HOW VARIATION IN SOIL PROCESSING AFFECTS THE MOISTURE/DENSITY RELATIONSHIP

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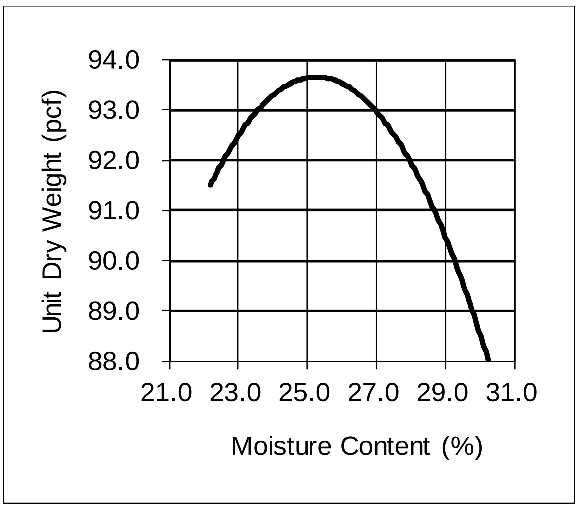
The moisture/density relationship, commonly known as the "Standard Proctor" test, is used to evaluate the required moisture and level of compaction of a soil to limit post-construction movement. An example of the typical moisture/density relationship is shown in the following graph. Development of this relationship is controlled by ASTM D 698.



Theoretically, because of ASTM D 698, the relationship between density and moisture should not be subject to variation between engineering companies. To evaluate this hypothesis, a large sample of highly plastic clay was blended than separated into five equal subsamples. These subsamples were then given to five engineering companies within the Dallas/Fort Worth Area. Each company was asked to develop the moisture/density relationship in accordance with ASTM D 698 for the subsample. Results for each of the engineering companies are shown in the following table.

Engineering Company	Optimum Moisture Content, %	Maximum Dry Density, pcf
1	27.4	91.7
2	27.8	90.2
3	26.0	95.0
4	25.5	92.9
5	29.6	88.0

The observed variation may not seem significant; however, it is. Compaction of an expansive clay to a density greater than 100 percent of the maximum Standard Proctor density, at a moisture content below the "optimum" moisture, significantly increases the potential for expansion or heave.

To illustrate the significance, assume the project specifications require a soil to be compacted to a density of between 92 and 98 percent of maximum ASTH D698 density, at a moisture content of +2 to +5 percentage points above optimum. For Engineering Company 5, this would be a density of between 81 pounds per cubic foot (pcf) and 86 pcf, at a moisture content between 31.6 and 34.6 percent. For Engineering Company 3, this would be a density of between 87 and 93 pcf, at a moisture content between 28.0 and 31.0 percent.

The importance of this variation can be observed during field testing of the compaction process. Let's say an engineering technician tested the soil represented by the above subsamples and obtained a field moisture of 29 percent and in-place density of 93 pcf. Specifications require compaction to +2 to +5 percentage points of optimum moisture at a density between 92 and 98 percent ASTM D 698 maximum density.

If we use the moisture/density relationship developed by Engineering Company 3, values of 29 percent moisture and 93 pcf are within specification. However, if we use the moisture/density relationship developed by Engineering Company 5, neither the moisture nor density meet specifications, and the soil would be judged to be over-compacted at low moisture.

To counter this variation between engineering companies, Reed Engineering Group recommends that samples obtained during development of the moisture/density relationship be subject to either swell or suction tests. Dependent upon the test results, the specified moisture content can be adjusted to reduce the potential for post-construction heave. For example, if the specifications require a minimum moisture of +2 percentage points above optimum, but a sample compacted to this moisture swells excessively, the required minimum moisture can be adjusted upwards to account for the heave.