1. **SCOPE**

1.1. **Description of Test**

This method describes the procedure for determining the relationship between the moisture content and density for soil cement mixtures obtained immediately after mixing on the road bed.

2. **APPARATUS AND MATERIALS**

2.1. **Equipment Required**

101.6 mm mold. A cylindrical metal mold with a nominal capacity of 950 cm$^3$ 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.

Rammer. A metal rammer having a 50.8 mm diameter circular face with a 2.5 kilogram weight which will drop freely for a distance of 305 mm.

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

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

Balance. A balance sensitive to 0.1 g.

Dry apparatus. Oven or stove suitable for drying samples.

Mixing tools. Mixing pans, trowel, and a water bottle with sprinkler top, and a 500 ml graduated cylinder.

Thermometer. A thermometer capable of recording temperatures between 38°C and 149°C.
3. **PROCEDURE**

3.1. **Sample Preparation**

Select a representative sample of the soil cement mixture from the mixed material from the truck box or on the subgrade surface immediately after the mixing operation has been completed.

Remove particles larger than 18 mm and replace with an equivalent weight of saturated, surface-dry particles passing the 18 mm sieve and retained on the 12.5 mm sieve.

3.2. **Test Procedure**

Divide the sample into four portions with each portion weighing 2200 grams.

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 optimum, as shown in the 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 wt. (g)</td>
<td>2200</td>
<td>2200</td>
<td>2200</td>
<td>2200</td>
</tr>
<tr>
<td>Natural Moisture (%)</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Optimum Moisture (%)</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>Water Req’d. (ml)</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 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 and collar and base plate attached and insert lucite liner. Place the assembly on the compaction base.

Take the mixed sample and compact in the mold in three 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 305 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 soil 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 a representative sample taken from top to bottom, on one of the cut faces, for moisture determination. The sample should be sufficiently large to provide an accurate moisture test. About 200 to 500 grams should be used.

Place the sample in a tared pan, weigh and carefully dry to a constant weight on the stove at a temperature not greater than 110°C. After cooling, weigh the sample and pan.

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 above optimum moisture and two specimens below optimum moisture.)
4. **RESULTS AND CALCULATIONS**

4.1. **Calculations**

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

- **Weight of soil**: 1966 g
- **Volume of mold**: 945 cm³
- **Tare No.**: 89
- **Wet soil and tare**: 141.69 g
- **Dry soil and tare**: 127.49 g
- **Weight of water**: 14.20 g
- **Tare weight**: 35.86 g
- **Weight of dry soil**: 91.63 g

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

\[
= \frac{14.20}{91.63} \times 100 = 15.5\%
\]

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

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

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

\[
= \frac{2080}{100 + 15.5} \times 100 = 1800 \text{ kg/m}^3
\]

4.1.1. **Moisture Density Plot**

Plot the moisture content versus dry density on graph paper with the vertical side representing dry density in kg/m³ 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.

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-cement mix at "optimum moisture content" in kilograms per cubic meter 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**

Compaction of molds for moisture-density curve must be completed as soon as possible after sampling to prevent rapid hydration.
New __ Revision _X__ Date of Previous Document 85-04-01
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):

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Quality Control Engineer Date

Approval Recommended by R.A. Widger ____________ - -
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Approval Recommended by A.R. Gerbrandt ____________ - -
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Approved by D.G. Metz ____________ - -
Assistant Deputy Minister, Infrastructure Date

Electronic File Updated - -
Update Mailed - -