METHOD OF SAMPLING AND TESTING
MT 229-24
PROCEDURE FOR SOLIDS - WATER - VOIDS RELATIONS OF SOIL MASSES (ZERO-AIR VOIDS)

1 Scope

1.1 This method covers the compaction of soils by using the solids-water-voids (zero-air voids) chart. This method usually applies to the north central, eastern and southeastern areas of Montana but may apply to other areas of the state. It will be the responsibility of the District Materials Supervisor to monitor the applicability of this method.

2 Referenced Documents

AASHTO
T 100 Specific Gravity of Soils

MT Materials Manual
MT 210 Moisture Density Relations of Soils Using a 5.5 Lb. Rammer and a 12 Inch Drop
MT 230 Moisture Density Relations of Soils Using a 10 Lb. Rammer and a 18 Inch Drop

3 Procedure

3.1 Air voids are another method used to determine the compaction of soils. The zero-air voids method will usually apply to soils classified from A-4 to A-7. When the zero-air voids method is not applicable, the 95% of maximum density and ±2% of optimum moisture will be used.

3.2 In order for this method to be accurate, it is necessary to find the specific gravity for the soils proposed for use. The most logical time to determine the specific gravity is during the pre-construction soil survey. However, due to the excavation process, which may result in a mixture of various soil strata, it may become necessary to perform additional specific gravity tests once the project is under contract. The specific gravity of soils is determined in accordance with AASHTO T 100. (An average specific gravity is determined for the soil samples secured within any individual project.)

3.3 Individual proctor tests determined during the pre-construction soil survey are plotted on the zero-air voids chart. If the plot of the peaks from the family of proctor curves from the preliminary soil survey falls on a line roughly parallel to the zero-air voids, the zero-air voids method should work. Tests that fall to the left of the 10% air voids line are generally single size granular particle soils or excessively wet condition type soils. With these soils, the 95% of maximum density and ±2% of optimum moisture will be used.

3.4 Tests taken in the field that lie outside, or to the right of the 0% air voids line, not within the band, should be reviewed and treated as a failing test or possibly a bad reading by the density gauge. However, it is unusual to get tests that fall to the right of the 0% line. If tests consistently fall to the right of the 0% line, a specific gravity on the soil in question should be determined in accordance with AASHTO T100. Special Provision covers Proctor tests that plot outside the zero-air voids chart under compaction control. All proctor tests must be plotted on a zero-air voids chart to see if each test fits the zero-air voids chart.

4 Calculations

4.1 Formula for calculating % voids:

$$V = 100 - \left(\left[\frac{d\left(1 + \left[G_s\left({}^{m}/_{100}\right)\right]\right)}{(G_s)(W)}\right] \times 100\right)$$

where:

US Standard

V = % Voids (report to nearest 0.1%)

d = Dry Density in lb/ft³ (report to nearest 0.1 lb/ft3)

Gs = Specific Gravity

m = % moisture (report to nearest 0.1%)

W = wt of water in lb/ft³ or 62.42796

Metric

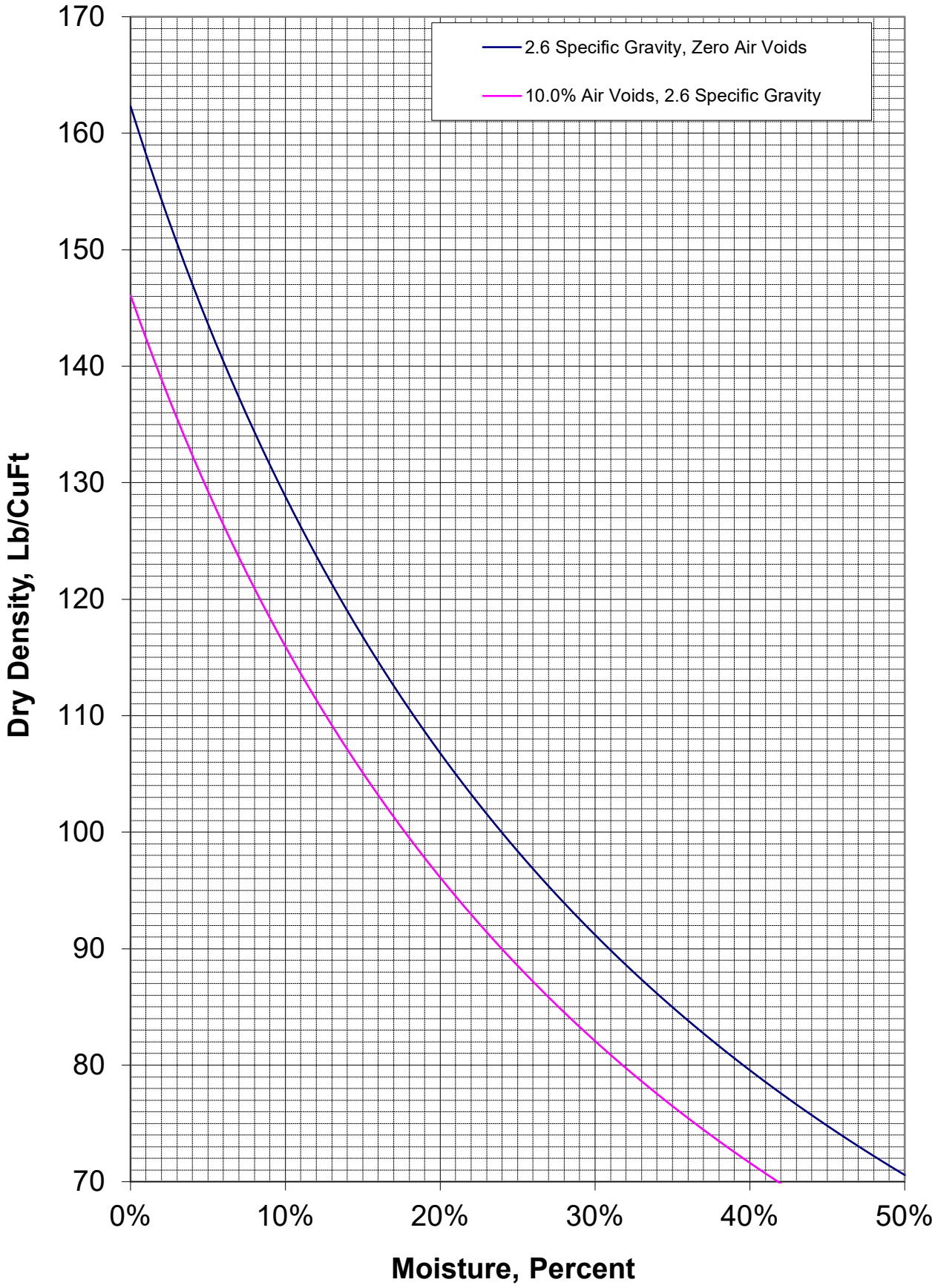
V = % Voids (report to nearest 0.1%)

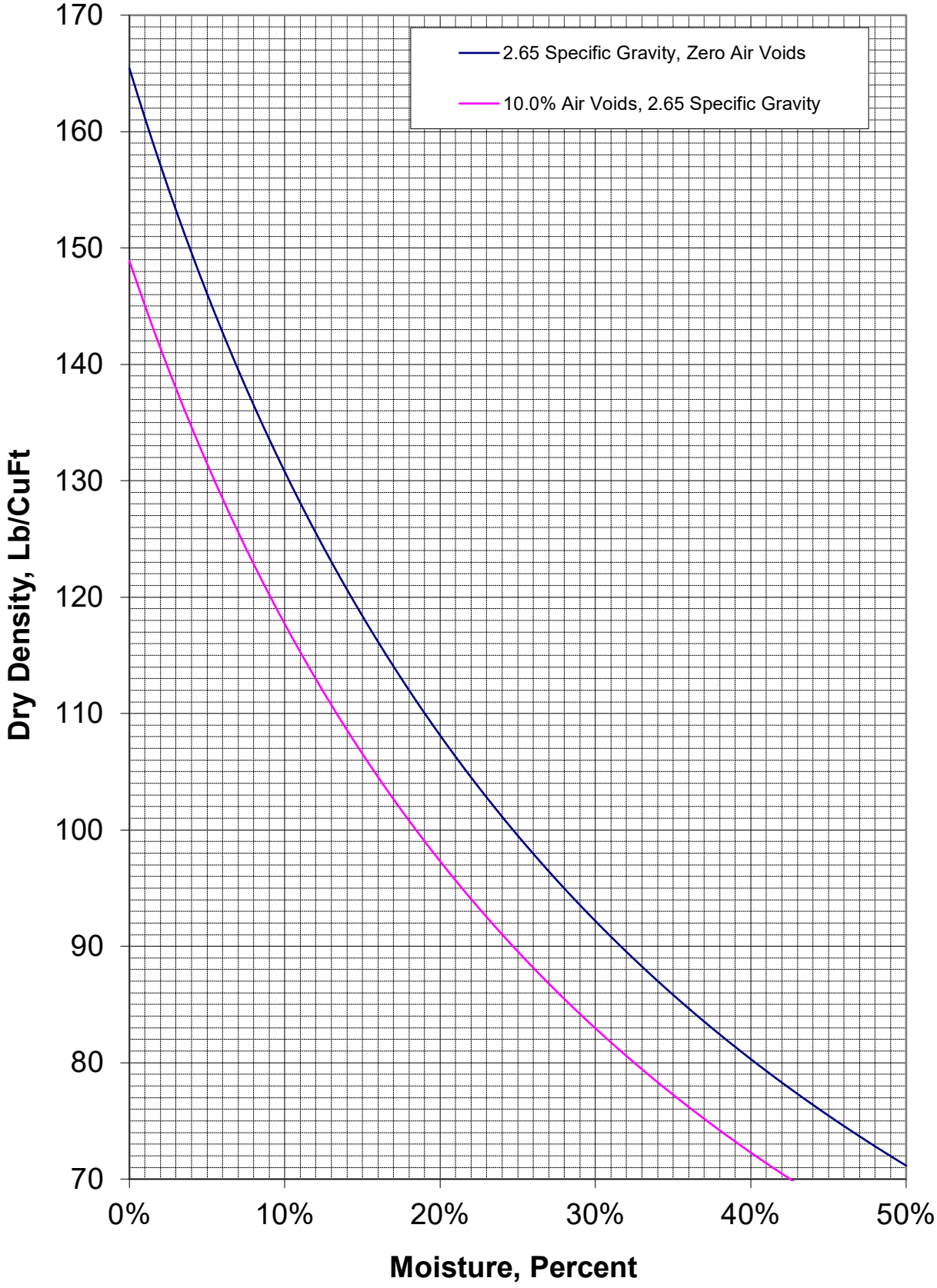
d = Dry Density in Kg/m³ (report to nearest 0.1 Kg/m3)

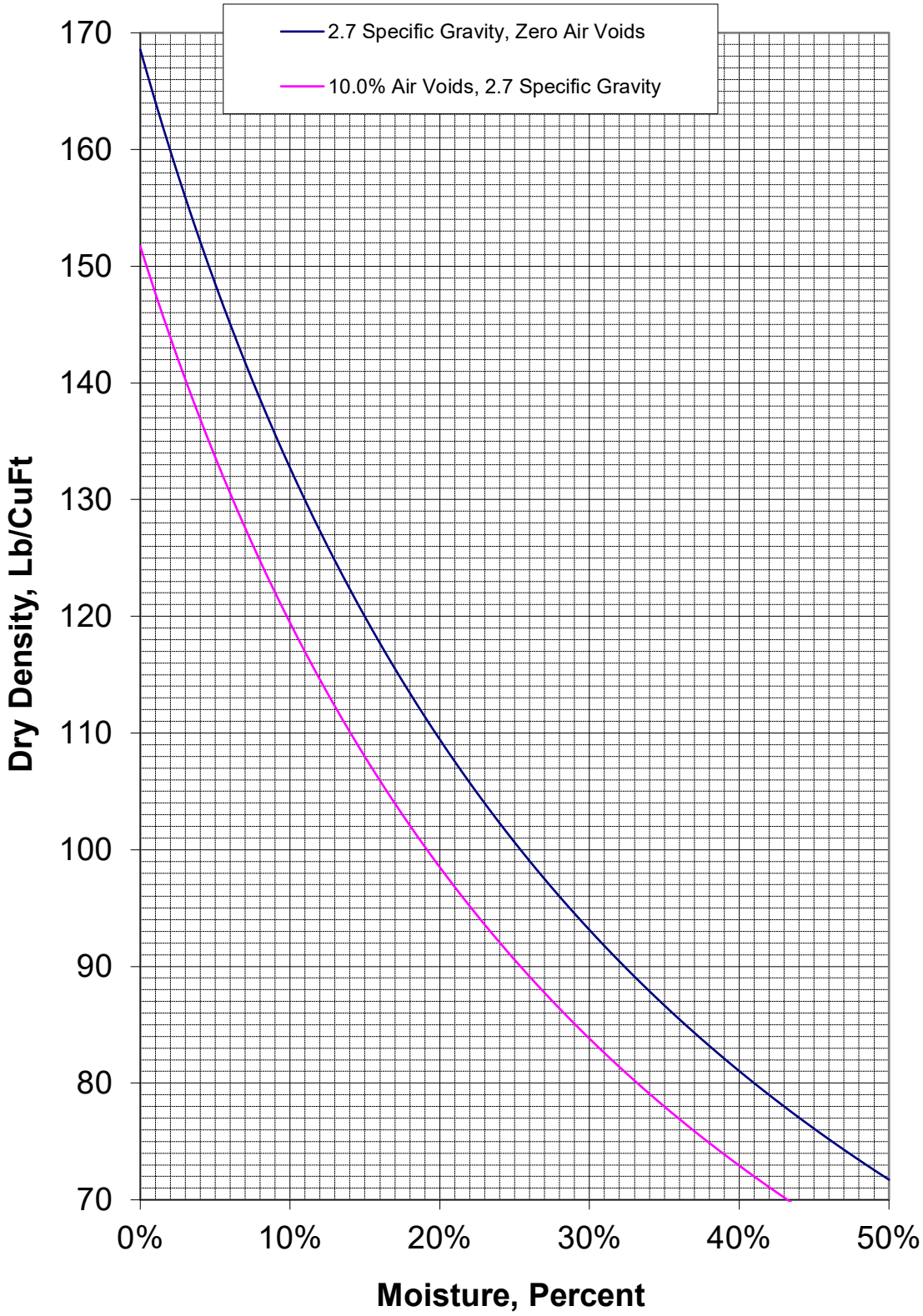
Gs = Specific Gravity

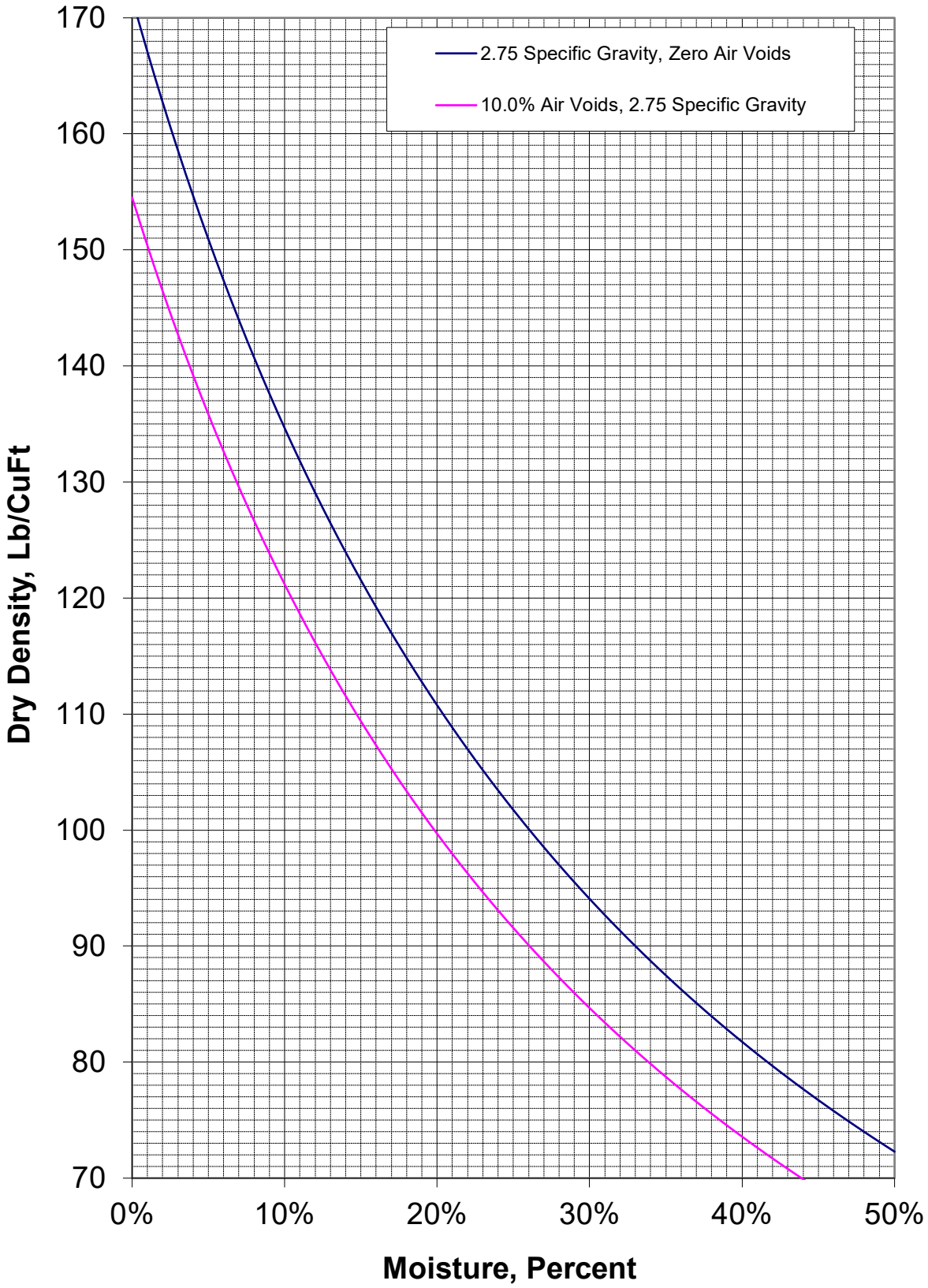
m = % moisture (report to nearest 0.1%)

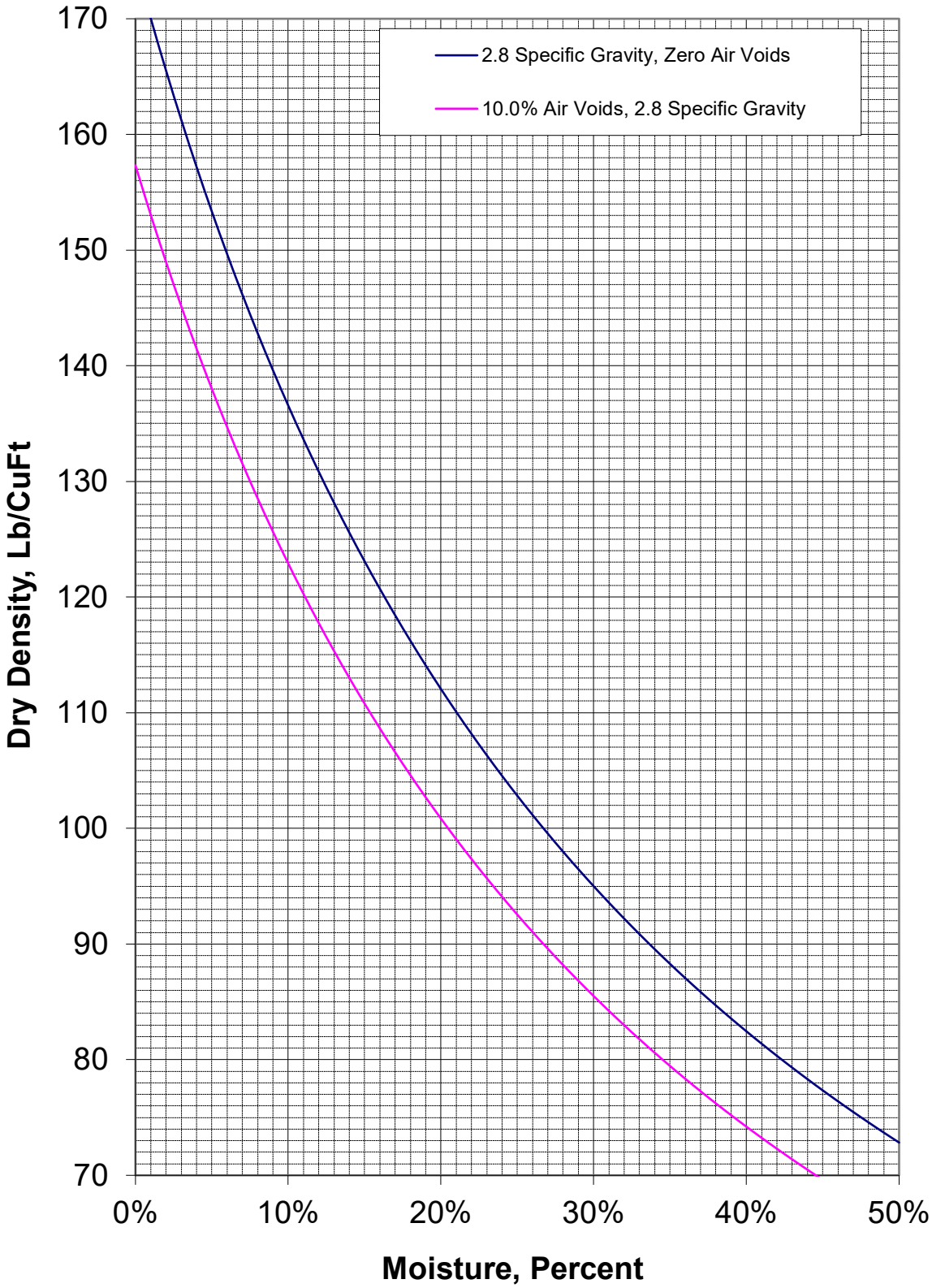
W = wt of water in Kg/m³ or 1000

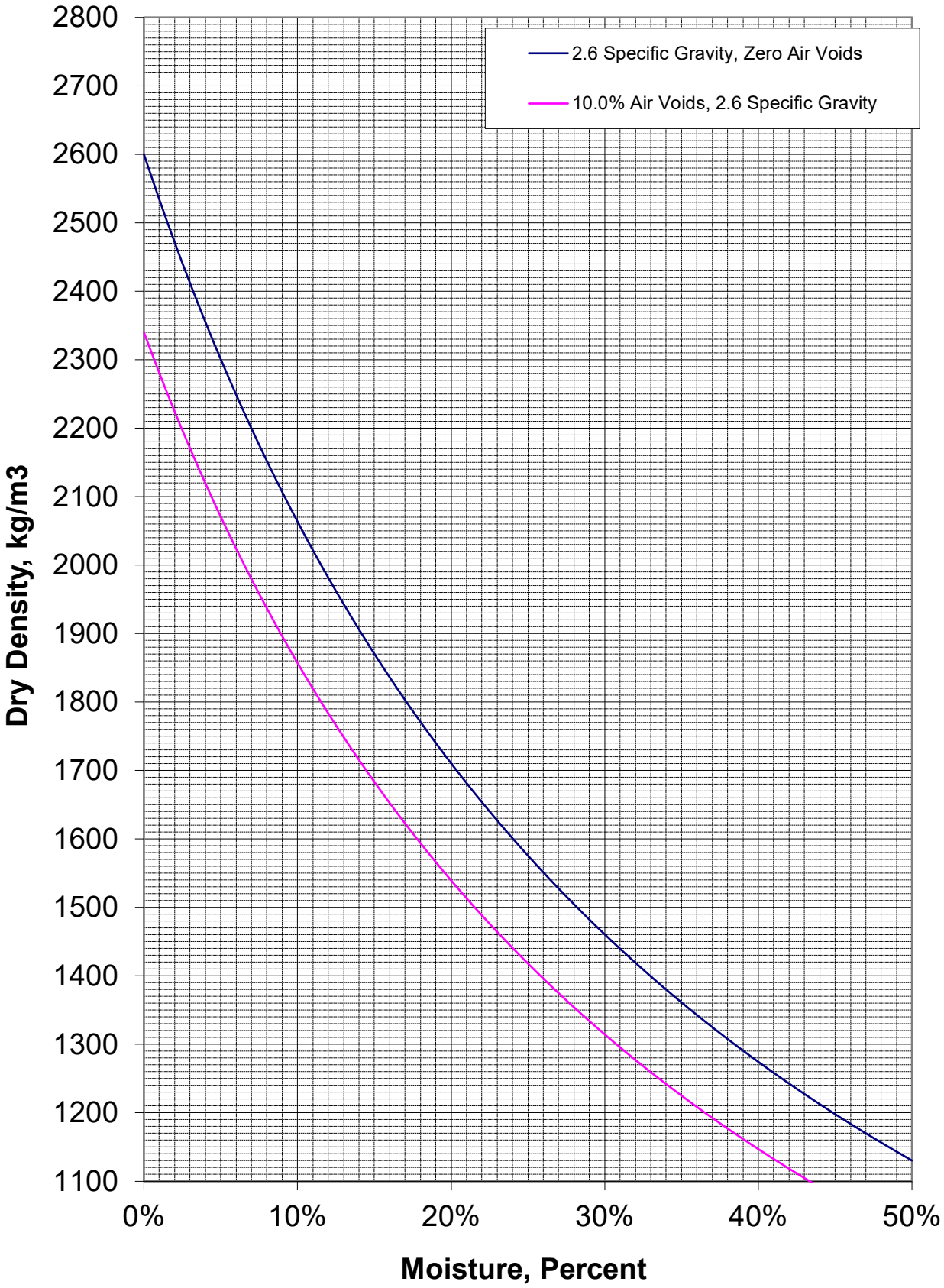

2.6 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.6 Specific Gravity
Dry Density, Lb/CuFt
170
160
150
140
130
120
110
100
90
80
70
0%
10%
20%
30%
40%
50%
Moisture, Percent

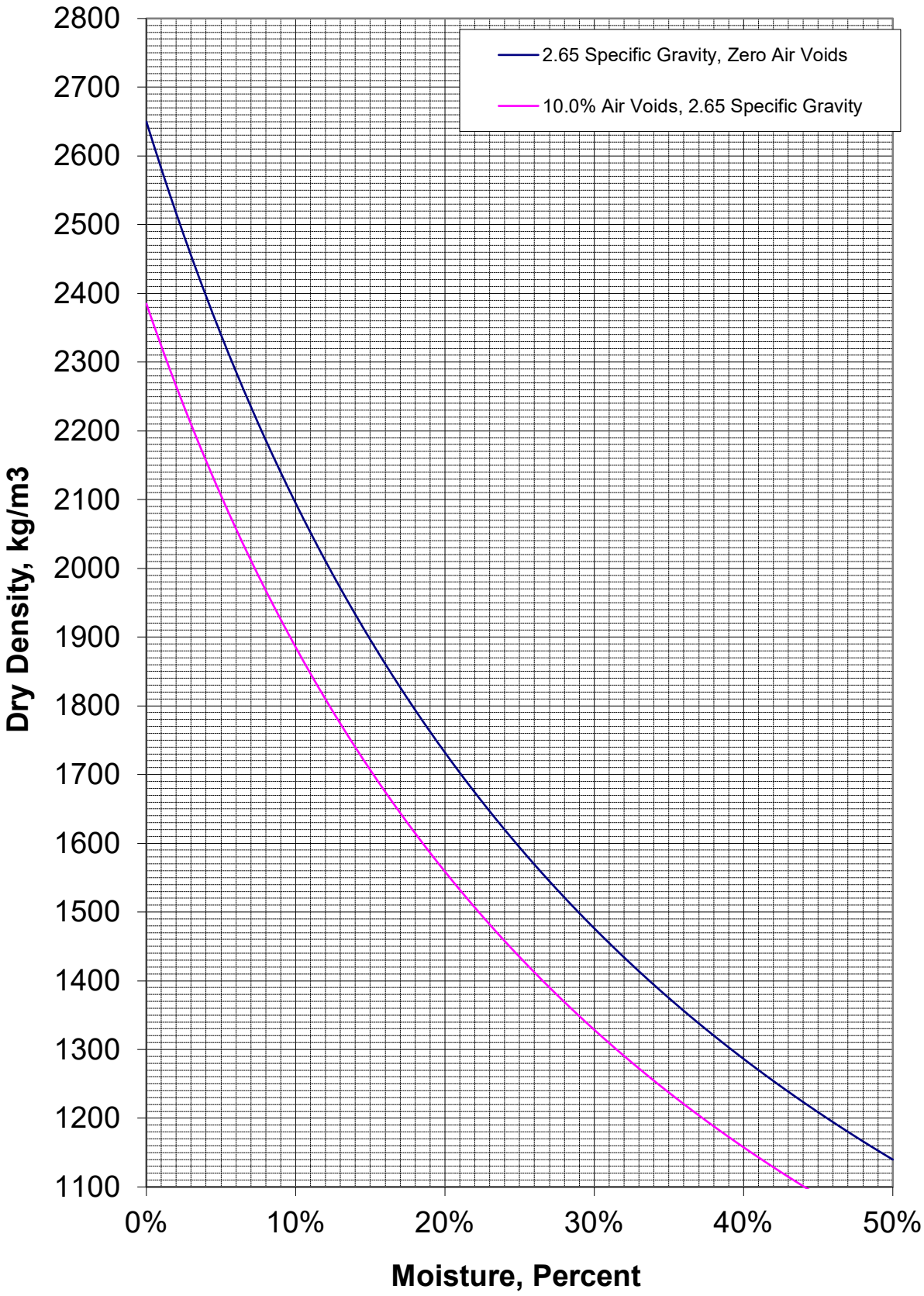

2.65 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.65 Specific Gravity
Dry Density, Lb/CuFt
170
160
150
140
130
120
110
100
90
80
70
0%
10%
20%
30%
40%
50%
Moisture, Percent

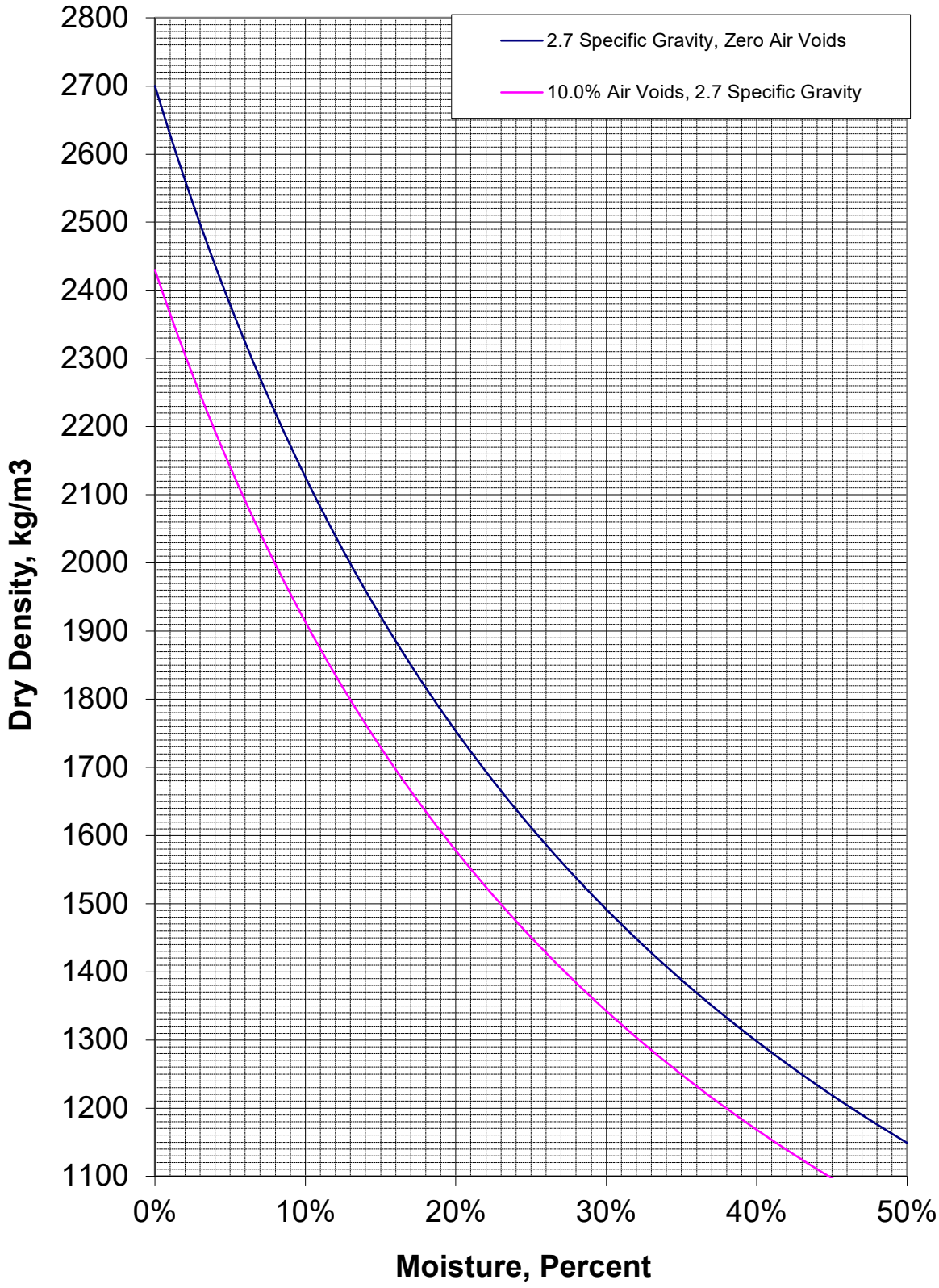

2.7 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.7 Specific Gravity
Dry Density, Lb/CuFt
170
160
150
140
130
120
110
100
90
80
70
0%
10%
20%
30%
40%
50%
Moisture, Percent

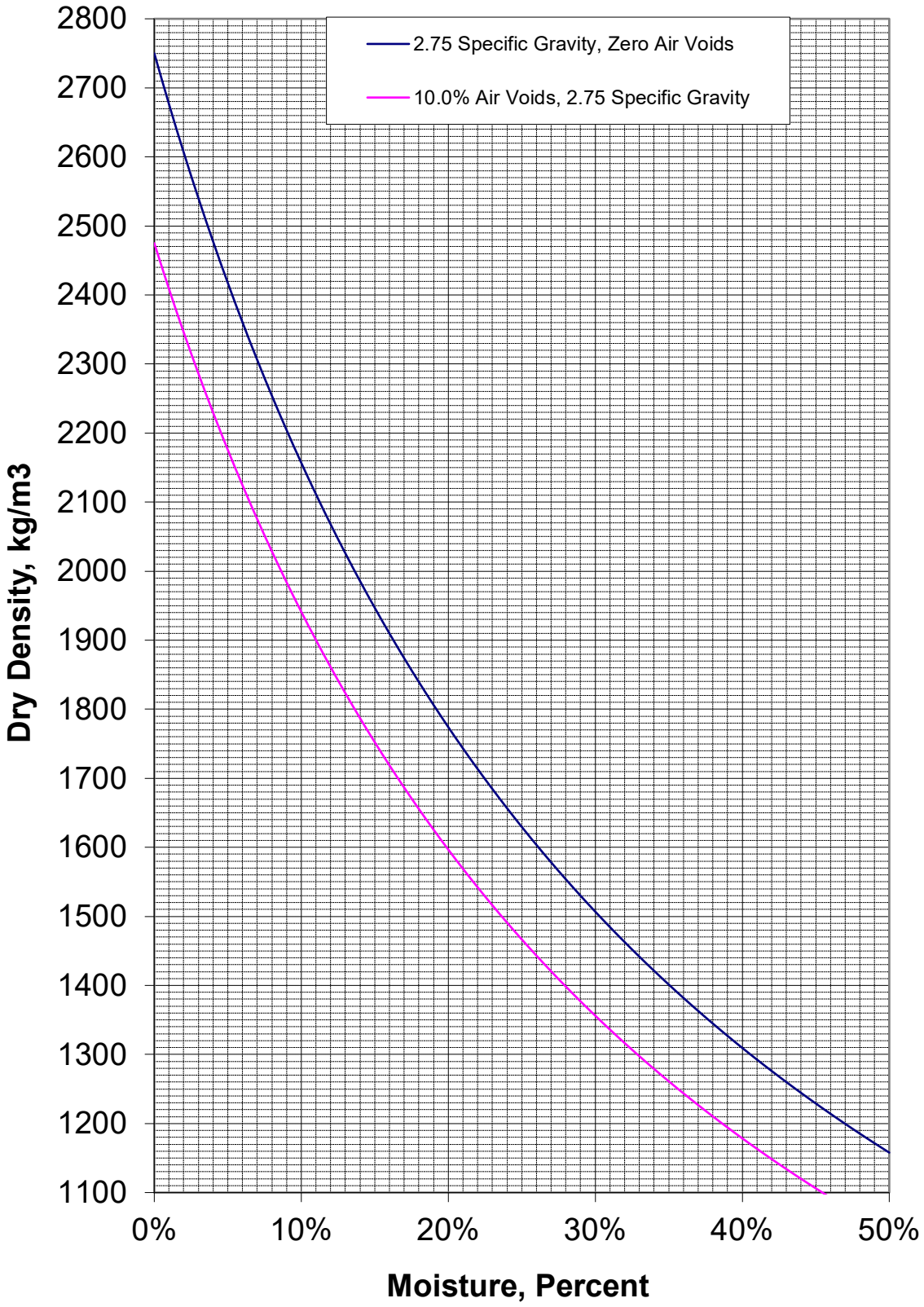

2.75 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.75 Specific Gravity
Dry Density, Lb/CuFt
170
160
150
140
130
120
110
100
90
80
70
0%
10%
20%
30%
40%
50%
Moisture, Percent

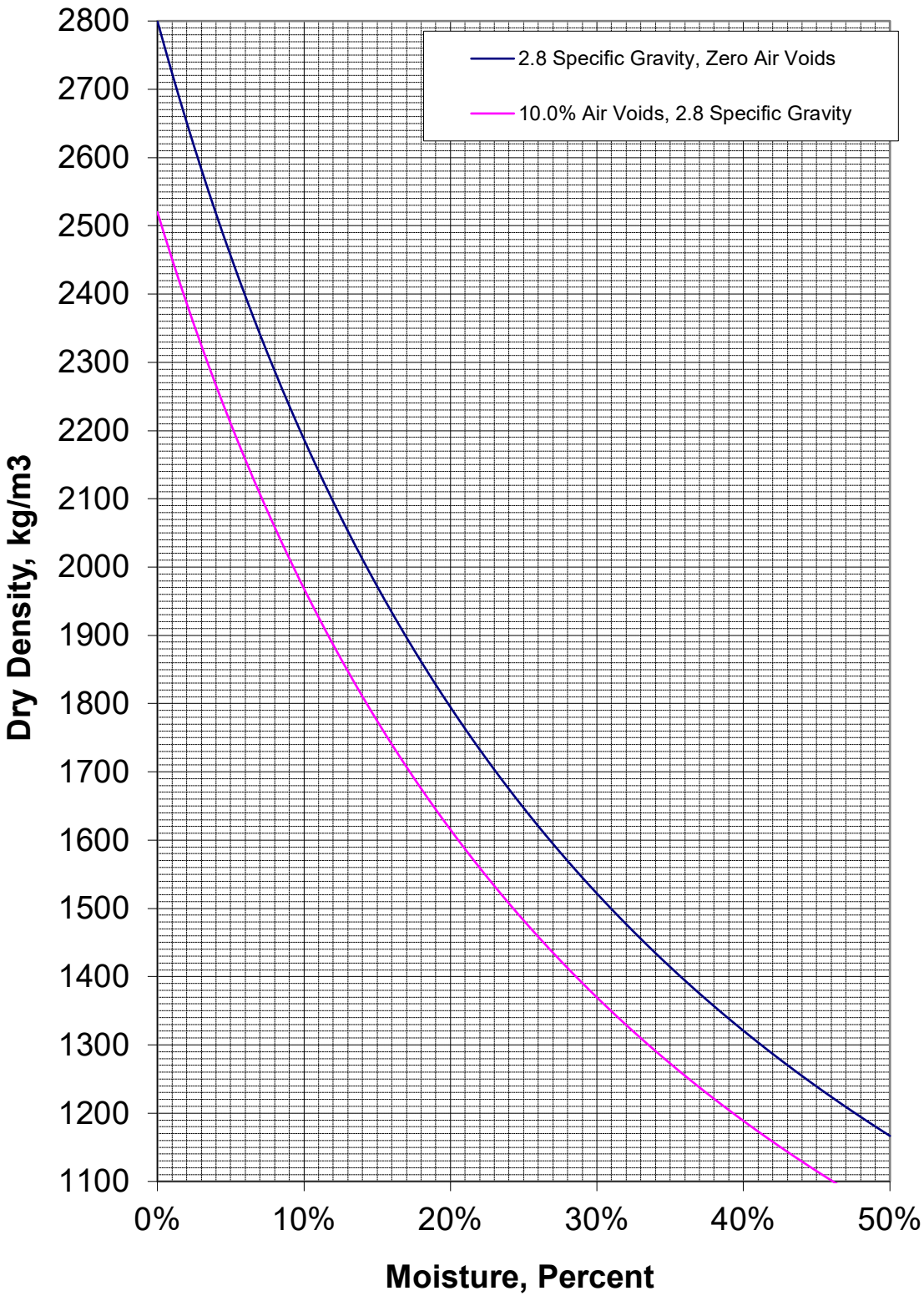

2.8 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.8 Specific Gravity
Dry Density, Lb/CuFt
170
160
150
140
130
120
110
100
90
80
70
0%
10%
20%
30%
40%
50%
Moisture, Percent


2.6 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.6 Specific Gravity
Dry Density, kg/m3
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
0%
10%
20%
30%
40%
50%
Moisture, Percent


2.65 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.65 Specific Gravity
Dry Density, kg/m3
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
0%
10%
20%
30%
40%
50%
Moisture, Percent


2.7 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.7 Specific Gravity
Dry Density, kg/m3
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
0%
10%
20%
30%
40%
50%
Moisture, Percent


2.75 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.75 Specific Gravity
Dry Density, kg/m3
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
0%
10%
20%
30%
40%
50%
Moisture, Percent


2.8 Specific Gravity, Zero Air Voids
10.0% Air Voids, 2.8 Specific Gravity
Dry Density, kg/m3
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
0%
10%
20%
30%
40%
50%
Moisture, Percent