SOIL FIELD SPECIAL INSPECTOR PRACTICAL EXAM

NOVEMBER 2021

WACEL SOIL FIELD SPECIAL INSPECTOR PRACTICAL EVALUATION
(REVISIONS, NOVEMBER 2021)

INSTRUCTIONS

On the following pages are the proficiency checklists that will be used by the WACEL Practical Examiner to record the candidate technicians' skills in the processing and testing of soil in the field using identified test procedures. Candidate technicians are strongly encouraged to use these checklists to properly prepare for formal evaluations. All of the included test procedures are incorporated. There is, however, one option for the technician being evaluated. **Technicians being evaluated need to only accomplish one of the non-nuclear-gauge density methods (i.e., either sand cone or drive cylinder).**

Following the checklists, are WACEL data gathering worksheets that can be used by the candidate technicians during the performance evaluation. On prior approval of the practical evaluator, similar worksheets prepared by the technician's employer can be authorized for use.

The checklist for the one-point proctor test merits some explanation.

a. There is no ASTM method to be used in conducting this test. There is an AASHTO test method, AASHTO T272, but its data curves are confusing to use. WACEL elected to use the Virginia Test Method-12, VTM-12, for instructional purposes.

b. VTM-12 is simpler to use, is more straightforward in its approach, and includes a simple monograph for density corrections if the oversize component is based on a No. 4 sieve. Density/moisture content curves are also based on the wet density of the sample, which makes this procedure more adaptable for field use. A copy of VTM-12 is attached.

c. Users should be aware that many state DOTs have different adaptation of AASHTO T272 to include slightly different procedures and different moisture/density curves.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

Name (Technician): ______________________________ Date(s): ______________

Office / Location: ______________________________ Final Rating (P or F): __________

Name of Examiner: ______________________________

Instructions: An approved WACEL Practical Examiner shall observe the testing technician perform the following tests. Rate the performance appropriately and score the overall performance as either pass or fail. A failure of any individual test will result as a failure of the practical exam. The examiner shall sign as witnessing each individual test method and shall sign the final page. Completed forms must be returned to WACEL.

ASTM D4959-16 Water (Moisture) Content of Soil by Direct Heating	**Pass**	**Fail**	**N/A**
1. Sample protected from moisture loss (sealed container, shielded from direct sunlight).			
2. Determine and record the mass of a clean, dry container to 0.1 g.			
3. Sample size conforms to the following: Nom./Max. Size (Largest sieve retaining >10%) — Minimum Mass of Moist Specimen No. 10 — 200-300 g No. 4 — 300-500 g 3/4" — 500-1000 g			
4. Representative portion of the sample placed into the container and the mass of the soil and container immediately determined and recorded.			
5. Heat applied to container, stirring frequently to minimize localized overheating.			
6. Continue heating until sample appears dry.			
7. Container removed from heat and allowed to cool until it can be safely handled.			
8. Determine and record the new mass of the container and sample.			
9. Container and sample returned to heat source and stirred.			
10. Care taken when stirring, and in general when handling the container, not to lose any material.			
11. Container removed from heat and allowed to cool until it can be handled.			
12. Determine and record the mass of the container and sample.			
13. Heating and weighing process repeated until constant mass (0.1% or less change) achieved.			
14. Moisture content calculated. $w = (mass_{water} / mass_{dry\ solids}) \times 100$ $= [(M_1-M_2)/(M_2-M_c)]\times 100$ $= M_w/M_s \times 100$ Where: w = water content in % M_1 = mass of container and wet specimen, g M_2 = mass of container and dry specimen, g M_c = mass of container, g M_s = mass of solid particles, g M_w = mass of water, g.			
Signature of examiner observing and overall results:			

See optional data sheet for recording information

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
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One-Point Proctor VTM-12 (Using T99 and T272)	**Pass**	**Fail**	**N/A**
1. Sample collected and weighed.			
2. Material sieved over #4 sieve.			
3. The +#4 material collected from sieve and weighed.			
4. Use -#4 material as is or dry to 4% less than assumed OMC.			
5. Compact -#4 material in 4" mold in 3 equal lifts and using 25 blows/layer.			
6. Remove Collar. Excess material should be observed.			
7. Excess screeded off using a straight edge.			
8. Mold cleaned, weighed, and wet density determined. D_w = net weight of soil / calibrated volume of mold (approximately 0.0333 ft^3)			
9. Soil removed from mold and split vertically through the center.			
10. 300-500 g of material removed from cut face(s).			
11. Moisture content of this sample determined in accordance with either D4959 or D4944.			
12. Plot the 1-point data for the -#4 material on the family of curves. (Family of curves and nomograph attached.)			
13. Closest curve selected and the MDD and OMC looked up in table.			
IF THERE IS > 10% OVERSIZE MATERIAL (+#4), CONTINUE TO GET CORRECTED VALUE. OTHERWISE STOP HERE. (Only continue with #14-20 if an oversize correction is necessary.)			
14. Using nomograph, line drawn from D_d to 2.65 (or actual SG if known) on Specific Gravity axis.			
15. Line 3/(1 + 2.0/100) (2.0% is assumed $\mathcal{W}$ of oversize)			
16. Dry weight of all -#4 material calculated. Dry Weight of -#4 = (*Line 1 – Line 3*) / (1+ <u>*Line 11*</u>) 100 note: write MC% from *Line 11* as decimal			
17. Calculate % of +#4 material. % +#4 *Line 15 / (Line 15 + Line 16)*			
18. % +#4 material marked at top of nomograph and line drawn down to intersection of previous line.			
19. At the point of intersection, line drawn horizontally back to the density axis and the corrected density determined.			
20. Corrected OMC calculated. $OMC_{corrected}$ = (% -#4 x MC of -#4) + (% +#4 x 2%) Where %+#4 and %-#4 are written as decimals and the MCs% are written as whole numbers. 2.0% $\mathcal{W}$ for coarse fraction assumed.			
Signature of examiner observing and overall results :			

See optional data sheet for recording information

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

ASTM D1556-15e1 Density and Unit Weight of Soil in Place by Sand Cone	Pass	Fail	N/A
1. The technician understands that the sand must be "calibrated" (bulk-density) and that the volume of funnel and base plate (or mass of sand required to fill the funnel) must be known/determined.			
2. Apparatus in working condition and is a set.			
3. Flat and level testing surface prepared.			
4. Outline of base plate marked (or secured, if necessary) to prevent movement.			
5. Depth of hole approximately the same depth as the lift(s) being tested.			
6. Hole dug ensuring that:			
• Sides of hole slope slightly inward.			
• Bottom is reasonably flat or concave.			
• The hole is free of pockets, overhangs, and protrusions.			
• Care is taken to avoid the loss of material.			
• Material is protected to prevent loss of moisture until water content sample is taken.			
7. Any material cleaned from flange of base plate.			
8. Mass of apparatus (sand, jar, & funnel) determined.			
9. Sand Cone inverted and funnel placed in base plate, in same position as calibration (marks matched).			
10. Vibration from personnel and equipment avoided (or minimized).			
11. Valve opened until sand ceases to flow.			
12. Valve closed and mass of apparatus (remaining sand, jar, & funnel) determined.			
13. If oversized material is encountered, mass of oversized material determined and corrected for.			
14. Determine mass of moist material removed from hole.			
15. Material thoroughly mixed and representative moisture content specimen taken (if not entire sample).			
16. Moisture content determined (preferably by D4959).			
17. Proper calculations:			

$$V = (M_1 - M_2) / \rho_1$$

Where:

V = Volume

M_1 = Mass of sand to fill test hole, funnel, & plate

M_2 = Mass of sand to fill funnel & plate

ρ_1 = Bulk-density of sand

$$\rho_m = M_3 / V$$

Where:

ρ_m = Wet density

M_3 = Mass of moist material from hole

V = Volume

$$\rho_d = \rho_m / (1 + w/100) \quad \text{or} \quad M_4 = 100\, M_3 / (w + 100)$$

Where:

ρ_d = Dry density

w = Moisture content as decimal

Where:

M_4 = mass of dry material

Signature of examiner observing and overall results:			

See optional data sheet for recording information

Only this density-determining procedure or the drive-cylinder method, D2937, needs to be accomplished.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

ASTM D2937-17, Density of Soil in Place by the Drive-Cylinder Method	Pass	Fail	N/A
1. The technician understand that the use of this test method is limited to certain soil types and with the bulk of the material having particle sizes less than 3/16 inch (4.75mm).			
2. Apparatus is in working condition and appears acceptable.			
3. Weight the cylinder and record its calibrated volume.			
4. Brush all loose particles from surface prepared by a shovel or auger for near surface sampling.			
5. Drive cylinder until it is approximately ½ inch (13mm) below the original ground surface.			
6. Remove the drive head and extract the cylinder using a shovel.			
7. Trim the ends of the sample flush ends of the cylinder.			
8. Discard the sample if incomplete, contains foreign material, or cylinder is deformed.			
9. Calculate the wet density ($\boldsymbol{\rho}_{wet}$) of the soil in the cylinder. $\boldsymbol{\rho}_{wet} = (M_1 - M_2)/V$ Where: M_1 = Mass of cylinder and wet soil sample, g; M_2 = Mass of cylinder, g; V = Volume of cylinder, cm^3			
10. Obtain a representative soil sample (not less than 100g) and compute water content (w) by an approved ASTM method.			
11. Calculate in-place dry density ($\boldsymbol{\rho}_d$) of the sample in g/cm^3 $(\boldsymbol{\rho}_d) = \dfrac{\boldsymbol{\rho}_{wet}}{(1 + (w/100)}$			
Signature of examiner observing and results:			

Only this density-determining procedure or the sand cone method, D1556, needs to be accomplished.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

ASTM D6938-17a Nuclear Density Gauge (Direct Transmission)	**Pass**	**Fail**	**N/A**
1. Gauge standardized at start of day's use.			
2. Testing location selected and surface prepared.			
3. Surface allows total contact with bottom of gauge, voids filled as necessary (no void > 1/8").			
4. Hole-forming device driven through guide to a depth at least 2" deeper than the testing depth.			
5. Hole-forming device removed and corners of guide marked.			
6. Any necessary repairs made to surface.			
7. Gauge carefully aligned on surface, placing the source rod over the hole (aligned from scoring marks).			
8. Source rod inserted into the hole to the testing depth.			
9. Gauge seated firmly by rotating back and forth.			
10. Gauge gently pulled such that the source rod is in contact with the side of the hole nearest detectors.			
11. Perform and record at least one reading for the normal measurement period.			
Signature of examiner observing and overall results:			

Overall Performance Evaluation

☐ **Pass** ☐ **Requires Retest**

I attest that the tests results reported above are accurate and testing was conducted and proctored in accordance with WACEL requirements.

____
PRINTED NAME OF WACEL EXAMINER

____
SIGNATURE

____
DATE

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

Field Moisture of Soil by Direct Heat
(ASTM D4959)

Date: ____________________ Technician: ___________________

DATA FORM FOR MOISTURE CONTENT OF SOIL

TEST NUMBER:		**1**	**2**	**3**
1.	Weight of container and wet soil, g			
2.	Weight of dry soil and container, g			
3.	Weight of water, g (1-2)			
4.	Weight of container, g			
5.	Weight of dry soil, g (2-4)			
6.	Percent moisture (3/5) x 100			

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(VTM-12/AASHTO T272)
(REVISED NOVEMBER 2021)

ONE-POINT PROCTOR WORK SHEET

Technician: ______________________________

Date:

Sample No:			
Description / USCS:			
Sample Location:			
I. Gravel(+4)Material % Determination			
a. Wt. of Total Sample + Container (lbs)			
b. Wt. of Container (lbs)			
c. Net Wt. of Total Sample (a-b) (lbs)			
d. Wt. of Gravel (+4) Material + Container (lbs)			
e. Wt. of Container (lbs)			
f. Net Wt. of Gravel (+4) Material (d-e) (lbs)			
g. % Gravel (+4) (f/c x 100)			
II. Moisture Content Determination			
h. Wt. of Wet Soil + Container g			
i. Wt. of Dry Soil + Container g			
j. Wt. of Container g			
k. Net Wt. of Dry Soil (i-j) g			
l. Wt. of Moisture (h-i) g			
m. % Moisture Content of Soil (m/l x 100)			
III. Proctor Determination			
n. Wt. of Wet Soil + Mold (lbs)			
o. Wt. of Mold (lbs)			
p. Net wt. of Wet Soil (o-p) (lbs)			
q. Wet Density (p x 30) (lb/ft^3)			
r. Moisture Content of Soil (%) (n)			
s. Max. Dry Density fr. Family of Curves (lb/ft^3)			
t. Opt. Moisture Content (%) fr. Family of Curves (%)			
IV. +4 Correction			
u. % Gravel (+4) (g)			
v. Corrected Max. Dry Density (lb/ft^3)			
w. Corrected Opt. Moist. Content (%)			

Note 1: The “30” in line q represents the nominal volume of the mold, 1/30th of a cubic foot.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

FIELD DENSITY TEST
(SAND CONE) (ASTM D1556)

Date: ___________________ Tech. ___________________________

TEST NUMBER:	**1**	**2**	**3**	**4**
TEST LOCATION:				
DEPTH BELOW GRADE OR ELEVATION:				
WET DENSITY:				
(A) Sand Density (lb/ft^3 or g/cm^3) (provided)				
(B) Wt. of Sand in Funnel and base plate (separate procedure or provided)				
(C) Wt. of Sand + Apparatus (before)				
(D) Wt. of Pan/Container				
(E) Wt. of Sand + Apparatus (after)				
(F) Wt. of Sand in Hole + Funnel **(C-E)**				
(G) Wt. of Sand in Hole **(F-B)**				
(H) Volume of Hole (G/A) (nearest 0.0001 ft^3)				
(I) Wt. of Pan/Container + Wet Soil				
(J) Wt. of Wet Soil **(I-D)**				
(K) Wet Density (ft^3) **(J/H)**				
MOISTURE CONTENT:				
(L) Wt. of Container + Wet Soil (note 1)				
(M) Wt. of Container + Dry Soil				
(N) Wt. of Water **(L-M)**				
(O) Wt. of Container				
(P) Wt. of Dry Soil **(M-O)**				
(Q) Percent (%) Moisture **(N/P X100)** (note 2)				
DRY DENSITY:				
(R) Dry Density (lb/ft^3) **K/(1+Q/100)** (closest 0.1 lb/ft^3)				
LABORATORY DATA:				
(S) Corrected Proctor Maximum Dry Density				
(T) Corrected Optimum Moisture Content				
RESULTS:				
(U) Percent (%) Compaction (R**/S)** X 100				

Note 1: Minimum of 200-300 g of moist soils.
Note 2: Take jar sample for lab analysis if required by project manager.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED NOVEMBER 2021)

DRIVE CYLINDER WORKSHEET (ASTM D2937)

Date: ___________________ Tech. ___________________________

TEST NUMBER:	**1**	**2**	**3**
a. Elevation / Depth			
b. “Calibrated” Volume of Drive Cylinder (DC), cm^3			
c. Weight of Wet Soil and DC, g			
d. Weight of Drive Cylinder, g			
e. Weight of Wet Soil, g (c-d)			
f. Water Content of Soil, $\mathcal{W}$% (other method)			
g. Wet Density of Soil, $\boldsymbol{\rho}_{wet}$, g/cmM^3 (e/b)			
h. Dry Density of Soil, g/cm^3 g $\boldsymbol{\rho}_{dry} = \boldsymbol{\rho}_{wet} / (1 + (w/100))$			

<u>Virginia Test Method – 12**</u>**

Use of One-Point Proctor Density – (Soils Lab)

March 4, 2019

AASHTO T 272 (Method A of T 99) shall be followed, except as modified below:

5. <u>Apparatus</u>

Add the following to Section 4.1:

a. "Speedy" moisture tester (AASHTO T 217) or drying apparatus (ASTM D4959).

7. <u>Procedure</u>

7.1 The representative sample must fall within the minimum and maximum curve range shown on Figure 1. If the point plotted within or on the family of curves (Figure 1) does not fall within the minimum and maximum curve range, compact another specimen, using the same material, at an adjusted moisture content that will place the one-point within this range. The maximum density determination will be more accurate the closer the moisture content is to the optimum moisture content.

7.4 Take a sample for moisture content determination by "Speedy" moisture tester in accordance with AASHTO T 217, or the manufacturer's directions labeled on the instrument. Moisture content can be also determined using a hot plate, gas stove, or burner in accordance with ASTM D4959 if "Speedy" tester is not available. Record the moisture content.

7.5 Delete.

8. <u>Maximum Density and Optimum Moisture Content Determination</u>

8.1 Delete.

8.2 Delete.

8.3 Family of Curves:

8.3.1 Results for wet density of the soil in pounds per cubic foot and moisture content shall be plotted on Typical Moisture Density Curves Set "C" (Figure 1).

8.3.2 Plot the wet density and moisture content results above on Figure 1. If this point falls on one of the curves, go to the upper right hand corner of the graph and use the Maximum Dry Density and Optimum Moisture Content that correspond to that curve.

8.3.3 When this point falls within the family but not directly on a curve, use the nearest existing curve in the family of curves.

8.3.4 When oversized particles have been removed, it is necessary to use the following procedures from VTM-1 to determine the corrected Maximum Dry Density and Optimum Moisture Content.

A. Correction for +No. 4 (4.75 mm) in the sample, if there is 10% or greater material retained on the No. 4 (4.75 mm) sieve.

The correction to be used for the +No. 4 (4.75 mm) material is determined by the following procedures:

(1) Record the percent of +No. 4 (4.75 mm) material from density hole.

(2) The theoretical maximum density, "D" of mixtures containing coarse aggregate larger than a No. 4 (4.75 mm) sieve will be determined by the formula:

Where:

$$D = \frac{D_f \, x Dc}{Pc\, D_f + P_f\, Dc}$$

D_f = Maximum dry laboratory density of minus No. 4 (4.75 mm)material (by AASHTO Designation: T 99), in lb/ft^3 (kg/m^3)

Dc = Maximum density of Plus No. 4 material {62.4 lb/ft^3 (1000 kg/m^3) x bulk specific gravity by AASHTO Designation: T85 or as estimated by the engineer} in lb/ft^3 (kg/m^3).

Pc = Percent plus No. 4 (4.75 mm) material, expressed as a decimal, and

P_f = Percent minus No. 4 (4.75 mm) material, expressed as a decimal.

(3) The optimum moisture content for the total soil will be determined by the formula:

Where:

$$W_t = (P_c\, W_c + P_f\, W_f)\ 100$$

W_t = Optimum moisture content for total soil,

Wc = Optimum moisture content, expressed as a decimal, for material retained on No. 4 sieve (4.75 mm) (estimated between 1% and 3%),

W_f = Optimum moisture content, expressed as a decimal, for material passing No. 4 (4.75 mm) sieve.

Pc = Percent, expressed as a decimal, of material retained on a No. 4 (4.75 mm) sieve, and

P_f = Percent, expressed as a decimal, of material passing a No. 4 (4.75 mm) sieve.

Alternatively, the corrected maximum dry density can be determined herein with the aid of the nomograph (Figure 2).

B. Percent Compaction

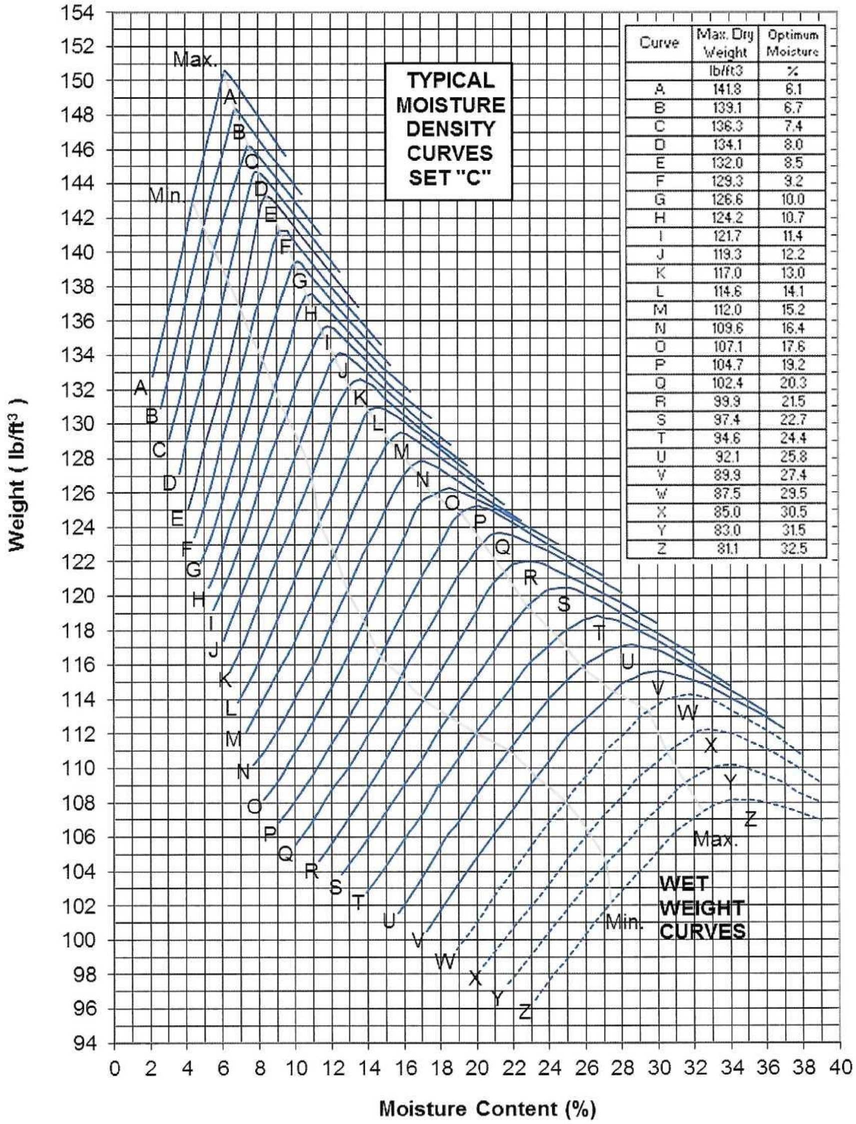
$$\text{Percent Compaction} = \frac{\text{Field Dry Density}}{\text{Maximum Dry Density}} \times 100$$

General Notes:

1 The density required in the work will be a variable percentage of the theoretical maximum density, "D", depending upon variations in the percentage of plus No. 4 (4.75 mm) material in the mixture and upon the position of the material in the work, and will be specified in the applicable section of the specifications.
2 The specific gravity of +4 material can be found in soil survey reports and contractor borrow material submittals for soils and Approved List No. 5 (http://www.virginiadot.org/business/resources/Materials/Approved_Lists.pdf) for aggregates. If this information is not available, the specific gravity can be assumed as directed by the District Material Engineer.

8.3.5 Perform a full moisture/density relationship if the one-point determination does not fall within the family of curves or cannot meet the minimum and maximum curve range.

ONE-POINT PROCTOR

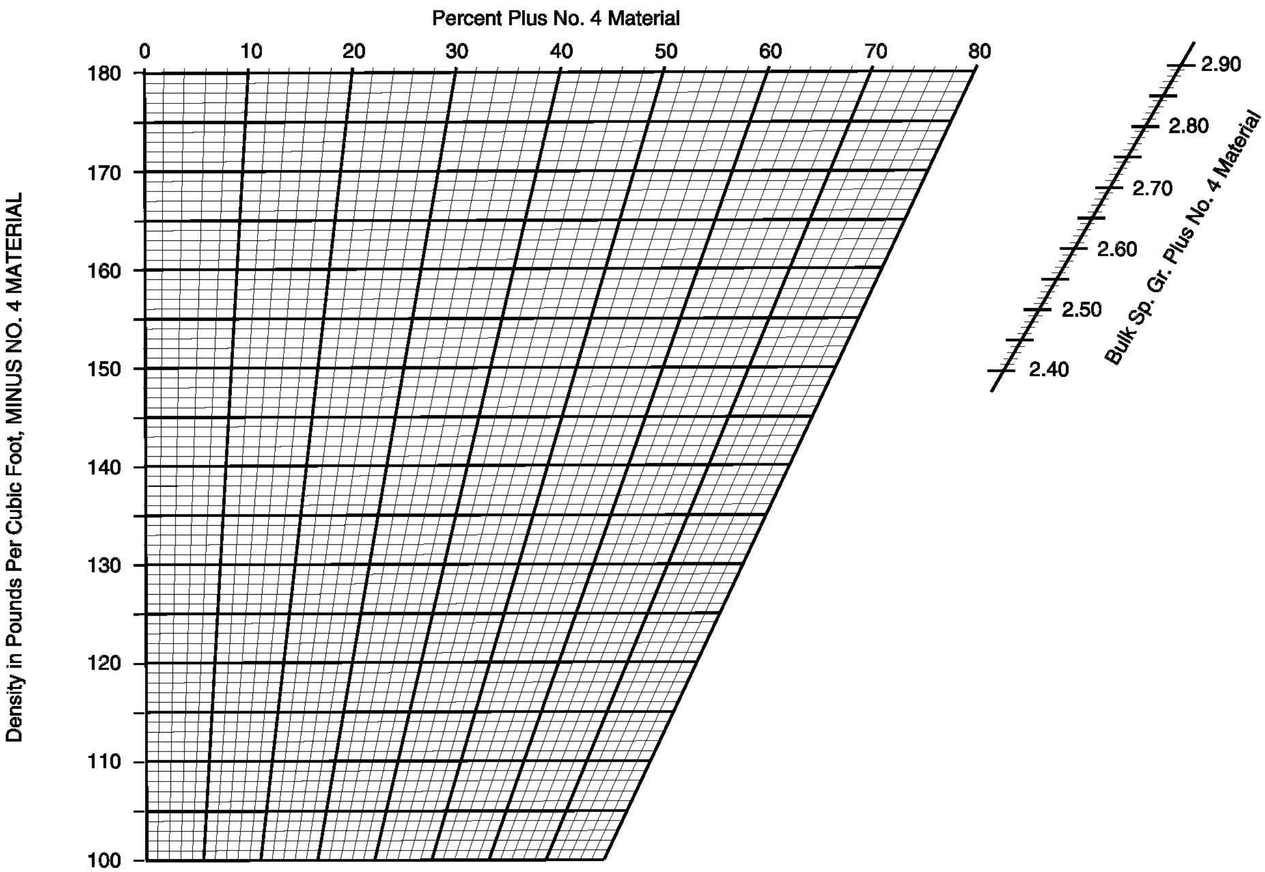


Curve	Max. Dry Weight	Optimum Moisture
	lb/ft3	%
A	141.8	6.1
B	139.1	6.7
C	136.3	7.4
D	134.1	8.0
E	132.0	8.5
F	129.3	9.2
G	126.6	10.0
H	124.2	10.7
I	121.7	11.4
J	119.3	12.2
K	117.0	13.0
L	114.6	14.1
M	112.0	15.2
N	109.6	16.4
O	107.1	17.6
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

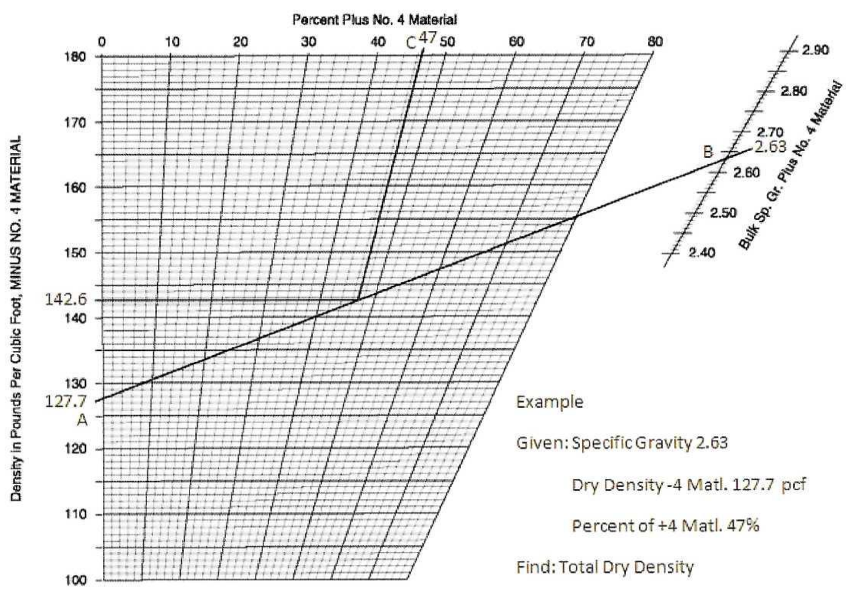
Figure 1

NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS

VTM-1



NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS



Example

Given: Specific Gravity 2.63

Dry Density -4 Matl. 127.7 pcf

Percent of +4 Matl. 47%

Find: Total Dry Density

1. Plot A, B and C
2. Using a straight edge draw a line from A to B
3. From C draw a line at the same slant as the nomograph lines to intersect line AB
4. Draw a straight line from the point of intersection to the left edge of the nomograph
5. Total Dry Density = 142.6 pcf

Figure 2b