One Point of Curve Method for Determining Moisture-Density Values

The purpose of the "One Point Family of Curves Method" is to quickly determine the optimum moisture and maximum density values for a specific earth fill test sample. The method is particularly useful when borrow areas contain materials of varying weight and texture, as is often the case in an alluvium flood plain from which earthen dams are frequently built.

The method has been used in state highway and SCS construction for several years at locations in several states and found to be reasonably accurate in predicting the optimum moisture-maximum density values that would be obtained by completing the compaction test curve as described for Method A compaction in ASTM Designation D-698. The method may also be useful for Methods B, C, and D described in the ASTM; however, because of little use of these methods in the contract specifications, there is limited test data available.

The method is outlined in six steps as follows: (1) construction of a family of curves, (2) making a one-point compaction test specimen from soil material representing the test sample, (3) plotting the one point moisture-density values on the family of curves constructed in Step (1), above, (4) drawing a new compaction curve through the one point plotted in Step (3) above, (5) locating the optimum moisture-maximum density point determined by the newly drawn curve, and (6) recording the optimum moisture-maximum density values representing the specific soil material.

Caution: This method should not be used for compaction control of earth fill materials with large variations of specific gravity such as may be present.

1. Construction of a Family of Curves

A family of curves is developed from compaction test data compiled on soil samples tested in accordance with the procedure as set forth in ASTM Designation D-698.

The compaction test curve data used to develop a family of curves should be from tests made on soil materials taken from the specific construction site, and from other compaction test curves available from nearby sites with similar soils.

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It is suggested that the family of curves be developed on 8" x 10 1/2" sheets of cross section paper with a scale of 5 percent moisture to the inch on the abscissa and 5 pounds per cubic foot to the inch on the ordinate.

The first step in developing the family of curves is to plot the optimum moisture-maximum density values available from each of the compacation test curves on the cross section paper. The points will fall into a slightly scattered pattern covering the range of soils represented. A smooth curve is then drawn through these points which will represent the average optimum moisture-maximum density values of the soils tested. This smooth curve forms a reference line and is the base line from which the family of curves is developed. Soils represented by optimum moisture and maximum density that fall more than two moisture percentage points away from the reference line should be identified for testing based on the ASTM D-698 information of the same material.

All compaction test curves used in plotting the points above, except those identified for special testing and handling, are then plotted to scale on the reference line. The plotting is accomplished by first shifting the moisture values of each compaction test curve either to the right or to the left by an amount and direction required to shift the maximum density value from its plotted position to the newly established reference line for the family of curves. These curves when plotted in this shifted position on the reference line will serve to guide the shape of the family of curves to be drawn.

A new set of curves originating from arbitrarily selected points along the reference line will be the family of curves. It is suggested that the family of curves be developed with one curve at each two-pound maximum density interval beginning at selected points on the reference line. Each curve of the family of curves is then drawn as guided by the compaction test data curves previously plotted. Care should be taken to evenly space each curve in relation to adjacent curves of the family and to prevent overlapping, even though the compaction test data curves may overlap at their extremeties. All curves of the family of curves are not likely to assume the same shape; therefore, they should be drawn with an even transition as well as kept evenly spaced. The family of curves consists of these newly drawn curves and the reference line. It can be lifted from the work sheet used in developing it to a new sheet of cross section paper for field use.

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The family of curves is a working tool to be used with a plotted point representing a specific soil sample as determined by the moisture-density values of a one-point compaction test (ASTM D-698). A compaction curve representing the specific soil sample is drawn through the one point and completed as guided by the family of curves. The optimum moisture and maximum density values of the soil sample are determined at the reference line. Plot the zero air void line using the high average specific gravity of the materials.

2. Making One Point Compaction Test Specimen

The one-point compaction test specimen shall be made in accordance with the procedure described in ASTM D-698. It shall be made from a part of the earth fill test sample or from the same soil mixture taken from the side of the test hole. It is important that the soil moisture of the material used for the one point compaction test specimen be adjusted to optimum, or a few (1-2) percentage points below optimum, as experience has shown that points in this range can be projected on the family of curves with the most reliable accuracy.

3. & 4. Plotting the One Point and Drawing the New Curve

The one point compaction test identifies one point on a standard compaction curve in accordance with ASTM D-698. When the one point is plotted on the family of curves, it will identify the location of a new curve representing the material sample. The new curve is then drawn through this point and shaped to conform to the adjacent curves of the family.

5. Locating the Optimum Moisture-Density Point

The optimum moisture-maximum density values for specific soil sample is determined by reading the values directly from the family of curves at the peak point of the newly drawn curve which is the point of intersection of the newly drawn curve and the reference line.

6. Recording the Optimum Moisture-Maximum Density Values

The optimum moisture-maximum density values are then recorded for use in determining moisture and density values required for a specific soil sample tested.

(EFM Notice IN-50, April 1988)

Example No. 1

a. Embankment M&D test results
   1. Dry Density = 108.7 #/cu. ft.
   2. Percent moisture = 18.2%

b. Using sample of same material as embankment M&D test make one point
   Proctor test by ASTM D-698.
   1. Find dry density = 110.6 #/cu. ft.
   2. Percent moisture = 16.1%

c. Plot on curve and project to locus line using same shape curve projection as shown by family of curves
   read - maximum dry density 110.7 #/cu. ft.
   read - optimum moisture 16.5%

d. Compute % compaction using

$$\frac{\text{Dry Density Step (a) } 108.7}{\text{Maximum Dry Density Step (c) } 110.7} = 98\%$$

e. Moisture is 1.7% above optimum found in Step C.

Example No. 2

a. Embankment M&D test results
   1. Dry Density - 107.1 #/cu. ft.
   2. Percent Moisture = 18.5%

b. Using sample of same material as Embankment M&D test make one point
   Proctor test by ASTM D-698.
   1. Find dry density = 110.1 #/cu. ft.
   2. Percent Moisture = 18.1%

c. Plot on curve. (Example 2a). This is on the right side of locus line and should not be used. Use field judgment of speedy moisture test to arrive at a moisture content of the sample about 2 or 3 percent less than original sample. Then repeat Step b at the new moisture content.
   1. Dry Density = 112.3 #/cu. ft.
   2. Percent Moisture = 15.1%

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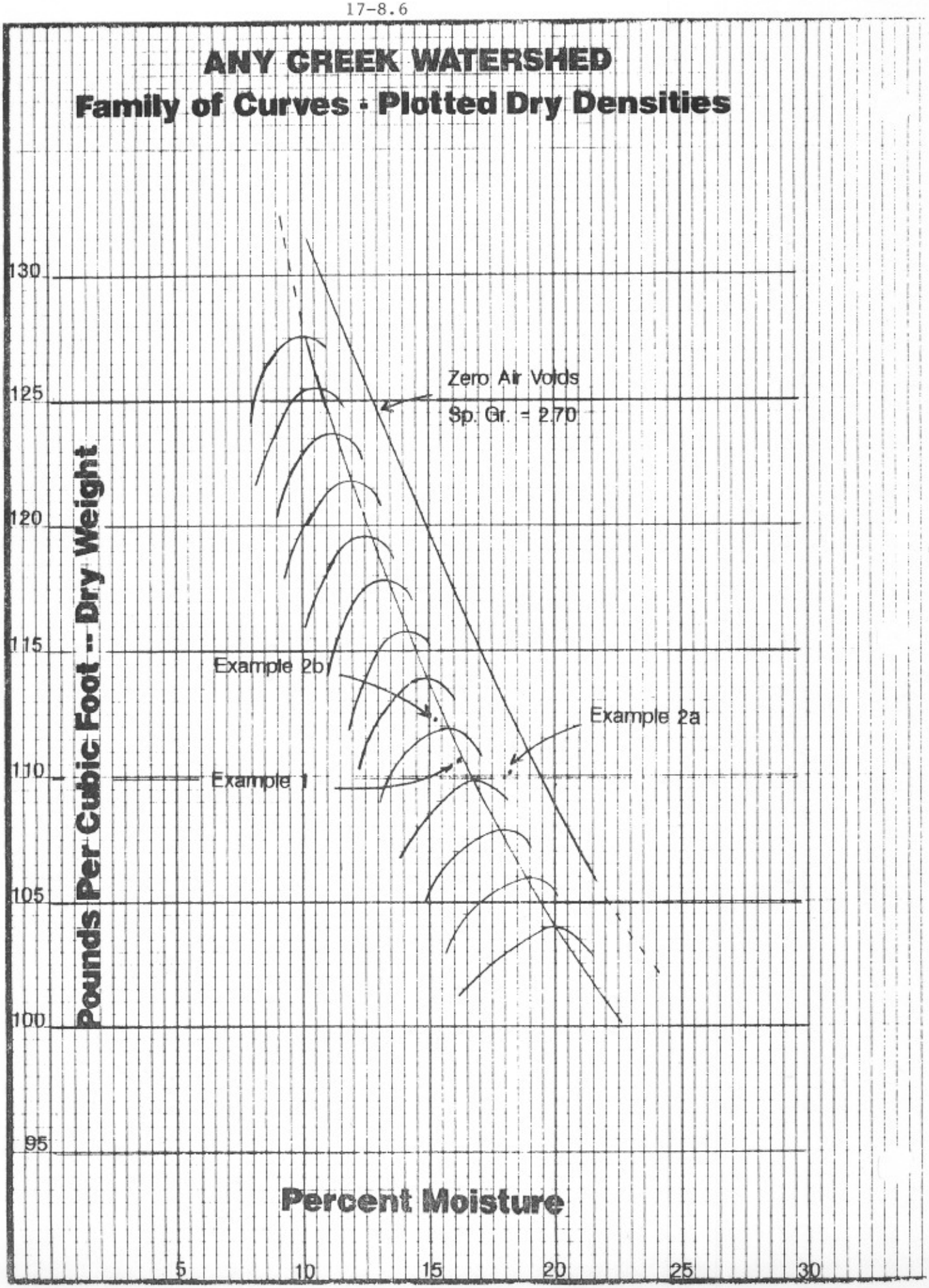
d. Plot on curve and project to locus line and read as follows:
(Example 2b)
1. Maximum dry density 112.6 #/cu. ft.
2. Percent Moisture = 15.7%

e. Compute % compaction using

$$\frac{\text{Dry Density (field) Step (a) } 109.6}{\text{Maximum Dry Density Step (c) } 112.6} = 95\%$$

f. Moisture is 2.8% above optimum.


ANY CREEK WATERSHED
Family of Curves - Plotted Dry Densities
Pounds Per Cubic Foot -- Dry Weight
130
125
120
115
110
105
100
95
Zero Air Voids
Sp. Gr. = 2.70
Example 2b
Example 2a
Example 1
Percent Moisture
5
10
15
20
25
30