1. **SCOPE**

1.1. **Description of Test**

This method describes the procedure for determining the relationship between the moisture and density of fine-grained or coarse-grained soils. Soils are compacted with a 4.53 kg rammer dropped from a height of 457 mm. Fine-grained soils are compacted in a 101.6 mm mold and coarse-grained soils in a 152.4 mm mold.

1.2. **Application of Test**

For the purpose of this test method, fine-grained soils include all soil materials having more than 90% of its particles passing a 5.00 mm Canadian Metric Standard sieve.

For the purpose of this test method, coarse-grained soils include all soil materials having more than 10% of its particles retained on a 5.00 mm Canadian Metric Standard sieve.

2. **APPARATUS AND MATERIALS**

2.1. **Equipment Required**

101.6 mm mold. A cylindrical metal mold with a nominal capacity of 950 cm³ and internal diameter of 101.6 mm and a height of 116.3 mm. The mold will be fitted with a detachable collar and base plate. The exact volume of the mold without the collar but including a lucite liner is determined by weighing the amount of water required to fill it.

152.6 mm mold. A cylindrical metal mold with a nominal capacity of 2125 cm³ and internal diameter of 152.4 mm and height of 116.3 mm. The mold will be fitted with a detachable collar and base plate. The exact volume of the mold without the collar is determined by weighing the amount of water required to fill it.

Rammer. A metal rammer having a 50.8 mm diameter circular face with a 4.53 kg weight which will drop freely for a distance of 457 mm.

Compaction base. A cube of concrete weighing not less than 45 kg.

Straight-edge. A steel straight-edge approximately 300 mm in length.
3. **PROCEDURE**

3.1. **Sample Preparation**

Select a representative sample of sufficient quantity to perform the test; fine-grained soils require approximately 9,000 grams taken from the portion of sample passing the 5.00 mm sieve; coarse-grained soils require approximately 22,000 grams.

Dry samples thoroughly in air or in the oven with a temperature not exceeding 60°C.

Break up aggregations, but do not crush individual particles.

For fine-grained soils, separate material on the 5.00 mm sieve. Regrind the fraction retained and again separate on the 5.00 mm sieve. Repeat until grindings produce only a small quantity of material. Mix the fractions passing the 5.00 mm sieve thoroughly and use for the compaction test in the 101.6 mm mold.

For coarse-grained soils, use all the material but replace particles retained on the 40.0 mm sieve with an equal weight of particles passing the 40.0 mm sieve and retained on the 18 mm sieve.

3.2. **Test Procedures**

3.2.1. **Test Procedure for Fine-Grained Soils**

Weigh out four 2,200 g samples in separate mixing pans and label 1, 2, 3 and 4.

Estimate the natural moisture content of the soil.

Estimate the optimum moisture for the soil as well as the amounts of water required to bracket the optimum. Strive for a spread of two percent in moisture.
content between samples with two samples below optimum and two above, as shown in the example.

Example:

<table>
<thead>
<tr>
<th>Sample No</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Weight (g)</td>
<td>2200</td>
<td>2200</td>
<td>2200</td>
<td>2200</td>
</tr>
<tr>
<td>Natural moist. (est.)%</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Optimum moist. (est.)%</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Added water req’d. %</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Total req’d. moist. %</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Added water req’d. mL</td>
<td>110</td>
<td>154</td>
<td>198</td>
<td>242</td>
</tr>
<tr>
<td>Round off mL water req’d.</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
</tbody>
</table>

Start the addition of water with sample No. 3, mix the required amount of water thoroughly with the soil and examine. If it is not over optimum moisture content, add additional water.

Adjust the amount of water to be added to the remaining samples by an equal amount.

If sample No. 3 (16% in the example) appears to be too far above optimum moisture when the required estimate of water is added, then it may be called sample No. 4. Reduce the quantity of water added to the other samples by an appropriate amount.

Assemble the 101.6 mm mold with collar and base plate attached with insert lucite liner. Place the assembly on the compaction base.

Take the mixed sample and compact in the mold in five equal layers to give a total compacted depth of approximately 127 mm.

Compact each layer with 25 blows from the rammer dropping freely from a height of 457 mm. Avoid bouncing the weight off the handle at the top of the stroke when operating the rammer. Distribute the blows uniformly over the surface of the layer being compacted.

After the specimen has been compacted, remove the collar from the mold and use the straight-edge to trim the compacted soils even with the top.
Remove the mold from the base plate, remove the compacted specimen and remove the liner.

Weigh the specimen and record the weight to the nearest gram.

Slice the sample vertically and remove approximately 100 grams of soil from the central section of the test specimen for moisture content determination. Place the sample in a tared aluminum can, weigh, and oven dry to a constant weight at 110°C.

Determine the difference between the wet and dry weights and record as weight of moisture for calculation of moisture content.

Repeat the procedure for compacting and moisture content determinations for each of the four samples (i.e. two specimens below optimum moisture).

3.2.2. Test Procedure for Coarse-Grained Soils

The procedure to be used is similar to the procedure for fine-grained soil with the following exceptions:

Weigh out four 5 500 g samples.

Compact the specimens in the 152.4 mm mold in five equal layers to give a total compacted depth of about 127 mm.

Compact each layer with 56 blows from the rammer dropping freely from a height of 457 mm. Distribute the blows uniformly over the surface.

Remove approximately 500 grams of material from the vertical central section of the test specimen for moisture content determination. Place this sample in a suitable pan and weigh.

Carefully dry the moisture sample on a hot plate or oven at a temperature not exceeding 110°C.

After cooling, weigh the pan and sample and determine the moisture content in a similar manner to that used for fine-grained soils.
4. **RESULTS AND CALCULATIONS**

4.1. **Calculations**

The calculations are similar for the fine-grained and coarse-grained test.

Calculate the moisture and density for each of the samples. The following example illustrates the method to be used for each specimen:

<table>
<thead>
<tr>
<th>Weight of soil</th>
<th>1 966 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of mold</td>
<td>945 mL</td>
</tr>
<tr>
<td>Tare No.</td>
<td>89</td>
</tr>
<tr>
<td>Wet soil and tare</td>
<td>141.69 g</td>
</tr>
<tr>
<td>Dry soil and tare</td>
<td>127.49 g</td>
</tr>
<tr>
<td>Weight of water</td>
<td>14.20 g</td>
</tr>
<tr>
<td>Tare weight</td>
<td>35.86 g</td>
</tr>
<tr>
<td>Weight of dry soil</td>
<td>91.63 g</td>
</tr>
</tbody>
</table>

Moisture = \( \frac{\text{weight moisture}}{\text{weight dry soil}} \times 100\)

\[ \frac{14.20 \times 100}{19.63} = 15.5\% \]

Wet Density = \( \frac{\text{weight soil}}{\text{volume mold}} \times 1000\)

\[ \frac{1966 \times 1000}{945} = 2080 \text{ kg/m}^3 \]

Dry Density = \( \frac{\text{wet density}}{100 + \% \text{ moisture}} \times 100\)

\[ \frac{2080 \times 100}{100 + 15.5} = 1800 \text{ kg/m}^3 \]
4.1.1. Moisture-Density Relationship

Plot the moisture content versus dry density on graph paper with the vertical side representing dry density in kg/m$^3$ and the horizontal side representing moisture content in percentages. Form MR-33 includes a suitable graph paper.

Plot the moistures and corresponding densities as coordinates and draw a "best fit" curve through them in the order of increasing moisture contents to form a parabolic curve.

The moisture content corresponding to the peak of the curve is the "optimum moisture" for the compaction effort used in the test.

If the coordinates on the dry and wet side of the apparent optimum percent are spaced too far apart to properly define the location of the curve at optimum, a fifth density specimen at the required moisture content will be necessary to define the curve properly.

The dry density of the soil at "optimum moisture content" in kg per cubic metre will be termed "maximum density" for the compacted effort used in the test.

4.2. Reporting Results

Report the moisture content and maximum density on Form MR-33.

5. ADDED INFORMATION

5.1. General

The modified Proctor is only used in special circumstances where high density is required in the field. Usually standard Proctor is specified (Method STP 205-5) for control of compaction of subgrade or base course. Modified Density is usually about 80 to 160 kg/m$^3$ higher than standard Proctor and optimum moisture is about 5 to 10% lower, depending on the soil type.
APPROVAL SHEET

New ___ Revision ___ Date of Previous Document 82-04-01
Effective Date: __-__

Description of Revision (Reason for Revision):
Format of test procedure updated.

Review/Implementation Process:
Reviewed by the Materials Section of the Technical Standards and Policies Branch.

Other Manuals/Policies Affected:
Nil

Follow Up/Training Required:
Nil

Comments/Concerns/Implications (Budget/Environment/Stakeholders):

Prepared and Recommended by D. MacLeod 93-12-01
Materials Standards Engineer Date

Approval Recommended by R.A. Widger ___-__
Senior Materials Engineer Date

Approval Recommended by A.R. Gerbrandt ___-__
Dir., Technical Standards & Policies Br. Date

Approved by D.G. Metz ___-__
Assistant Deputy Minister, Infrastructure Date

Electronic File Updated ___-__
Update Mailed ___-__