

Field Compaction Methods for Soils

Vincent D. Reynolds, M.B.A., P.E.

Course Content

Compaction is the densification of soil materials by the use of mechanical energy. Soil is compacted by removing air and water from its pore space. There exists a certain amount of moisture that a soil can have where a maximum unit weight is obtained. When the soil is compacted to this state it is referred to as the maximum moisture/ unit weight. The maximum Moisture/ unit weight is used exclusively to determine the degree of compaction of the earth backfill. There are several steps to determine the degree of compaction of soil; the most widely used of those steps are described below:

Lab Analysis:

Generally before any soil compaction occurs various samples of the proposed embankment or fill is analyzed in the Lab. One such lab test is Proctor compaction test. The proctor compaction test is a test that compacts the soil material at various moisture contents. There are two proctor tests that defined by the American Association of Highway Officials and American Standard Testing Material. The Standard Proctor test (ASTM D-698, AASHTO T-99), and the Modified Proctor test (ASTM D-1557 and AASHTO T-180). The use of the Standard Proctor or Modified Proctor should be used at the discretion of the Professional Engineer. The Standard Proctor Test is generally for fills requiring the minimal sub-grade compaction, such as small parking lots, and building structures and while the Modified Proctor is generally used to for fills that will support large loads, such as Roadways, Airport Runways, and Concrete Parking Aprons.

The reader should study ASTM or AASHTO Standards for Modified and Standard proctors to aid in understanding Example#1 as shown on the next page.

Field Compaction:

Field compaction of soils is mainly done with various types of rollers. The three most common types of rollers are:

1. Sheepfoot rollers, used mainly for clayey and Silty Soils.
2. Smooth-drum rollers, Used primarily for Granular Soils.
3. Vibratory Rollers, Used primarily for Granular Soils.

Several Factors affect the degree of field compaction. Those factors are moisture type of soil and depth of fill. Soil is generally placed in lifts of 6" to 1 ft high. The size and type of the compaction equipment and desired relative density is essential to determining the depth of lift. It is at the discretion of the engineer to specify the fill lifts when compacting backfill. Soil lifts should be specified as to give the required compaction with the least amount of passes of the compaction equipment.

Generally a contractor is given a percentage of optimum compaction that must be attained in the field. This is referred to as the Relative Density or R(%). Relative densities generally range from 90% -95% as compared to the modified proctor and 95% - 100% as compared to the standard proctor. Generally granular fills are required to be compacted to 95% - 100% in the field.

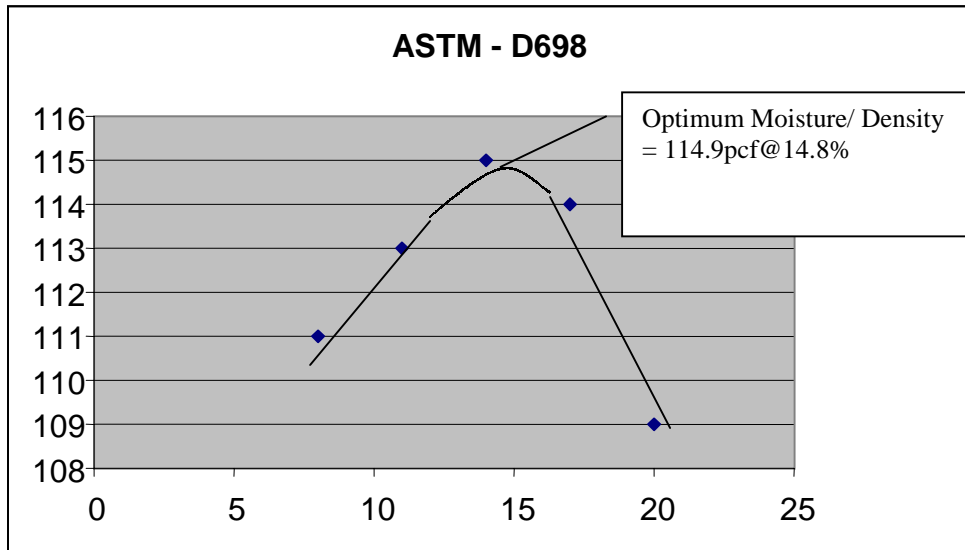
Example 1A:

An earth fill project utilizes soil backfill soil classified as a silty-sand. A representative sample of the backfill is taken to the lab to have a proctor test performed to find its optimum/moisture density relationship.

After performing the proctor test on the specimen the following Moisture Density relationships are ascertained:

<u>Water Content %</u>	<u>Dry Unit Weight, pcf</u>
8	111
11	113
14	115
17	114
20	109

The Moisture Density points are the graphed to produce a proctor curve:



Field Analysis (In-Place Density Tests):

The determination of the field compaction is essential to acquiring the Relative compaction of soil. The most widely used field tests for field compaction are:

1. Sand Cone Method (ASTM D-1556)
2. Drive Tube Method
3. Nuclear Method.

All three tests produce results with sufficient accuracy to determine the degree of compaction. Of the above-referenced testing procedures the Sand Cone Method has proven to be the most accurate and is generally the required test of several Municipal Authorities. The Drive Tube Method and Nuclear Method are the most time efficient tests and are widely used by several testing agencies.

Once the field compaction is determined, a plot of the field moisture density compaction test is then compared to the proctor compaction curve. Using the following formula the Relative compaction can be determined:

$$R (\%) = (\text{Density}_{\text{Field}} / \text{Density}_{\text{Max}}) \times 100$$

Example 1B:

After the grading contractor placed an 8" lift of soil a moisture density test was performed using a nuclear density gauge. The result of a particular test is as follows:

Density = 113.5 pcf

Moisture = 15%

$$R (\%) = (113.5\text{pcf} / 114.9\text{pcf}) \times 100 = 98.8\% \text{ or } 99 \%$$

A 99% relative compaction shows that the soil is densely compacted in the field. Please note that we used the standard proctor to represent field conditions. Often a modified proctor would be used where a more densely compacted soil is required. The use of the modified or standard proctor is at the discretion of the Engineer.