MOISTURE - DENSITY RELATIONSHIP USING TYPICAL MOISTURE - DENSITY CURVES (ONE POINT PROCTOR) METHOD A

(An Arizona Method)

SCOPE

1. (a) This method of test is for the determination of the optimum moisture content and maximum dry density of a soil or soil-aggregate mixture utilizing one moisture-density determination on the portion of the sample passing the No. 4 sieve. Some materials may be more appropriately tested by Arizona Test Method 246, “Moisture-Density Relationship using Typical Moisture-Density Curves (One Point Proctor) Alternate Method D”.

(b) The one-point proctor is used with the typical moisture-density curves, shown on the back of the One Point Proctor Density Test Card (Figures 1 and 2); or by utilizing a family of moisture-density curves developed for the immediate local conditions.

(c) This method is not to be used for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the absorption of the coarse aggregate is greater than 4.0%.

(d) This method may be used to determine if an existing proctor maximum density determination is valid for the soil being tested. If the existing proctor maximum density determination is not valid, a full proctor according to Arizona 225 should normally be run to determine the maximum density required for that soil type.

(e) An example is provided in Section 7, and Figures 3 and 4, for the calculations and determinations referenced herein.

(f) This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

APPARATUS

2. The apparatus shall consist of the following:

(a) The general apparatus utilized for this test method shall conform to the apparatus requirements of Arizona Test Method 225.

(b) In place of the oven listed in the general apparatus, a hot plate or stove capable of maintaining a temperature of approximately 230° F. may be used. A Speedy Moisture Tester with a conversion table or calibration curve may also be used for moisture determinations made in the field. Finally, a microwave oven may be used in accordance with Arizona Test Method 719.

(c) Instead of the scale or balance capable of measuring the weight to be determined to at least one gram, a scale capable of measuring the weight to at least 0.01 pound may be utilized.

CALIBRATION OF MOLD

3. Molds shall be calibrated in accordance with APPENDIX A of ARIZ 225.

SAMPLE

4. A representative sample of passing No. 4 material weighing approximately 2500 grams shall be obtained for each one-point proctor.

PROCEDURE

5. (a) The approximate 2500 gram sample of passing No. 4 material shall be thoroughly mixed with sufficient water to bring the sample to slightly less than its optimum moisture content.

(b) Form a specimen by compacting the prepared soil in the four inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

NOTE: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

(c) When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom of the mold with waterproofing grease. All excess grease shall be wiped from the mold and base plate.

(d) Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, “WD”, of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb)*}}$$

Where:

WD	=	Wet density of compacted soil, Ib./cu. ft.
Ml	=	Weight of compacted specimen and mold, grams or lbs.
M2	=	Weight of the mold, grams or lbs.
VM	=	Volume of the mold, cu. ft. (See Section 3 of this procedure).

* If the weights of the compacted specimen and mold, Ml, and the empty mold, M2, are measured in pounds, eliminate 453.6 (grams/lb.) from the denominator of the above equation.

(e) Remove the material from the mold and slice vertically through the center. Take a representative minimum 300 gram sample from the full length and width of one of the cut faces. Record the weight of wet soil to the nearest 0.1 gram as “WW”. Dry the sample to constant weight at approximately 230° F. and record weight of dry soil to the nearest 0.1 gram as “DW”. The percent moisture shall be recorded to the nearest 0.1 percent. The equation below is used when the percent moisture is determined by drying the sample. For testing performed in the field, the Speedy Moisture Tester (AASHTO T 217), may be used. For the Speedy Moisture Tester, a representative

sample of the pass No. 4 material shall be utilized and tested in accordance with the instructional manual for that apparatus.

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

MAXIMUM DENSITY DETERMINATION

6. (a) The point representing the wet density and moisture content (dry basis) is then plotted on the Typical Moisture-Density Curves (Figure 2) and the maximum wet density and optimum moisture content determined. When this plotted point falls between two moisture-density curves, a minor interpolation is necessary. The maximum dry density in lb/cu. ft. and the corresponding percent optimum moisture is then read directly or interpolated from the chart. The family of typical moisture-density curves provided should be periodically verified for the local conditions. If it is ascertained that the family of curves provided by Figure 2 is of questionable reliability for given local conditions, then an independent family of curves should be established and used.

(b) The plotted point for wet density and moisture content should be on the dry side of the curve at or near optimum, as it is difficult to interpolate between curves for friable soils when on the wet side of the peak.

(c) If the plotted point representing the wet density and moisture content of the compacted material is on the right of the peak, the test should be repeated using a lower moisture content. An exception to this rule must be made for those soils having high clay contents and relatively flat curves. These soils cannot readily be dried to optimum in the field due to the creation of a cloddy condition which will cause voids in the proctor. Proctors for these materials should be made as near to optimum as possible.

EXAMPLE

7. An illustration of determining the maximum dry density and optimum moisture content is described below, and shown in Figures 3 and 4:

For:

Wet Density	= 120.0 lb./cu. ft.
Moisture Content	= 20.0%

By plotting this point on the Typical Moisture-Density Curves and interpolating, it shows a point which is approximately 60 percent of the distance from Curve Q to Curve R. From the chart, the dry density for Curve Q is 102.4 @ 20.3% moisture and Curve R is 99.9 @ 21.5% moisture.

By interpolation:

Density: 102.4 - 99.9 = 2.5
.60 X 2.5 = 1 .5 lb./cu. ft. difference

Moisture: 21 .5 - 20.3 = 1 .2
.60 X 1.2 = 0.7% difference

Therefore:

Maximum dry density = 102.4 - 1.5
= 100.9 lb./cu. ft.

Optimum Moisture = 20.3 + 0.7 = 21.0%

* As an alternate to performing the interpolation procedure, Table 1 below can be used to determine the maximum dry density and optimum moisture content when the plotted point falls between two moisture-density curves.

NOTE: The optimum moisture and maximum dry density determinations above are for the material passing the No. 4 sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains.

REPORT

8. Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required.

A	**141.8**	**6.6**	**F**	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**
10%	141.5	6.7	**10%**	128.7	9.8	**10%**	116.8	13.6	**10%**	104.5	19.3	**10%**	91.9	26.0
20%	141.3	6.7	**20%**	128.2	9.9	**20%**	116.5	13.7	**20%**	104.2	19.4	**20%**	91.7	26.1
30%	141.0	6.8	**30%**	127.6	9.9	**30%**	116.3	13.8	**30%**	104.0	19.5	**30%**	91.4	26.3
40%	140.7	6.8	**40%**	127.0	10.0	**40%**	116.0	13.9	**40%**	103.8	19.6	**40%**	91.2	26.4
50%	140.5	6.9	**50%**	126.5	10.1	**50%**	115.8	14.1	**50%**	103.6	19.8	**50%**	91.0	26.6
60%	140.2	7.0	**60%**	125.9	10.2	**60%**	115.6	14.2	**60%**	103.3	19.9	**60%**	90.8	26.8
70%	139.9	7.0	**70%**	125.3	10.3	**70%**	115.3	14.3	**70%**	103.1	20.0	**70%**	90.6	26.9
80%	139.6	7.1	**80%**	124.7	10.3	**80%**	115.1	14.4	**80%**	102.9	20.1	**80%**	90.3	27.1
90%	139.4	7.1	**90%**	124.2	10.4	**90%**	114.8	14.5	**90%**	102.6	20.2	**90%**	90.1	27.2
B	**139.1**	**7.2**	**G**	**123.6**	**10.5**	**L**	**114.6**	**14.6**	**Q**	**102.4**	**20.3**	**V**	**89.9**	**27.4**
10%	138.8	7.3	**10%**	123.7	10.6	**10%**	114.3	14.7	**10%**	102.2	20.4	**10%**	89.7	27.6
20%	138.5	7.3	**20%**	123.7	10.6	**20%**	114.1	14.8	**20%**	101.9	20.5	**20%**	89.4	27.8
30%	138.3	7.4	**30%**	123.8	10.7	**30%**	113.8	15.0	**30%**	101.7	20.7	**30%**	89.2	28.0
40%	138.0	7.5	**40%**	123.8	10.8	**40%**	113.6	15.1	**40%**	101.4	20.8	**40%**	88.9	28.2
50%	137.7	7.6	**50%**	123.9	10.9	**50%**	113.3	15.2	**50%**	101.2	20.9	**50%**	88.7	28.5
60%	137.4	7.6	**60%**	124.0	10.9	**60%**	113.0	15.3	**60%**	100.9	21.0	**60%**	88.5	28.7
70%	137.1	7.7	**70%**	124.0	11.0	**70%**	112.8	15.4	**70%**	100.7	21.1	**70%**	88.2	28.9
80%	136.9	7.8	**80%**	124.1	11.1	**80%**	112.5	15.6	**80%**	100.4	21.3	**80%**	88.0	29.1
90%	136.6	7.8	**90%**	124.1	11.1	**90%**	112.3	15.7	**90%**	100.2	21.4	**90%**	87.7	29.3
C	**136.3**	**7.9**	**H**	**124.2**	**11.2**	**M**	**112.0**	**15.8**	**R**	**99.9**	**21.5**	**W**	**87.5**	**29.5**
10%	136.1	8.0	**10%**	124.0	11.3	**10%**	111.8	15.9	**10%**	99.7	21.6	**10%**	87.3	29.6
20%	135.9	8.0	**20%**	123.7	11.3	**20%**	111.5	16.0	**20%**	99.4	21.7	**20%**	87.0	29.7
30%	135.6	8.1	**30%**	123.5	11.4	**30%**	111.3	16.1	**30%**	99.2	21.9	**30%**	86.8	29.8
40%	135.4	8.1	**40%**	123.2	11.5	**40%**	111.0	16.2	**40%**	98.9	22.0	**40%**	86.5	29.9
50%	135.2	8.2	**50%**	123.0	11.6	**50%**	110.8	16.4	**50%**	98.7	22.1	**50%**	86.3	30.0
60%	135.0	8.3	**60%**	122.7	11.6	**60%**	110.6	16.5	**60%**	98.4	22.2	**60%**	86.0	30.1
70%	134.8	8.3	**70%**	122.5	11.7	**70%**	110.3	16.6	**70%**	98.2	22.3	**70%**	85.8	30.2
80%	134.5	8.4	**80%**	122.2	11.8	**80%**	110.1	16.7	**80%**	97.9	22.5	**80%**	85.5	30.3
90%	134.3	8.4	**90%**	122.0	11.8	**90%**	109.8	16.8	**90%**	97.7	22.6	**90%**	85.3	30.4
D	**134.1**	**8.5**	**I**	**121.7**	**11.9**	**N**	**109.6**	**16.9**	**S**	**97.4**	**22.7**	**X**	**85.0**	**30.5**
10%	133.9	8.6	**10%**	121.5	12.0	**10%**	109.4	17.0	**10%**	97.1	22.9	**10%**	84.8	30.6
20%	133.7	8.6	**20%**	121.2	12.1	**20%**	109.1	17.1	**20%**	96.8	23.0	**20%**	84.6	30.7
30%	133.5	8.7	**30%**	121.0	12.1	**30%**	108.9	17.3	**30%**	96.6	23.2	**30%**	84.4	30.8
40%	133.3	8.7	**40%**	120.7	12.2	**40%**	108.6	17.4	**40%**	96.3	23.4	**40%**	84.2	30.9
50%	133.1	8.8	**50%**	120.5	12.3	**50%**	108.4	17.5	**50%**	96.0	23.6	**50%**	84.0	31.0
60%	132.8	8.8	**60%**	120.3	12.4	**60%**	108.1	17.6	**60%**	95.7	23.7	**60%**	83.8	31.1
70%	132.6	8.9	**70%**	120.0	12.5	**70%**	107.9	17.7	**70%**	95.4	23.9	**70%**	83.6	31.2
80%	132.4	8.9	**80%**	119.8	12.5	**80%**	107.6	17.9	**80%**	95.2	24.1	**80%**	83.4	31.3
90%	132.2	9.0	**90%**	119.5	12.6	**90%**	107.4	18.0	**90%**	94.9	24.2	**90%**	83.2	31.4
E	**132.0**	**9.0**	**J**	**119.3**	**12.7**	**O**	**107.1**	**18.1**	**T**	**94.6**	**24.4**	**Y**	**83.0**	**31.5**
10%	131.7	9.1	**10%**	119.1	12.8	**10%**	106.9	18.2	**10%**	94.4	24.5	**10%**	82.8	31.6
20%	131.5	9.1	**20%**	118.8	12.9	**20%**	106.6	18.3	**20%**	94.1	24.7	**20%**	82.6	31.7
30%	131.2	9.2	**30%**	118.6	12.9	**30%**	106.4	18.4	**30%**	93.9	24.8	**30%**	82.4	31.8
40%	130.9	9.3	**40%**	118.4	13.0	**40%**	106.1	18.5	**40%**	93.6	25.0	**40%**	82.2	31.9
50%	130.7	9.4	**50%**	118.2	13.1	**50%**	105.9	18.7	**50%**	93.4	25.1	**50%**	82.1	32.0
60%	130.4	9.4	**60%**	117.9	13.2	**60%**	105.7	18.8	**60%**	93.1	25.2	**60%**	81.9	32.1
70%	130.1	9.5	**70%**	117.7	13.3	**70%**	105.4	18.9	**70%**	92.9	25.4	**70%**	81.7	32.2
80%	129.8	9.6	**80%**	117.5	13.3	**80%**	105.2	19.0	**80%**	92.6	25.5	**80%**	81.5	32.3
90%	129.6	9.6	**90%**	117.2	13.4	**90%**	104.9	19.1	**90%**	92.4	25.7	**90%**	81.3	32.4
F	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**	**Z**	**81.1**	**32.5**

TABLE 1

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = _____ Cu. ft.
Weight of Mold = M2 = _____ grams _____ pounds
Weight of Sample and Mold = M1 = _____ grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6\ (\text{grams/lb.})^*} = _____\ \text{lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\%\ \text{Moisture} = \frac{WW - DW}{DW} \times 100 = _____\ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

% Moisture in Pass No. 4 material from Speedie = W = _____ %

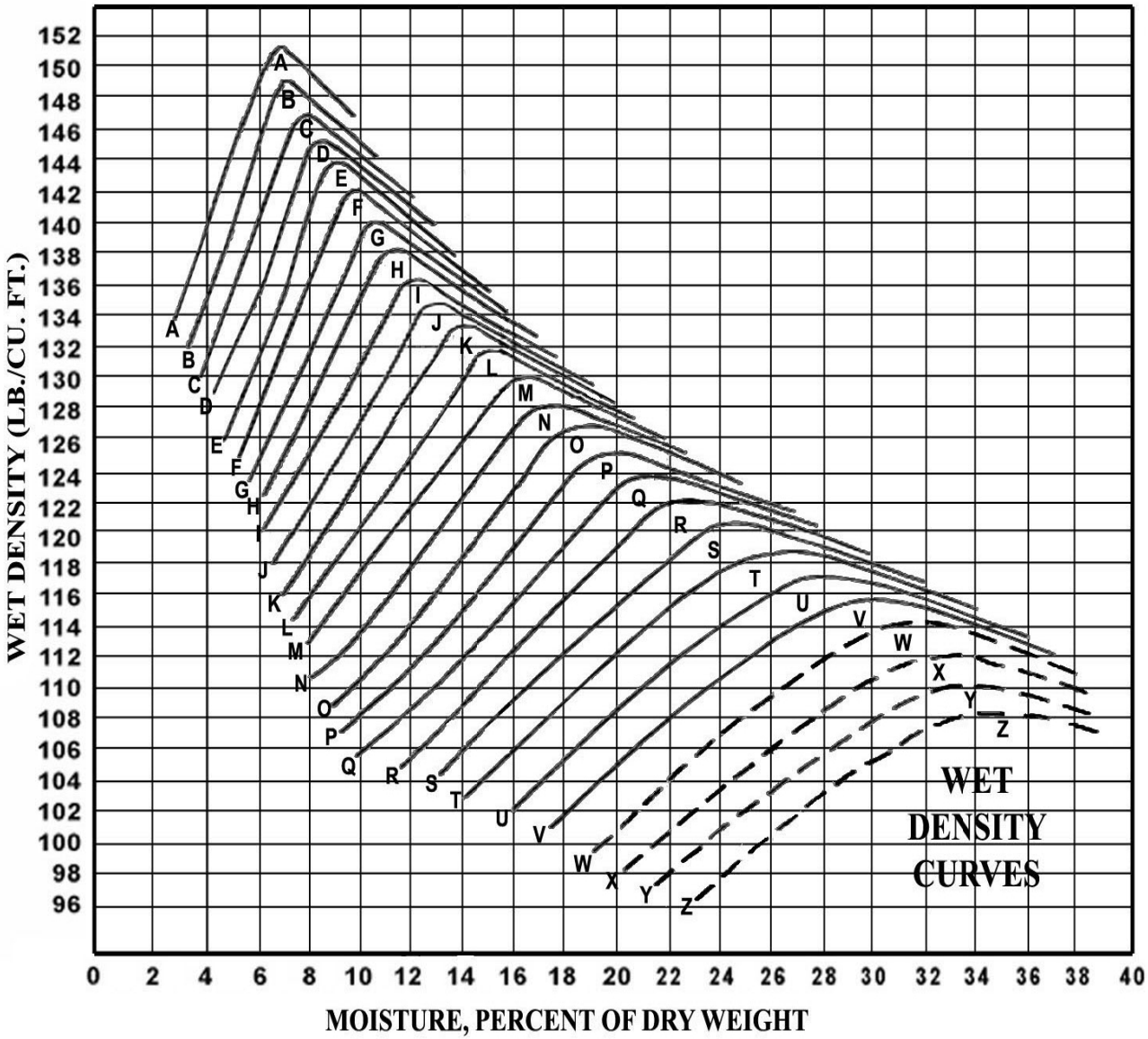
$$\text{Total \% Moisture} = TW = \frac{W(l00 — PR4) + PR4}{100} = _____\ \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = _____ lb./cu. ft.
Percent Optimum Moisture = OM = _____ %

REMARKS: _____

FIGURE 1

TYPICAL MOISTURE-DENSITY CURVES



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
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 2

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ **X** _____ Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = **0.0335** Cu. ft.
Weight of Mold = M2 = _____ grams **10.23** pounds
Weight of Sample and Mold = M1 = _____ grams **14.25** pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6\ (\text{grams/lb.})^*} = \mathbf{120.0}\ \text{lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = **340.4** grams
Dry Weight of Moisture Sample = DW = **283.7** grams

$$\%\ \text{Moisture} = \frac{WW - DW}{DW} \times 100 = \mathbf{20.0}\ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

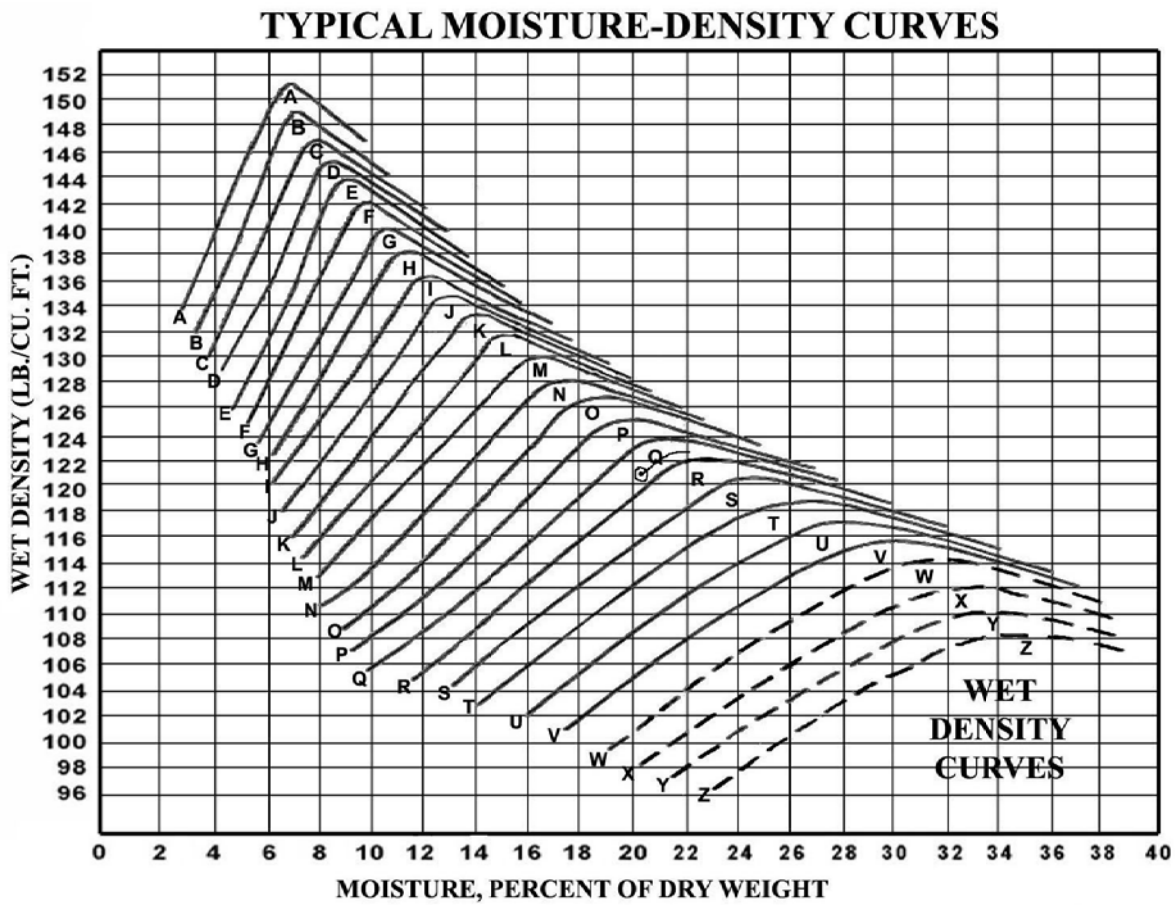
% Moisture in Pass No. 4 material from Speedie = W = _____ %

$$\text{Total \% Moisture} = TW = \frac{W(l00 — PR4) + PR4}{100} = _____\ \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = **100.9** lb./cu. ft.
Percent Optimum Moisture = OM = **21.0** %

REMARKS: _____

FIGURE 3



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
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

Approx. 60% Below Curve Q

Interpolated Max. Dry Density: 102.4 (Curve Q)
- 99.9 (Curve R)
2.5 X 0.60 = 1.5 lb./cu. ft. *102.4 - 1.5 = 100.9 lb. / cu. ft.*

Interpolated % Optimum Moisture: 21.5 (Curve R)
- 20.3 (Curve Q)
1.2 X 0.60 = 0.7% *20.3 + 0.7 = 21.0%*

FIGURE 4