.02 \times M)$$

where:

N_{n-1} = volume of water added to the previous representative portion, mL
M = total mass of material & additive, g
0.02 = decimal equivalent for a 2% increment of moisture

example:

N_{n-1} = 286 mL
M = 7119 g

$$N_n = 286 + (0.02 \times 7119)$$

$$= 286 + 142.38$$

$$N_n = 428$$

Note F-8: *1 g of water = 1 cc of water = 1 mL of water.*

E. Perform all calculation steps for the material in accordance with Method E, Step V.C- L.

VII. Report

A. Report the Maximum Dry Density and the Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. For sand clay gravel or other materials accepted by gradation determined in accordance with DOTD TR 112 and DOTD TR 113, the report of soil group index and classification will not be required.

C. From DOTD TR 407 and DOTD TR 423, report on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
   1. Grain Size Distribution.
   2. Atterberg Limits.
   3. Soil Group.
   4. Group Index.
   5. Classification.

D. Report the type and percent by volume of additive to the nearest 0.1 percent for cement and to the nearest percent for lime on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.

VIII. Normal Test Reporting Time

Normal test reporting time is 6 days.

Note F-9: *When percent cement is to be determined by DOTD TR 432, Method B or the percent lime by DOTD TR 416, normal test reporting time will be 3 weeks or 2 weeks, respectively.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4196
Metric
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods E & (F)
(Metric)

PROJECT NO: 999-99-0099 DATE: 12/1/97 LAB NO: 22-999999
*TYPE ADDITIVE: Hydrated Lime TYPE SOIL: Clay Loam / Siliceous Aggr. SAMPLE NO: S-2
TESTED BY: K.B. CHECKED BY: G.C.

SIEVE	***	***	Wt. Retained, g	+25.0 mm Replacement $B_n/(1-(A/C))$	Prorated Wt. Ret., g (lb) (F)	% Retained (F/E) x 100 (G)	Adjusted Wt., g (G x 7000) ÷ 100	Accumulated Wt. g
25.0 mm	A		150					
19.0 mm	B_1		458	489 →	489	4.91	344	344
12.5 mm	B_2		322	344 →	344	3.46	242	586
4.75 µm	B_3		172	183 →	183	1.84	129	715
2.00 mm	B_4		1293	1379 →	1379	13.86	970	1685
Subtotal	C	$A+\Sigma B_{1..n}$	2395 →	2395				
-2.00 mm	D		7557 →		7557	75.93	5315	7000
Total	E	C + D	9952 →		9952	100	K = 7000	

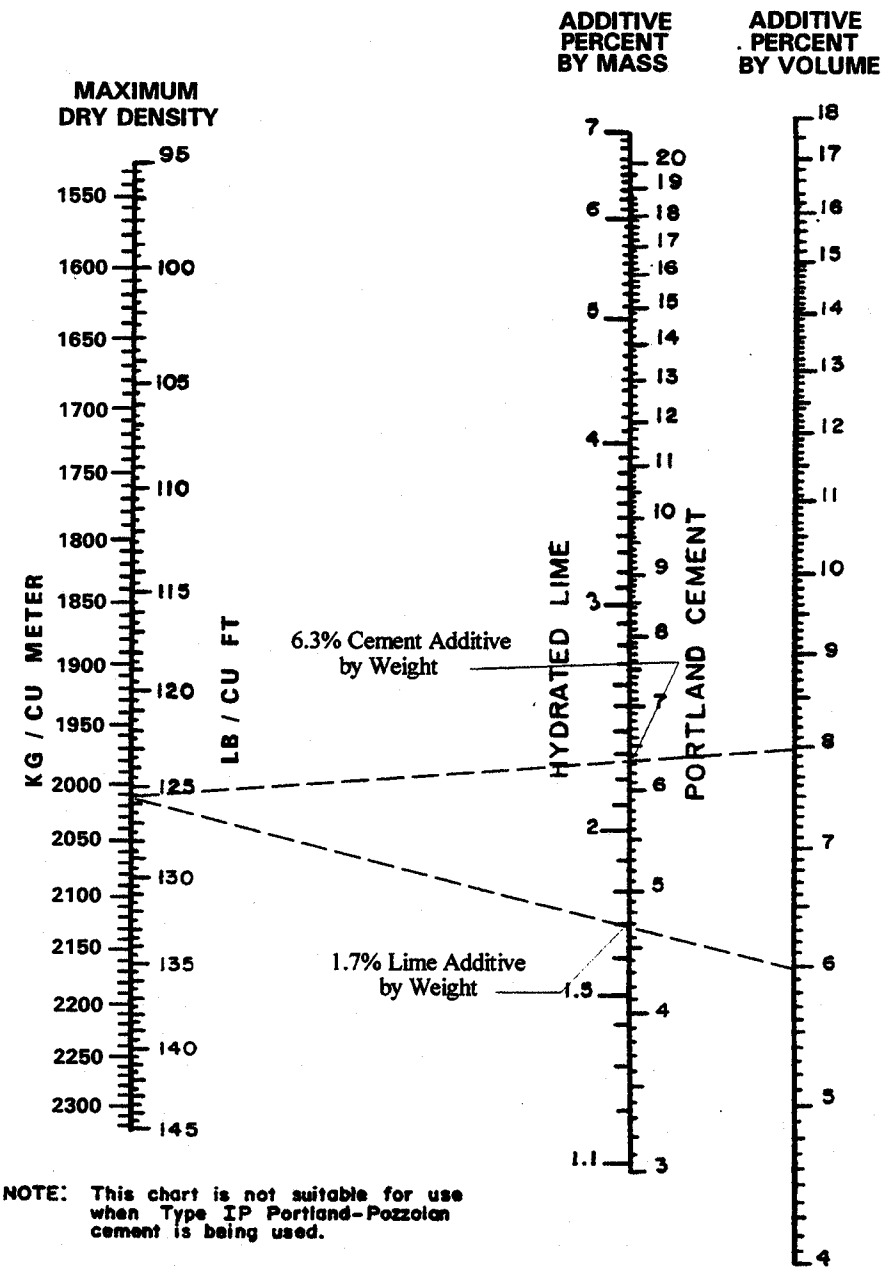
*MAX. DRY DENSITY OF MATERIAL (___ TR 418-E, ___ TR 415-A), kg/m³	H		2010
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-A, ___ TR 432-B, ___ TR 416, ___ specified)	I		6.0
*% WT. OF ADDITIVE (___ chart, ___ formula)	J		1.7
DRY WT. OF MATERIAL (Representative Portion), g	K		7000
*WT. OF ADDITIVE TO BE ADDED, g	L	(J x K) ÷ 100	119
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, g	M	K + L	7119

* ***FOR USE WITH DOTD TR 418, METHOD F ONLY.***

CURVE POINT NO.	***		1	2	3	4	5	6
WATER ADDED, mL	N	See Calculations	986	428	570	712	854	
WT. MOLD, BASE (if applicable) & WET MATERIAL, g	O		12111	12265	12433	12524	12510	
WT. MOLD & BASE (if applicable), g	P		6387	6387	6387	6387	6387	
WT. WET COMPACTED MATERIAL, g	Q	O - P	5724	5878	6046	6137	6123	
VOLUME OF MOLD (or specimen), m³	R		0.002832					
WT. OF PAN & DRY MATERIAL, g	S		8110	8106	8260	7897	8015	
WT. OF PAN, g	T		2617	2549	2635	2313	2508	
WT. OF DRY MATERIAL, g	DW	S - T	5493	5557	5625	5584	5507	
WT. OF WATER, g	WW	Q - DW	231	321	421	553	616	
WET DENSITY, kg/m³	WWD	$\frac{Q}{(1000)\,R}$	2021	2076	2135	2167	2162	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.2	5.8	7.5	9.9	11.2	
DRY DENSITY, kg/m³	DWD	$\frac{WWD}{100+MC} \times 100$	1940	1962	1986	1972	1944	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4196)
Figure F-1 (Metric)



ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY MASS OF OVEN-DRY SOIL, SOIL-AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure F-2 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD F

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 2 Lab No. 22-999999

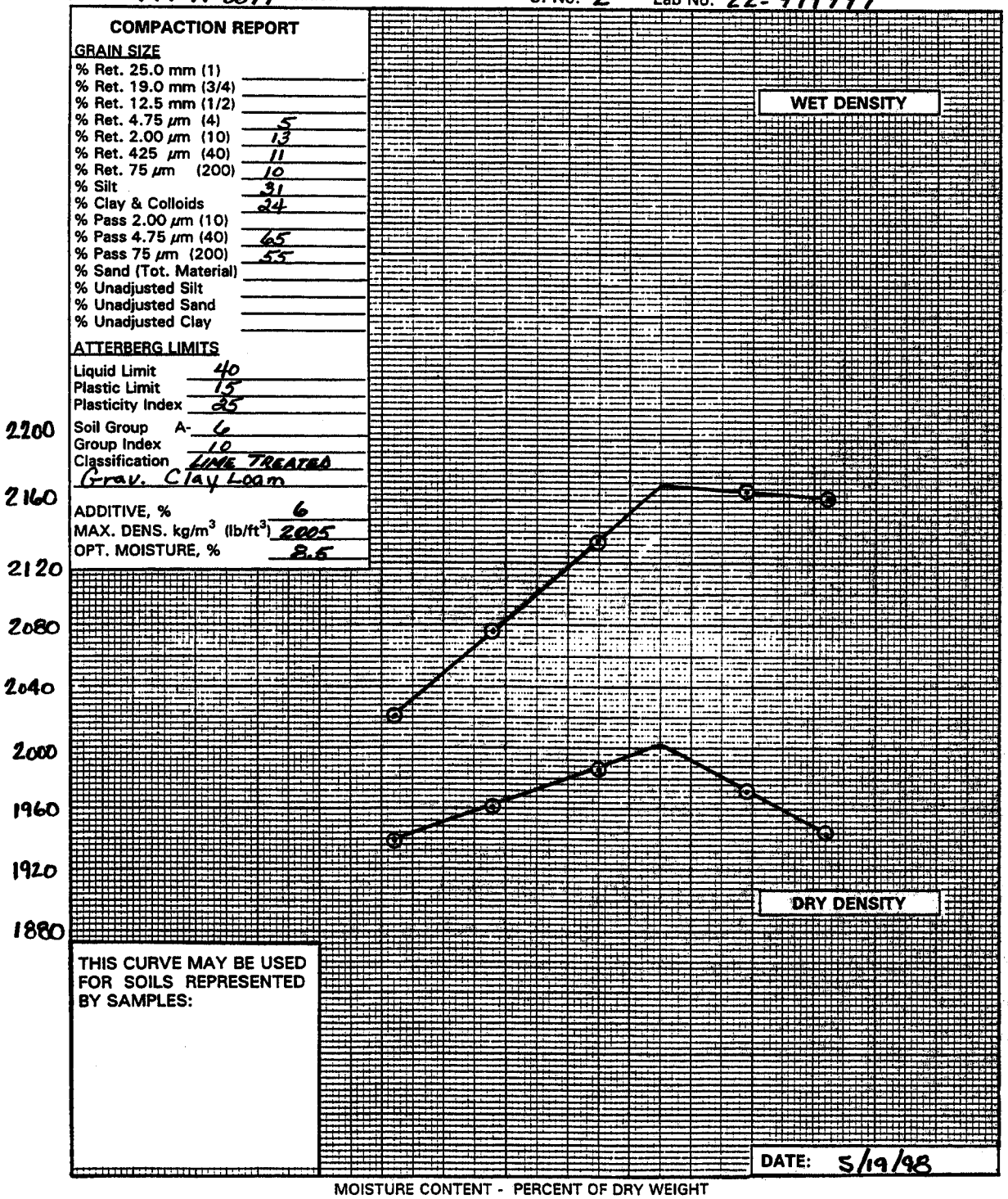
COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	40
Plastic Limit	15
Plasticity Index	25
Soil Group A-	6
Group Index	10
Classification	LIME TREATED Grav. Clay Loam
ADDITIVE, %	6
MAX. DENS. kg/m³ (lb/ft³)	2005
OPT. MOISTURE, %	8.5



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

Laboratory Compaction Report (03-22-4165)
Figure F-3 (Metric)

MATT MENU SELECTION - 14 | Louisiana Department of Transportation and Development | DOTD 03-22-0723

SOILS/SOIL-AGGREGATE | Rev. 5/98

Metric / English M *(M or E - Located on MATT Menu)*

Project No. 999-999-101919 | **Material Code** 4016 | **Lab. No.** 24-9999999

Date Sampled 12-201-97 | **Submitted By** 01619 | **Quantity**

Purp. Code 3 | **Pit No.** | **Spec Code** 3

Date Tested 12-27-97 | **Ident.** 3-7 | **Parish No.**

From Station + | **To Station** + | **Location**

Hole No. | **Depth, m (ft)** | **Log Distance, km (mi)**

Item No. | **Sampled by:**

Remarks 1

Hydrometer Analysis (DOTD TR 407) | Graduate No. | **Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)**

Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	6
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (#10)	76
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	40
% Unadjusted Sand	28
% Unadjusted Clay	

LIQUID LIMIT
No. Blows
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Factor
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

PLASTIC LIMIT
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

% Organic Matter (TR 413)
Liquid Limit (TR 428) 40
Plasticity Index (TR 428) 20
Natural Moisture Content, % (TR 403)
Optimum Moisture Content, % (TR 418) 8.5
Maximum Density, kg/m³ (lb/ft³) (TR 418) 2105
Laboratory Compaction Method (TR 418) F

% Cement (TR 432 or Plans)
% Lime (TR 416) 6
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-6 (10)
Classification (TR 423) Clay Loam w/Siliceous Agg.
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if +2.00 mm (No.10, g) material equals or exceeds 5%)

Remarks 2

Tested By: Checked By: **APPROVED BY:**
Date: Date: **DATE:**

Soils/Soil-Aggregate Form (03-22-0723)
Figure F-4 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD G

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry density of designated materials, including stone, crushed slag or recycled portland cement concrete, when the material is compacted in the laboratory in accordance with this procedure.

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 0.002124 m^3, manufactured with an internal diameter of 152.46 ± 0.66 mm and a height of 116.43 ± 0.13 mm, and with a detachable collar approximately 64 mm in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 153.39 mm or the height is less than 115.57 mm at any point.

Note G-1: Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.

B. **Compactive device**
1. Automatic Rammer - a 4.536 ± 0.045 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 152 mm inside diameter mold and arranged to control the height of drop to 457 ± 2 mm
2. Manual Rammer - a 4.536 ± 0.045 kg rammer, with a circular striking face with a diameter of 50.80 ± 0.25 mm and arranged to control the height of drop to 457 ± 2 mm

C. **Compaction block** - a stable block or pedestal composed of portland cement concrete and with a mass of 90 kg.

D. **Straightedge** - steel straightedge, approximately 300 mm in length.

E. **Scale** - a scale of 10 kg or more capacity sensitive to 5 grams or less.

F. **Sieves** - a set of the following sieves conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).
1. 25 mm
2. 19 mm
3. 12.5 mm
4. 4.75 mm

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screwdriver to remove material from mold.

H. **Graduated cylinder** - incremented in mL.

I. **Engineer's curves** - Alvin 1010-21 or equivalent.

J. **Wax paper**

K. **Laboratory Moisture - Density Worksheet, Method G** - DOTD Form No. 03-22-4197. (Figure G-1)

L. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure G-2)

M. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure G-4)

III. Test Sample

A. Obtain a representative sample with a mass of 82 kg (6 full sample sacks).

B. Dry entire sample in accordance with DOTD TR 411.

IV. Procedure

A. Preparation
1. Prepare the total sample in accordance with DOTD TR 411, using the 25 mm, 19 mm, 12.5 mm, and 4.75 mm sieves.

Note G-2: If a gradation has been performed previously on this material, this gradation may be used in lieu of Step IV.A.1.

2. Retain the separated material in separate containers.
3. Determine the mass of each fraction. Record the mass of material retained on the 25 mm sieve as **A** on the worksheet. Record the mass of the fractions retained on the 19 mm, 12.5 mm and 4.75 mm sieves as $\mathbf{B_n}$, corresponding to the

appropriate sieve size. Record the material passing the 4.75 mm sieve as **D**.

4. Prepare a minimum of five 8 kg composited representative portions, with the same proportions of each size fraction as the original sample, except that for each representative portion remove the material retained on the 25 mm sieve and replace it with an equal mass of material based on the prorated percentages retained on the 19 mm, 12.5 mm and 4.75 mm sieves. Mix each representative portion thoroughly. (Refer to Step V.A for example.)

B. Testing

1. Add a quantity of water, measured in mL, to make the 8 kg representative portion to be used for the first point with sufficient water slightly damp. Mix thoroughly. Record the quantity added as **H** on the worksheet.
2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 8 kg representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted, if necessary. (Refer to Step V.B). Record the quantity added to each representative portion as **H** on the worksheet.
3. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for a minimum of 30 min.
4. Compact the representative portions using an approved rammer.
   a. If mold requires an attachable base plate, attach base plate. Determine the mass of the mold and base plate and record as **J** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on base. Place mold over wax paper and attach. Determine the mass of the mold and base plate and record as **J** on the worksheet.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield slightly more than 1/5 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material.
   g. Rest the rammer on top of the layer to be compacted. Compact the layer using 56 blows with the rammer.
   h. Note height of compacted material. If compacted layer is not 1/5 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.4.d-h for four more layers.
   j. After the fifth layer has been compacted, remove the mold, base plate (if applicable), and compacted specimen from the automatic rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
   l. Note the height of the compacted test specimen.
      (1) If the compacted material is greater than 15 mm above the height of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
      (2) If the compacted material is below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
   m. Keeping the mold, base plate, (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
   n. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.
   o. Remove wax paper (if applicable), and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.
   p. Determine the mass of the mold, base plate (if applicable), and compacted test specimen and record as **I** on the worksheet.
   q. Remove the base plate (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.

r. Repeat Steps IV.B.4.a-q for each 8 kg representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet mass of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the plus 25 mm replacement, the prorated mass retained, the percent retained, and the adjusted mass as shown on the worksheet. Calculate the accumulated mass in accordance with DOTD TR 113. Record these values where indicated.

B. Calculate the quantity of water to be added to each representative portion (H_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$H_n = H_{n-1} + 163$$

where:

H_{n-1} = volume of water, mL, added to the previous representative portion
163 = a constant representing the volume of water in mL required for a two percent moisture content for an 8 kg representative portion

example:

H_{n-1} = 326 mL

$$H_n = 326 + 163$$

$$H_n = 489$$

Note G-3: *1 g of water = 1 cc of water = 1 mL of water.*

C. Calculate wet mass of compacted material in mold (K) in grams for each representative portion in accordance with the following formula and record on the worksheet.

$$K = I - J$$

where:

I = mass of mold, base plate (if used), and compacted wet material, g
J = mass of mold and base plate (if used), g

example:

I = 10225 g
J = 5765 g

$$K = 10225 - 5765$$

$$K = 4460$$

D. Calculate wet density (WWD) in kg/m^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{K}{2.124}$$

where:

K = wet mass of compacted material, g
2.124 = a constant representing 1000 times the volume of the mold, m^3

example:

K = 4460 g

$$WWD = \frac{4460}{2.124}$$

$$= 2099.81$$

$$WWD = 2100$$

E. Calculate the mass of water (WW) in g and the mass of dry material (DW) in grams, using the formulas shown on the worksheet and record.

F. Calculate the moisture content (MC) in percent for each representative portion as shown on the worksheet and record.

G. Calculate the dry density (DWD) in kg/m^3 for each representative portion using the following formula.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet density, kg/m^3
MC = moisture content, %

example:

WWD = 2100 kg/m^3
MC = 4.0 %

$$DWD = \frac{2100}{100 + 4.0} \times 100$$

$$= \frac{2100}{104.0} \times 100$$

$$= 20.192 \times 100$$

$$DWD = 2020$$

H. Beginning with the lowest moisture content, plot a point, on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet densities and dry densities have been plotted. Repeat the process for each moisture content, substituting dry densities for wet densities.

I. Form a smooth line, using the engineer's curve by connecting the plotted points to form two curves, Wet Density vs. Moisture Content and Dry Density vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note G-4: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

J. Determine the Optimum Moisture Content (%) of the total material, which is the moisture content corresponding to the peak of the Dry Density curve.

K. Determine the Maximum Dry Density of the total material, which is the density corresponding to the peak of the Dry Density curve.

VI. Report

A. Report the Maximum Dry Density and the Optimum Moisture Content on the Laboratory Compaction Report and on the Aggregate Test Report to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. Report the Gradation from DOTD TR 112 and TR 113 and Atterberg Limits from DOTD TR 428.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4197
Metric
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Method G
(Metric)

PROJECT NO: 999-99-9999 DATE: 12/27/97 LAB NO: 22-999999
TYPE ADDITIVE: _____ TYPE SOIL: Limestone SAMPLE NO: LS-3
TESTED BY: G.C. CHECKED BY: J.B.W.

SIEVE	***	[redacted]	Mass Retained, g	+25.0 mm Replacement $B_n/(1 - (A/C))$	Prorated Mass Ret., g (F)	% Retained (F/E) x 100 (G)	Adjusted Mass, g (G x 8000) ÷ 100	Accumulated Mass g
25.0 mm	A	[redacted]	272	[redacted]		[redacted]	[redacted]	[redacted]
19.0 mm	B_1	[redacted]	2903	3002 —	3002	19.91	1593	1593
12.5 mm	B_2	[redacted]	1052	1088 —	1088	7.21	577	2170
4.75 µm	B_3	[redacted]	4041	4178 —	4178	27.70	2216	4386
Subtotal	C	$A+B_1+B_2+B_3$	8268	—	8268	[redacted]	[redacted]	[redacted]
4.75 µm	D	[redacted]	6813	——	6813	45.18	3614	8000
Total	E	C + D	15081	——	15081	100	K = 8000	[redacted]

CURVE POINT NO.	***	[redacted]	1	2	3	4	5	6
WATER ADDED, mL	H	See Calculations	326	489	652	815	978	
MASS MOLD, BASE (if applicable) & WET MATL., g	I	[redacted]	10225	10347	10537	10610	10538	
MASS MOLD & BASE (if applicable), g	J	[redacted]	5765	5765	5765	5765	5765	
MASS WET COMPACTED MATERIAL, g	K	I - J	4460	4582	4772	4845	4763	
MASS OF PAN & DRY MATERIAL, g	L	[redacted]	6904	6890	7076	6763	6831	
MASS OF PAN, g	M	[redacted]	2617	2549	2635	2313	2508	
MASS OF DRY MATERIAL, g	DW	L - M	4287	4341	4441	4450	4323	
MASS OF WATER, g	WW	K - DW	172	241	331	395	440	
WET DENSITY, kg/m³	WWD	$\frac{K}{2.124}$	2100	2157	2247	2281	2242	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.0	5.6	7.5	8.9	10.2	
DRY DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	2020	2043	2090	2095	2034	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4197)
Figure G-1 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD G

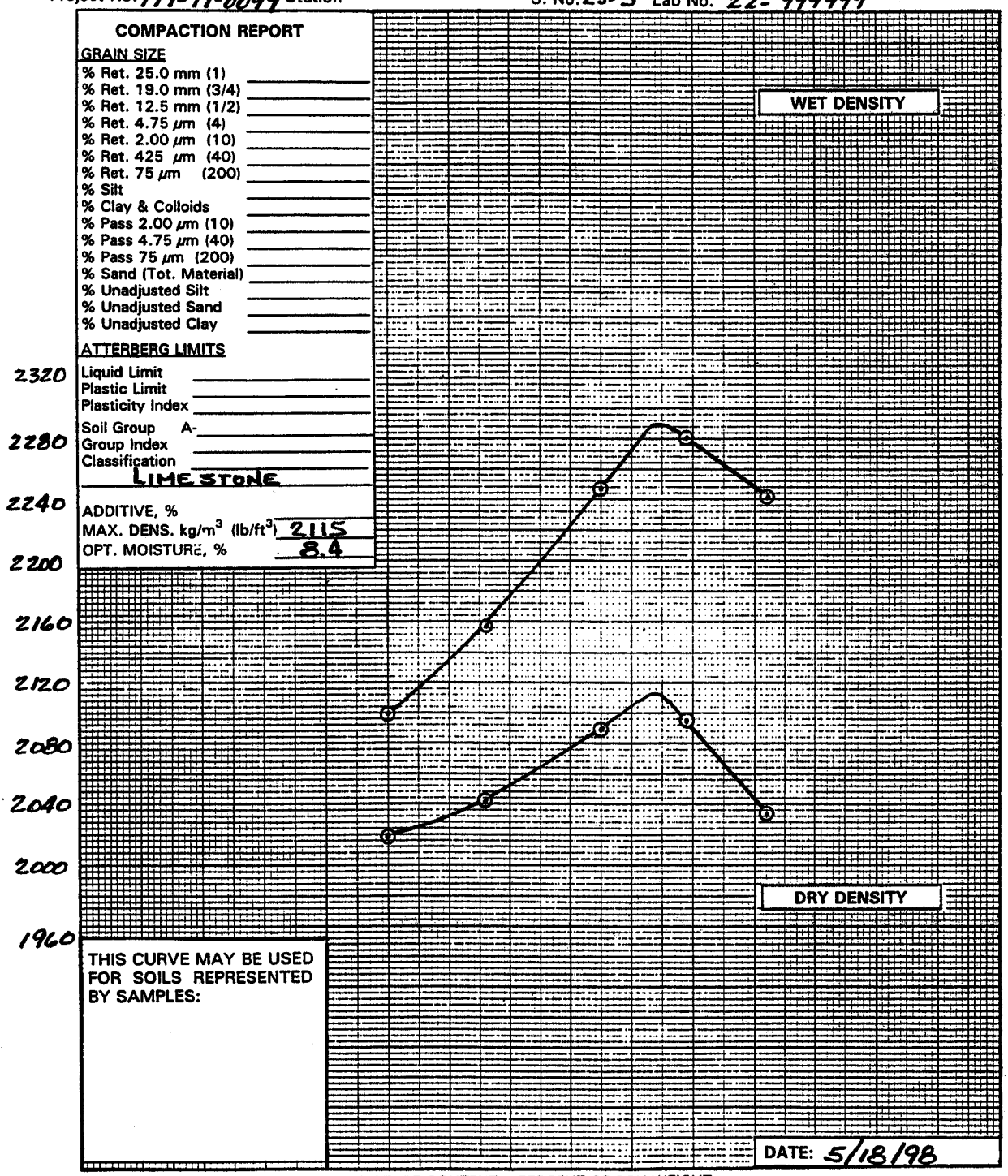
DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. LS-3 Lab No. 22-999999

COMPACTION REPORT

GRAIN SIZE
- % Ret. 25.0 mm (1)
- % Ret. 19.0 mm (3/4)
- % Ret. 12.5 mm (1/2)
- % Ret. 4.75 µm (4)
- % Ret. 2.00 µm (10)
- % Ret. 425 µm (40)
- % Ret. 75 µm (200)
- % Silt
- % Clay & Colloids
- % Pass 2.00 µm (10)
- % Pass 4.75 µm (40)
- % Pass 75 µm (200)
- % Sand (Tot. Material)
- % Unadjusted Silt
- % Unadjusted Sand
- % Unadjusted Clay

ATTERBERG LIMITS
- Liquid Limit
- Plastic Limit
- Plasticity Index
- Soil Group A-
- Group Index
- Classification: LIMESTONE
- ADDITIVE, %
- MAX. DENS. kg/m³ (lb/ft³): 2115
- OPT. MOISTURE, %: 8.4



Laboratory Compaction Report (03-22-4165)
Figure G (Metric)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 999-99-0999 | Material Code 4016 | Lab No. 22-999999999
Date Sampled 12-3101-97 | Submitted By 06104 | Quantity
Purp Code 7 | Source Code A0516 | Spec Code 1 | P.O. No.
Date Tested - - | Ident 45-3 | Plant Code | Frict.Rating (1-4)
Item No. 301 | Date Rec'd (lab) 1/3/97 | Sampled By: J.D.
Remarks 1

Tested By D.B. | Date 1/7/97 | Checked By T.L.C. | Date 1/9/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

mm	Sieve in.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1	2724	1.80	1.80	98
19.0	3/4	29013	19.25	21.05	79
16.0	5/8				
12.5	1/2	11052	6.98	28.03	72
9.5	3/8				
4.75	No. 4	40424	26.80	54.83	45
Mass Matl.in Pan		6811.3	45.17		
Acc. Total		15082			
Initial Dry Total Mass			% Diff:		

Unit 1 = grams 2 = pounds

mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10				
1.18	16				
600	30				
425	40	199.010	24.98	79.81	20
300	50				
180	80				
150	100				
75	200	148.910	12.34	92.15	8
53	270				
Mass Matl.in Pan		216.818			
Decant Loss		4.24			
Acc. Total		179.02			
Initial Dry Total Mass		1179.120	% Diff:	0.10	
Dry Mass After Wash		1174.916			

Remarks 2:

DOTD TR 428

Liquid Limit | Plastic Limit
No. of Blows | Mass Cup + Wet Soil,g | Mass Cup + Dry Soil,g | Mass Water | Cup No. | Factor | Mass Cup, g | Mass Dry Soil | % Moisture
Plasticity Index NP

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content,% (TR 418)	8.4
Maximum Density (TR 418) kg/m³ (lb/ft³)	2115
Lab Comp Method (TR 418)	G
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part,% (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part.,Iron Ore, Coal & Lignite, Wood),% (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1=Pass, 2=Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: | Date:

Aggregate Test Report (03-22-0745)
Figure G-3 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD H

I. Scope

This method of test is designed to determine the optimum moisture content and the maximum dry density of recycled in-place material compacted in the laboratory in accordance with this procedure. This method of test is specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.

Note H-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415.*

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 0.002832 m^3, manufactured with an internal diameter of 152.46 ± 0.66 mm and a height of 154.90 ± 0.41 mm, and with a detachable collar approximately 90 mm in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 153.39 mm or the height is less than 152.40 mm at any point.

Note H-2: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive device**
1. Automatic Rammer
   a. A 4.536 ± 0.045 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 152 mm inside diameter mold and arranged to control the height of drop to 457 ± 2 mm
   b. A 2.495 ± 0.023 kg rammer, with a striking face that is a 2026.83 mm^2 sector face for use with a 152 mm inside diameter mold, and arranged to control the height drop to 305 ± 2 mm
2. Manual Rammer
   a. A 4.536 ± 0.045 kg rammer, with a circular striking face with a diameter of 50.80 ± 0.25 mm and arranged to control the height of drop to 457 ± 2 mm
   b. A 2.495 ± 0.023 kg rammer, with a circular striking face with a diameter of 50.80 ± 0.25 mm and arranged to control the height of drop to 305 ± 2 mm

C. **Compaction block** - a stable block or pedestal composed of portland cement concrete and with a mass of 90 kg.

D. **Straightedge** - steel straightedge, approximately 300 mm in length.

E. **Scale** - a scale of 10 kg or more capacity sensitive to 5 g or less.

F. **Sieves** - a set of the following sieves conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).
1. 25 mm
2. 19 mm
3. 12.5 mm
4. 4.75 mm
5. 2.00 mm
6. 425 μm
7. 75 μm

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screwdriver to remove material from mold.
6. Finishing tool.
7. Height gauge - dial micrometer incremented in 0.025 mm, accurate to 0.025 mm, mounted on a stand.
8. Beakers, Dispersing Agent, and Stirring Apparatus, and Dispersion Cup from DOTD TR 407.

H. **Graduated cylinder** - incremented in mL.

I. **Engineer's Curve** - Alvin 1010-21 or equivalent.

J. **Wax paper**

K. **Power driven wedge crusher.**

L. **Laboratory Moisture - Density Worksheet, Methods H & I** - DOTD Form No. 03-22-4198. (Figure H-1)

M. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure H-2)

N. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure H-3)

Note H-3: *It is convenient, but not essential, to have a mechanical device for removing the compacted material from the mold. Such a device may consist of a closed, cylindrical sleeve slightly less than 152 mm in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

A. Obtain a representative sample with a mass of 80 kg (6 full sample sacks) of material.
B. Dry entire sample in accordance with DOTD TR 411, except for materials containing reclaimed asphaltic concrete (RAP), oils or other hydrocarbons. The maximum drying temperature will be 60°C.

IV. Procedure

A. Preparation
1. Set the crusher to produce a sample with 95% - 100% passing the 25 mm sieve.
2. Pass the entire dried sample through the crusher.

Note H-4: *When passing the sample through the crusher, do not crush or reduce the size of stone or gravel aggregate or trash such as bottle caps, pavement markers, broken pieces of culvert, steel, etc. Remove these materials prior to the crushing operation. Discard these materials retained on the 25 mm sieve. Do not remove or discard RAP or treated soils prior to crushing.*

3. Obtain a representative portion of material in accordance with DOTD TR 108 (minimum size in accordance with DOTD TR 113). Record as Initial Dry Total Mass on the top portion of the Aggregate Test Report.
4. Determine the Atterberg Limits of the material in accordance with DOTD TR 428.
5. Determine the mass of the material retained on the 25 mm, 19 mm, 12.5 mm, and 4.75 mm sieves, in accordance with DOTD TR 113 and the mass retained on the 2.00 mm, 425 μm, and 75 μm sieves, in accordance with DOTD TR 112 with the following exceptions for the material passing the 4.75 mm sieve. Record all data on the Aggregate Test Report.
   a. The test specimen will be 100 g.
   b. The test specimen will be soaked in a beaker filled with dispersing agent for a minimum of one hour.
   c. The test specimen will be dispersed with the mechanical stirrer for three minutes. Prior to dispersion, wash any material remaining in the beaker into the dispersion cup with distilled water and add additional distilled water to the dispersion cup until it is approximately two-thirds full.
   d. Pour the test specimen from the dispersion cup over a nest of sieves, containing the 2.00 mm, 425 μm, and 75 μm. Wash any remaining particles out of the dispersion cup over the sieve nest.
   e. Place the material retained on each sieve in a separate tared container, place in an oven, dry to a constant mass in accordance with DOTD TR 403 at 110±5°C (maximum 60°C, if the material contains RAP, oils or other hydrocarbons). Record each dry mass separately as Mass Retained on the Aggregate Test Report.

Note H-5: *The values for percent retained, percent passing and Atterberg Limits will be used in lieu of classification in accordance with DOTD TR 423 to identify similar materials for moisture-density purposes.*

6. Mix the material prepared in Steps IV.A.1 - 2 and separate into a minimum of five 7 kg representative portions.

B. Testing
1. Add a quantity of water, measured in mL, to make the 7 kg representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity added as **G** on the worksheet.

Note H-6: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 7 kg representative portion to increase the moisture content of each portion by 2% more than the moisture content of the

previous portion. The 2% increment may be adjusted, if necessary. (Refer to Step V.B) Record the quantity added to each representative portion as **G** on the worksheet.

3. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for a minimum of 30 minutes.
4. Remix the individual representative portions, protect them so that the moisture content remains constant, then allow them to slake for a minimum of 12 hours.
5. Compact the test specimens using an approved rammer.
   a. If mold requires an attachable base plate, attach base plate. Determine the mass of the mold and base plate and record as **I** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on base. Place mold over wax paper and attach. Determine the mass of the mold and base plate and record as **I** on the worksheet.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield approximately 1/3 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material.
   g. Rest the rammer on top of the layer to be compacted. Compact the layer using 28 blows with the 4.536 kg rammer or 75 blows with the 2.495 kg rammer.
   h. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.5.d-h for two more layers.
   j. After the third layer has been compacted, remove the mold, base plate (if applicable), and compacted specimen from the rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
   l. Note the height of the compacted test specimen.
      (1) If the compacted material is more than 15 mm above the height of the mold or more than 10 mm below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
      (2) If the compacted material is above the top of the mold, but not more than 15 mm above, proceed as follows:
          Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
      (3) If the compacted material is below the top of the mold, but less than 10 mm below, proceed as follows:
          (a) Place the finishing tool on the compacted surface and rotate it while tapping very lightly to smooth and level the surface. Do not impart additional compactive effort to the specimen.
          (b) Determine the height of the specimen by measuring to the nearest 1 mm at three locations spaced equally around the circumference, and averaging.
          (c) Calculate the volume of the specimen in accordance with Step V.C and record as **K** on the worksheet.
   m. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.
   n. Remove wax paper (if applicable), and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.
   o. Determine the mass of the mold, base plate (if applicable), and compacted test specimen and record as **H** on the worksheet.
   p. Remove the base plate (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.
   q. Repeat Steps IV.B.5.a-p for each 7 kg representative portion, cleaning the mold

between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet mass of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the initial dry total mass of sample, the percent retained on the 2.00 mm and larger sieves, and the percent passing each of these sieves in accordance with DOTD TR 113. Determine the percent retained and percent passing on the 425 μm and 75 μm sieves in accordance with the applicable sections of DOTD TR 407. Record in the appropriate location on the worksheet and the Aggregate Test Report.

B. Calculate the quantity of water to be added to each representative portion (G_n) in mL to yield a moisture content incremented by 2% above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + 136$$

where:

G_{n-1} = volume of water, mL, added to the previous representative portion
136 = a constant representing the volume of water, mL, required for a two % moisture content for a 7 kg representative portion

example:

G_{n-1} = 429 mL

$$G_n = 429 + 136$$

$$G_n = 565$$

***Note H-7:** 1 g of water = 1 cc of water = 1 mL of water.*

C. Calculate the volume of the test specimen (K) in m^3 in accordance with the following formula and record on the worksheet.

$$K = \frac{h}{1000} \times 0.01858$$

where:

h = avg. height of test specimen, mm
0.01858 = constant equal to the volume of a 152.4 mm diameter mold, per mm of height, m^3
1000 = conversion factor to convert mm to m

example:

h = 155 mm

$$K = \frac{155}{1000} \times 0.01858$$

$$= 0.0028799$$

$$K = 0.002880$$

D. Calculate wet mass of compacted material in mold (J) for each point in accordance with the following formula and record on the worksheet.

$$J = H - I$$

where:

H = mass of mold, base plate (if used), and compacted wet material, g
I = mass of mold and base plate (if used), g

example:

H = 11499 g
I = 6387 g

$$J = 11499 - 6387$$

$$J = 5112$$

E. Calculate wet density (WWD) in kg/m^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{J}{1000 \times K}$$

where:

J = wet mass of compacted material, g
K = (0.002832) a constant representing the volume of the mold or the volume of the specimen (if applicable), as calculated in Step C, m^3

example:

J = 5112 g
K = 0.002832 m^3

$$WWD = \frac{5112}{1000 \times 0.002832}$$

$$WWD = 1805$$

F. Calculate the mass of water (WW) and the mass of dry material (DW), using the formulas shown on the worksheet and record.

G. Calculate the moisture content (MC) in percent for each representative portion as shown on the worksheet and record.

H. Calculate the dry density (DWD) in kg/m^3 for each representative portion using the following formula.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet density, kg/m^3
MC = moisture content, %

example:

WWD = 1805 kg/m^3
MC = 6.3 %

$$DWD = \frac{1805}{100 + 6.3} \times 100$$

$$= \frac{1805}{106.3} \times 100$$

$$= 16.9802 \times 100$$

$$DWD = 1698$$

I. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet densities have been plotted. Repeat the process for each moisture content, substituting dry densities for wet densities.

J. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet density Vs. Moisture Content and Dry Density Vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note H-8: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

K. Determine the Optimum Moisture Content (%), which is the moisture content corresponding to the peak of the dry density curve.

L. Determine the maximum dry density, which is the density corresponding to the peak of the dry density curve.

VI. Report

A. Report the Maximum Dry Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Aggregate Test Report to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. Report the Gradation and Atterberg Limits on the Laboratory Compaction Report and on the Aggregate Test Report.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4198
Metric
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods (H) & I
(Metric)

PROJECT NO. 999-99-9999 DATE: 12/1/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Sdy. Loam/Asph. SAMPLE NO.: S-7

TESTED BY: N.S.H. CHECKED BY: B.J.D.

*MAX. DRY DENSITY OF MATL. (FROM TR 418, METHOD H), kg/m³	A		
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-B, ___ TR 416, ___ specified)	B		
*% MASS OF ADDITIVE (___ chart, ___ formula)	C		
DRY MASS OF MATERIAL (Representative portion), g	D		7000
*MASS OF ADDITIVE TO BE ADDED, g	E	(C x D) ÷ 100	
*TOTAL DRY MASS OF MATERIAL AND ADDITIVE, g	F	D + E	

* *FOR USE WITH DOTD TR 418, METHOD I ONLY.*

CURVE POINT NO.	***		1	2	3	4	5	6
WATER ADDED, mL	G	See Calculations	429	565	701	837	973	
MASS MOLD, BASE (if appl.) & WET MATL.,g	H		11499	11617	11857	11735	11503	
MASS MOLD & BASE (if applicable), g	I		6387	6387	6387	6387	6387	
MASS WET COMPACTED MATERIAL, g	J	H - I	5112	5230	5470	5348	5116	
VOLUME OF MOLD (or specimen), m³	K		0.002892					
MASS OF PAN & DRY MATERIAL, g	L		7435	7412	7607	7112	7053	
MASS OF PAN, g	M		2617	2549	2635	2313	2508	
MASS OF DRY MATERIAL, g	DW	L - M	4808	4863	4972	4799	4545	
MASS OF WATER, g	WW	J - DW	304	367	498	549	571	
WET MASS DENSITY, kg/m³	WWD	$\frac{J}{1000\ K}$	1805	1847	1931	1888	1806	
MOISTURE CONTENT, %	MC	(WW/DW)x100	6.3	7.5	10.0	11.4	12.6	
DRY MASS DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	1698	1718	1755	1695	1603	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4198)
Figure H-1 (Metric)

LAB COMPACTION REPORT - DOTD TR 418 METHOD H

DOTD 03-22-4165
Metric / English
Rev. 3/98

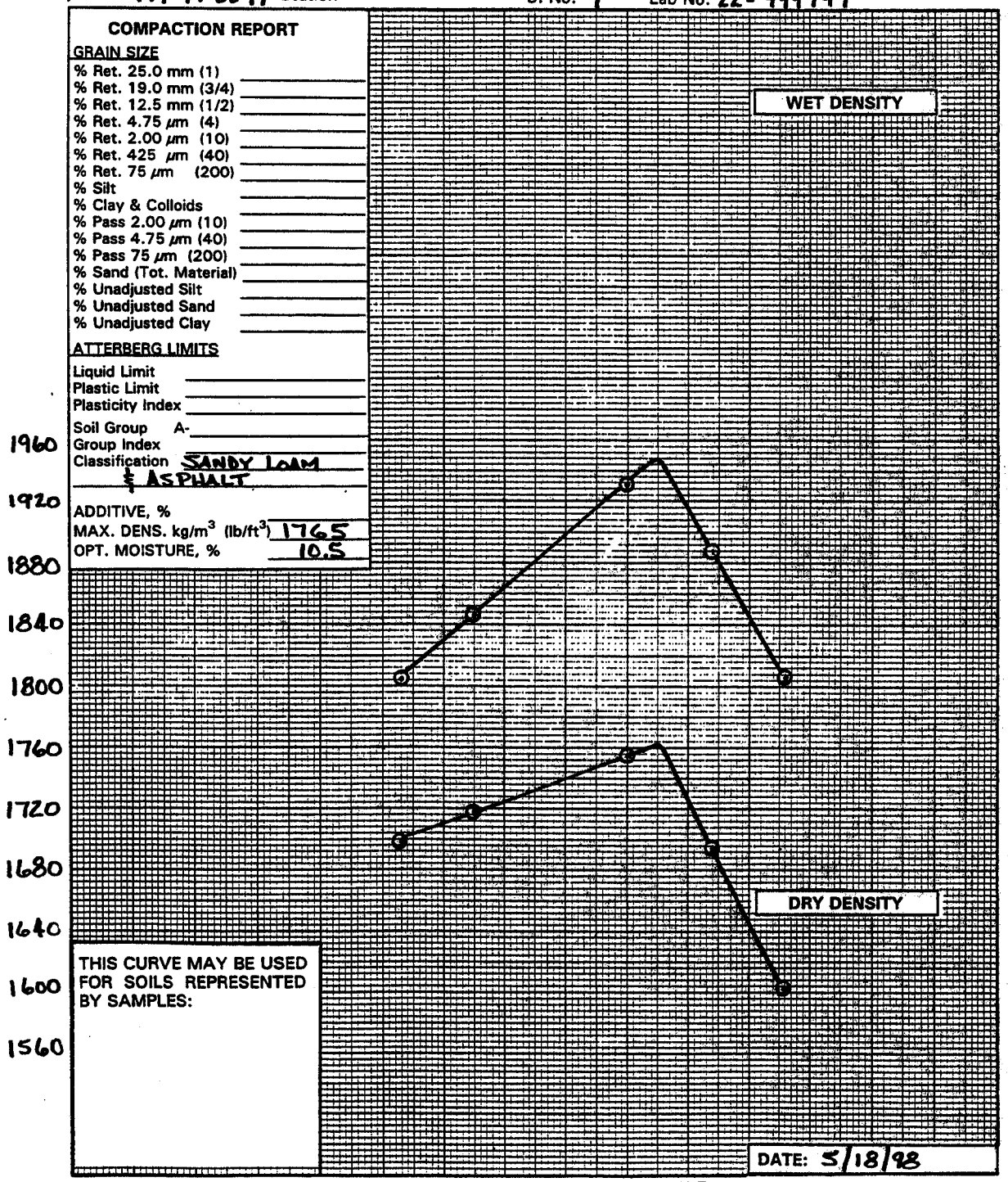
Project No. 999-99-0099 Station S. No. 7 Lab No. 22-999999

COMPACTION REPORT

GRAIN SIZE
- % Ret. 25.0 mm (1)
- % Ret. 19.0 mm (3/4)
- % Ret. 12.5 mm (1/2)
- % Ret. 4.75 μm (4)
- % Ret. 2.00 μm (10)
- % Ret. 425 μm (40)
- % Ret. 75 μm (200)
- % Silt
- % Clay & Colloids
- % Pass 2.00 μm (10)
- % Pass 4.75 μm (40)
- % Pass 75 μm (200)
- % Sand (Tot. Material)
- % Unadjusted Silt
- % Unadjusted Sand
- % Unadjusted Clay

ATTERBERG LIMITS
- Liquid Limit
- Plastic Limit
- Plasticity Index
- Soil Group A-
- Group Index
- Classification SANDY LOAM & ASPHALT

ADDITIVE, %
MAX. DENS. kg/m³ (lb/ft³) 1765
OPT. MOISTURE, % 10.5



Laboratory Compaction Report (03-22-4165)
Figure H-2 (Metric)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 99991-999-101099 | Material Code 4118 | Lab No. 22-9999999999
Date Sampled 01-01-14-97 | Submitted By 01/01/14 | Quantity 10101
Purp Code 7 | Source Code A10999 | Spec Code 1 | P.O. No.
Date Tested 01-01-16-97 | Ident 5-71 | Plant Code | Frict.Rating (1-4)
Item No. | Date Rec'd (lab) 1/5/97 | Sampled By: J.W.
Remarks 1

Tested By G.C. | Date 1/6/97 | Checked By B.W. | Date 1/7/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2	101.00	0	0	100
9.5	3/8				
4.75	No. 4	317.70	33.0	33.0	67
Mass Matl.in Pan		171.80	67.03		
Acc. Total		1150.50			
Initial Dry Total Mass				% Diff:	

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10	119.70	13.2	46.2	54
1.18	16				
600	30				
425	40	247.10	18.1	64.3	36
300	50				
180	80				
150	100				
75	200	224.70	16.5	80.8	19
53	270				
Mass Matl.in Pan		258.80			
Decant Loss					
Acc. Total		100.30			
Initial Dry Total Mass		1010.40		% Diff:	0.10
Dry Mass After Wash					

Remarks 2:

DOTD TR 428

Liquid Limit 23 | Plastic Limit 12

No. of Blows	23	Mass Cup + Wet Soil,g	28.13
Mass Cup + Wet Soil,g	40.24	Mass Cup + Dry Soil,g	25.02
Mass Cup + Dry Soil,g	32.16	Mass Water	3.1
Mass Water	7.6	Cup No.	
Factor	0.9899	Mass Cup, g	10.0
Cup No.		Mass Dry Soil	25.2
Mass Cup, g	10.0	% Moisture	12.3
Mass Dry Soil	22.6		
% Moisture	33.3	Plasticity Index	11

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content,% (TR 418)	10.5
Maximum Density (TR 418) kg/m³ (lb/ft³)	176.5
Lab Comp Method (TR 418)	H
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part,% (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part.,Iron Ore, Coal & Lignite, Wood),% (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: _____ Date: _____

Aggregate Test Report (03-22-0745)
Figure H-3 (Metric)

DOTD Designation: TR 418M-98
METRIC VERSION

METHOD I

I. Scope

This method of test is designed to determine the optimum moisture content and the maximum dry density of recycled in-place material to be cement stabilized or treated, or lime treated or conditioned, when compacted in the laboratory in accordance with this procedure. This method of test is specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.

Note I-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415. For field conditioned material which requires the addition of additives, TR 415 Method B can be used in the laboratory to determine moisture-density relationships of the material and additive combination only if the required amount of additive is known; however, for field conditioned material brought into the laboratory for the purpose of determining the required amount of additive, it is not permissible to use Method B of TR 415.*

II. Apparatus

A. **Same as DOTD TR 418, Method H.**
B. **Cement or lime.**

Note I-2: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit mass of 1500 kg/m^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement, a unit mass of 1440 kg/m^3 shall be used. For Type II cement, a unit mass of 1500 kg/m^3 shall be used.

Lime shall meet DOTD specifications for hydrated lime. A unit mass of 560 kg/m^3 shall be used.

C. **Personal protective equipment**
1. Respirator.
2. Gloves.
3. Apron.
4. Goggles.

D. **Laboratory Moisture - Density Worksheet, Methods H & I** - DOTD Form No. 03-22-4198. (Figure I-1)
E. **Additive Conversion Chart.** (Figure I-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure I-3)
G. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure I-4)

III. Test Sample

Same as DOTD TR 418, Method H.

IV. Health Precautions

Care must be taken not to allow cement or lime to contact skin or to inhale its reaction fumes.

V. Procedure

A. Preparation
1. Determine the maximum dry density of the recycled material in accordance with Method H. Record as **A** on the worksheet.
2. Determine the percent by volume of cement in accordance with DOTD TR 432 or the percent of lime in accordance with DOTD TR 416 or use the percent specified. Record as **B** on the worksheet.
3. Convert percent by volume to percent by mass and record as **C** on the worksheet. (Refer to Step VI.A or B for mass-volume conversion calculations).
4. Obtain a minimum of five 7 kg representative portions using the material prepared in accordance with Method H.

B. Testing
1. Add a sufficient quantity of water to make each 7 kg representative portion slightly damp. Mix thoroughly.

Note I-3: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

2. Protect the representative portions so that the moisture content remains constant and

allow them to soak for a minimum of 12 hours.

3. Calculate the mass of additive to be added to each representative portion in accordance with Step VI.C and record as **E** on the worksheet. Add this quantity of additive to each representative portion.
4. Add additional water, measured in mL, to bring the 7 kg representative portion to be used for the first point back to the slightly damp condition described in ***Note I-3***. Mix thoroughly. Record the quantity added as **G** on the worksheet.
5. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 7 kg representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. (Refer to Step VI.D) The 2% increment may be adjusted, if necessary. Record the quantity of water added to each representative portion as **G** on the worksheet.
6. Cover the representative portions to which water and additive have been added and allow them to stand for a minimum of 30 min.
7. Remix the individual representative portions, cover and protect them so that the moisture content remains constant, then allow them to slake as follows.
   a. Recycled material mixed with cement: The combined standing and slaking time (beginning with Step V.B.6), plus the compaction time in the laboratory shall approximate the moist mixing time, plus the compaction time in the field, but is not to exceed 90 min.
   b. Recycled material mixed with lime: The combined standing and slaking time (beginning with Step V.B.6) plus compaction time in the laboratory shall approximate the moist mixing time and mellowing time in the field, but shall not be less than 15 hours.
   c. When recycled material is lime conditioned prior to cement treatment or stabilization, mix the recycled material with the lime and allow it to slake in accordance with Step V.B.7.b. Then, add the required percent cement (determined in accordance with Step VI.A or B) to the lime mixture and allow the lime mixture to slake in accordance with Step V.B.7.a.

Note I-4: *When during a project, the recycled material has been lime treated or conditioned in accordance with Section 304 of the specifications prior to sampling for cement treatment or stabilization, it shall be slaked in accordance with Step V.B.7.a.*

8. Compact the test specimen in accordance with Method H, Step IV.B.5.

VI. Calculations

A. Determine percent of additive by mass by using the Additive Conversion Chart. This chart may be used for Type IB portland cement and lime.
   1. Enter the chart on the left scale. Reading vertically, place a point at the appropriate maximum dry density of the soil-aggregate mixture obtained in Step V.A.1.
   2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of additive.
   3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
   4. Read the percent by mass directly from the additive scale on the chart at the point where the line drawn in Step 3 intersects the scale for the additive being used.
   5. Record this value as **C** on the worksheet.
   6. Example: *(Figure I-3)*

      a. Type IB Cement

      D = 1765 kg/m^3
      V = 8% Type IB cement by volume

      (1) Follow the left scale to the point represented by 1765 kg/m^3.
      (2) Follow the right scale to the point represented by 8% by volume.
      (3) Draw a straight line across the scale, connecting the two points.
      (4) The percent cement by mass, read directly from the middle scale, is 7.3%.

      b. Lime

      D = 1710 kg/m^3
      V = 6% hydrated lime, by volume

      (1) Follow the left scale to the point represented by 1710 kg/m^3.
      (2) Follow the right scale to the point represented by 6% by volume.
      (3) Draw a straight line across the scale, connecting the two points.

(4) The percent lime by mass, read directly from the middle scale, is 2.0%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by mass of additive (C) using the following formula.

$$C = \frac{(UB/100)}{A - (UB/100)} \times 100$$

$$C = \frac{1}{(A/UB) - 0.01}$$

where:

A = maximum dry density of the soil-aggregate, kg/m^3
B = % by volume of additive
U = unit mass of additive, kg/m^3
100 = constant
0.01 = constant

1. Example: *(Type IP Cement)*

A = 2080 kg/m^3
B = 8%
U = 1440 kg/m^3

$$C = \frac{1}{[2080/(1440 \times 8)] - 0.01}$$

$$= \frac{1}{(0.1806) - 0.01}$$

$$= \frac{1}{0.1706}$$

$$C = 5.9$$

Note I-5: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

2. Example: *(Lime)*

A = 2080 kg/m^3
B = 6%
U = 560 kg/m^3

$$C = \frac{1}{[2080/(560 \times 6)] - 0.01}$$

$$= \frac{1}{(0.6190) - 0.01}$$

$$= \frac{1}{0.6090}$$

$$C = 1.6$$

C. Calculate the mass of additive (E) in grams to be incorporated into the representative portion of soil using the following formula and record as **E** on the worksheet.

$$E = \frac{C \times D}{100}$$

where:

C = % by mass of additive (from chart or formula)
D = dry mass of representative portion, g
100 = constant

example:

C = 7.3 %
D = 7000 g

$$E = \frac{7.3 \times 7000}{100}$$

$$= \frac{51100}{100}$$

$$E = 511$$

D. Calculate the quantity of water to be added to each representative portion (G_n), in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + (0.02 \times F)$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
F = total mass of material and additive, g
0.02 = a constant representing a 2% increment of moisture

example:

G_{n-1} = 551 mL
F = 7511 g

$$G_n = 551 + (0.02 \times 7511)$$

$$= 551 + 150.22$$

$$G_n = 701$$

Note I-6: *1 g of water = 1 cc of water = 1 mL of water.*

E. Perform all calculation steps for the recycled material in accordance with Method H, Step V. C-L.

VII. Report

A. Report the Maximum Dry Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Aggregate Test Report to the nearest 5 kg/m^3 and 0.1 percent, respectively.

B. Report the Gradation and Atterberg Limits on the Laboratory Compaction Report and on the Aggregate Test Report.

C. Report the Type and Percent by Volume of Additive to the nearest percent on the Laboratory Compaction Report and on the Aggregate Test Report.

VIII. Normal Test Reporting Time

Normal test reporting time is 6 days.

Note I-7: *When percent cement must be determined by DOTD TR 432, Method B or the percent lime by DOTD TR 416, normal test reporting time will be 3 weeks or 2 weeks, respectively.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4198
Metric
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods H & I
(Metric)

PROJECT NO. 999-999999 DATE: 1/6/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: _____ SAMPLE NO.: _____

TESTED BY: _____ CHECKED BY: _____

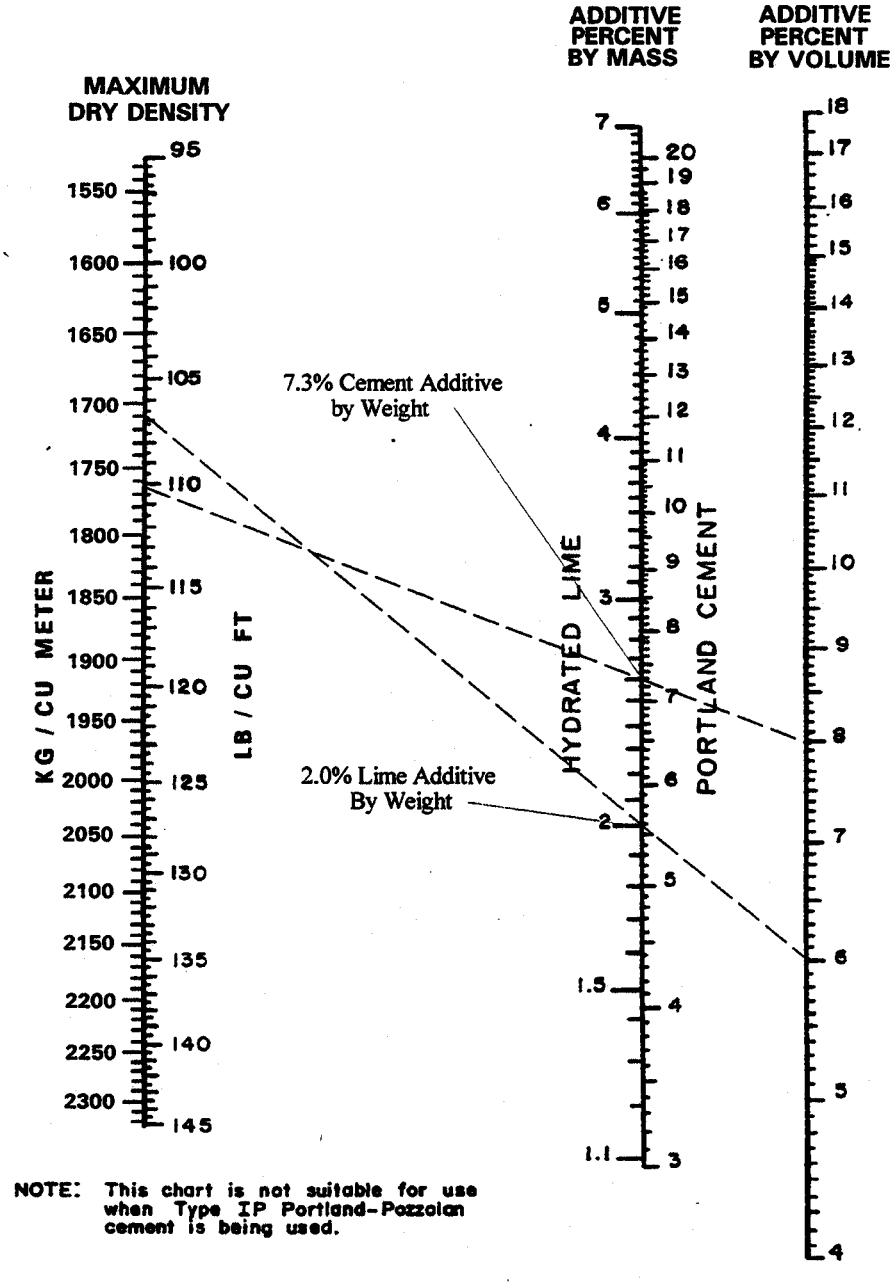
*MAX. DRY DENSITY OF MATL. (FROM TR 418, METHOD H), kg/m³	A		1765
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-B, ___ TR 416, ___ specified)	B		8
*% MASS OF ADDITIVE (___ chart, ___ formula)	C		7.3
DRY MASS OF MATERIAL (Representative portion), g	D		7000
*MASS OF ADDITIVE TO BE ADDED, g	E	(C x D) ÷ 100	511
*TOTAL DRY MASS OF MATERIAL AND ADDITIVE, g	F	D + E	7511

* *FOR USE WITH DOTD TR 418, METHOD I ONLY.*

CURVE POINT NO.	***		1	2	3	4	5	6
WATER ADDED, mL	G	See Calculations	551	701	851	1001	1151	
MASS MOLD, BASE (if appl.) & WET MATL.,g	H		11567	11825	11998	12079	12066	
MASS MOLD & BASE (if applicable), g	I		6387	6387	6387	6387	6387	
MASS WET COMPACTED MATERIAL, g	J	H - I	5180	5438	5611	5692	5679	
VOLUME OF MOLD (or specimen), m³	K		0.002832					
MASS OF PAN & DRY MATERIAL, g	L		7407	7484	7670	7321	7430	
MASS OF PAN, g	M		2617	2549	2635	2313	2508	
MASS OF DRY MATERIAL, g	DW	L - M	4790	4935	5035	5008	4922	
MASS OF WATER, g	WW	J - DW	390	503	576	684	757	
WET MASS DENSITY, kg/m³	WWD	$\frac{J}{1000\ K}$	1829	1920	1981	2010	2005	
MOISTURE CONTENT, %	MC	(WW/DW)x100	8.1	10.2	11.4	13.7	15.4	
DRY MASS DENSITY, kg/m³	DWD	$\frac{WWD}{100 + MC} \times 100$	1692	1742	1778	1768	1737	

REMARKS: 0 → mass

Laboratory Moisture - Density Relationship Worksheet (03-22-4198)
Figure I-1 (Metric)



ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY MASS OF OVEN-DRY SOIL, SOIL-AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure I-2 (Metric)

DOTD 03-22-4165
Metric / English
Rev. 3/98

LAB COMPACTION REPORT - DOTD TR 418 METHOD I

Project No. 999-99-0099 Station S. No. 7 Lab No. 22-999999

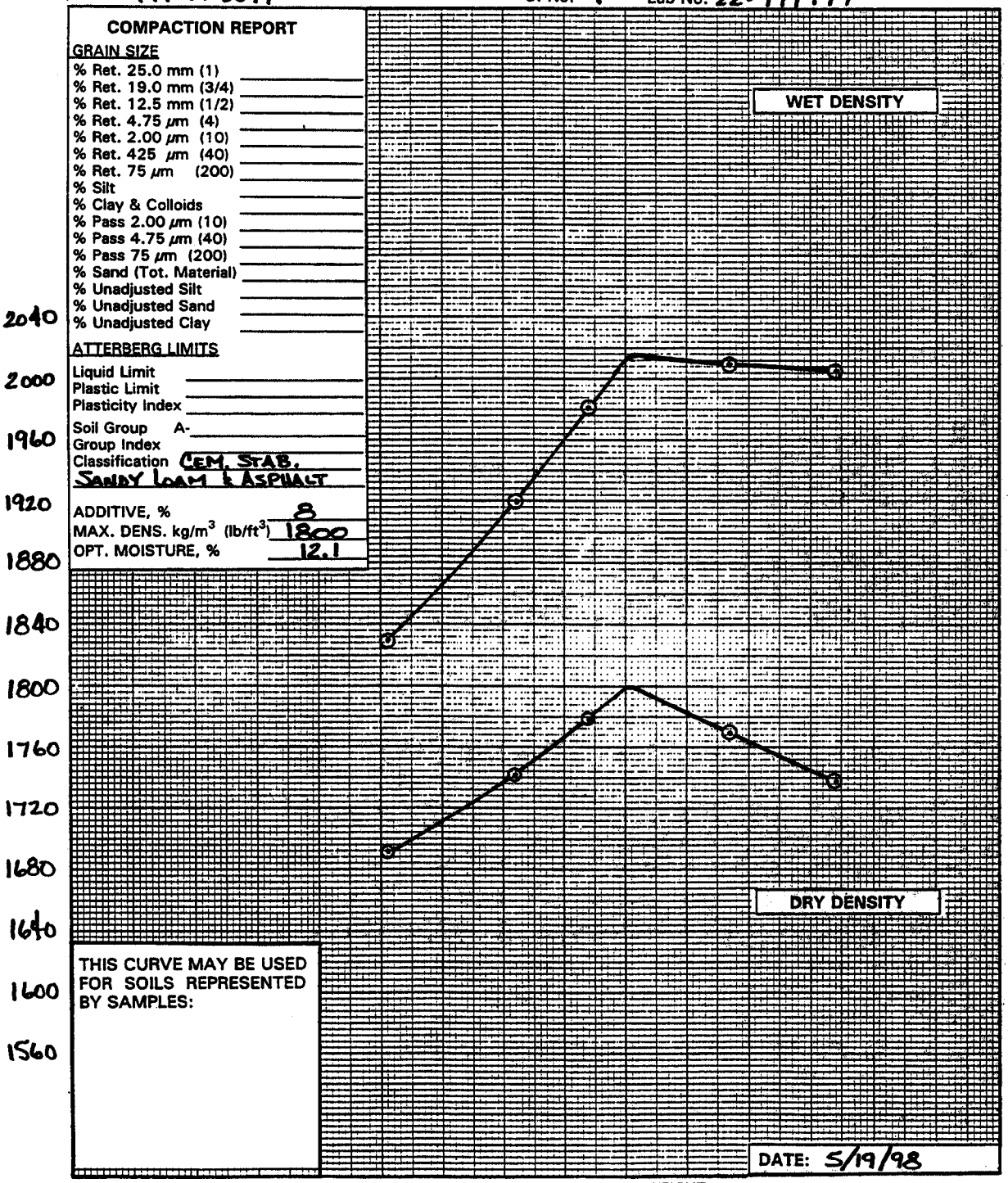
COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 μm (4)	
% Ret. 2.00 μm (10)	
% Ret. 425 μm (40)	
% Ret. 75 μm (200)	
% Silt	
% Clay & Colloids	
% Pass 2.00 μm (10)	
% Pass 4.75 μm (40)	
% Pass 75 μm (200)	
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	
Plastic Limit	
Plasticity Index	
Soil Group A-	
Group Index	
Classification	CEM. STAB. SANDY LOAM & ASPHALT
ADDITIVE, %	8
MAX. DENS. kg/m³ (lb/ft³)	1800
OPT. MOISTURE, %	12.1



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

Laboratory Compaction Report (03-22-4165)
Figure I-3 (Metric)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 9991-919-010919 | Material Code 418 | Lab No. 22-19191919
Date Sampled 011-0161-1917 | Submitted By 01610H | Quantity 1010101
Purp Code 7 | Source Code | Spec Code 1 | P.O. No.
Date Tested 011-1113-1917 | Ident S1-71 | Plant Code | Frict.Rating (1-4)
Item No. | Date Rec'd (lab) | Sampled By: B.W.
Remarks 1

Tested By G.C. | Date 1/13/97 | Checked By B.W. | Date 1/14/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2	10.00	0	0	100
9.5	3/8				
4.75	No. 4	379.70	33.0	33.0	67
Mass Matl.in Pan		771.80	67.03		
Acc. Total		1150.50			
Initial Dry Total Mass				% Diff:	

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10	119.70	13.2	46.2	54
1.18	16				
600	30				
425	40	247.10	18.1	64.3	36
300	50				
180	80				
150	100				
75	200	241.70	16.5	80.8	19
53	270				
Mass Matl.in Pan		218.80			
Decant Loss					
Acc. Total		100.30			
Initial Dry Total Mass		1010.40		% Diff: 0.10	
Dry Mass After Wash					

Remarks 2:

DOTD TR 428

Liquid Limit 23 | Plastic Limit 12

No. of Blows		Mass Cup + Wet Soil,g	
Mass Cup + Wet Soil,g		Mass Cup + Dry Soil,g	
Mass Cup + Dry Soil,g		Mass Water	
Mass Water		Cup No.	
Factor		Mass Cup, g	
Cup No.		Mass Dry Soil	
Mass Cup, g		% Moisture	
Mass Dry Soil			
% Moisture		Plasticity Index	11

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content, % (TR 418)	12.1
Maximum Density (TR 418) kg/m³ (lb/ft³)	1810
Lab Comp Method (TR 418)	E
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part, % (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: | Date:

Aggregate Test Report (03-22-0745)
Figure I-4 (Metric)