INTRODUCTION

The moisture content of soil (also referred to as water content) is an indicator of the amount of water present in soil. By definition, moisture content is the ratio of the mass of water in a sample to the mass of solids in the sample, expressed as a percentage. In equation form,

\[ w = \frac{M_w}{M_s} \times 100 \]  

(3-1)

where:

- \( w \) = moisture content of soil (expressed as a percentage)
- \( M_w \) = mass of water in soil sample (i.e., initial mass of moist soil minus mass of oven-dried soil)
- \( M_s \) = mass of soil solids in sample (i.e., the soil’s “oven-dried mass”)

\( M_w \) and \( M_s \) may be expressed in any units of mass, but both should be expressed in the same unit.

It might be noted that the moisture content could be mistakenly defined as the ratio of mass of water to total mass of moist soil (rather than to the mass of oven-dried soil). Because the total mass of moist soil is the sum of the mass of water and oven-dried soil, this incorrect definition would give a fraction in which both numerator and denominator vary.
(but not in the same proportion) according to the amount of moisture present. Such a definition would be undesirable, because moisture content would then be based on a varying quantity of moist mass of soil rather than a constant quantity of oven-dried soil. Stated another way, with the incorrect definition, the moisture content would not be directly proportional to the mass of water present. With the correct definition given by Eq. (3–1), moisture content is directly proportional to the mass of water present. This characteristic makes moisture content, as defined by Eq. (3–1), one of the most useful and important soil parameters.

**APPARATUS AND SUPPLIES**

- Drying oven (with accurate temperature control and temperature gage)
- Balance (with accuracy to 0.01 g)
- Containers (e.g., tin or aluminum moisture cans with lids)
- Desiccator
- Container-handling apparatus: gloves, tongs, or suitable holder for moving and handling hot containers after drying
- Miscellaneous: knives, spatulas, scoops, quartering cloth, sample splitters, etc.

**SAMPLES [1]**

1. Samples shall be preserved and transported in accordance with ASTM Test Method D 4220 Groups B, C, or D soils. Keep the samples that are stored prior to testing in noncorrodible airtight containers at a temperature between approximately 3° and 30°C and in an area that prevents direct contact with sunlight. Disturbed samples in jars or other containers shall be stored in such a way as to prevent or minimize moisture condensation on the insides of the containers.

2. The water content determination should be done as soon as practicable after sampling, especially if potentially corrodeable containers (such as thin-walled steel tubes, paint cans, etc.) or plastic sample bags are used.

**TEST SPECIMEN [1]**

1. For water contents being determined in conjunction with another ASTM method, the specimen mass requirement stated in that method shall be used if one is provided. If no minimum specimen mass is provided in that method, then the values given below shall apply.

2. The minimum mass of moist material selected to be representative of the total sample shall be in accordance with the following:
### Determining the Moisture Content of Soil (Conventional Oven Method)

#### Table: Minimum Mass for Water Content Reporting

<table>
<thead>
<tr>
<th>Maximum Particle Size (100% passing)</th>
<th>Standard Sieve Size</th>
<th>Recommended Minimum Mass of Moist Test Specimen for Water Content Reported to ±0.1%</th>
<th>Recommended Minimum Mass of Moist Test Specimen for Water Content Reported to ±1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mm or less</td>
<td>No. 10</td>
<td>20 g</td>
<td>20 g*</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>No. 4</td>
<td>100 g</td>
<td>20 g*</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>¾-in.</td>
<td>500 g</td>
<td>50 g</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>½-in.</td>
<td>2.5 kg</td>
<td>250 g</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>1⅞-in.</td>
<td>10 kg</td>
<td>1 kg</td>
</tr>
<tr>
<td>75.0 mm</td>
<td>3-in.</td>
<td>50 kg</td>
<td>5 kg</td>
</tr>
</tbody>
</table>

NOTE: *To be representative not less than 20 g shall be used.

(2.1) The minimum mass used may have to be increased to obtain the needed significant digits for the mass of water when reporting water contents to the nearest 0.1%.

(3) Using a test specimen smaller than the minimum indicated in (2) requires discretion, though it may be adequate for the purposes of the test. Any specimen used not meeting these requirements shall be noted on the test data forms or test data sheets.

(4) When working with a small (less than 200 g) specimen containing a relatively large gravel particle, it is appropriate not to include this particle in the test specimen. However, any discarded material shall be described and noted on the test data forms or test data sheets.

(5) For those samples consisting entirely of intact rock, the minimum specimen mass shall be 500 g. Representative portions of the sample may be broken into smaller particles, depending on the sample’s size, the container, and balance being used, and to facilitate drying to constant mass, see Section (4) under “Procedure.”

**TEST SPECIMEN SELECTION [1]**

(1) When the test specimen is a portion of a larger amount of material, the specimen must be selected to be representative of the water condition of the entire amount of material. The manner in which the test specimen is selected depends on the purpose and application of the test, type of material being tested, the water condition, and the type of sample (from another test, bag, block, and the likes).

(2) For disturbed samples, such as trimmings, bag samples, and the like, obtain the test specimen by one of the following methods (listed in order of preference):

(2.1) If the material is such that it can be manipulated and handled without significant moisture loss and segregation, the material should be mixed thoroughly and then select a representative portion using a scoop of a size that no more than a few scoopfuls are required to obtain the proper size of specimen defined by No. (2) under the Section “Test Specimen.”
(2.2) If the material is such that it cannot be thoroughly mixed and/or split, form a stockpile of the material, mixing as much as possible. Take at least five portions of material at random locations using a sampling tube, shovel, scoop, trowel, or similar device appropriate to the maximum particle size present in the material. Combine all the portions for the test specimen.

(2.3) If the material or conditions are such that a stockpile cannot be formed, take as many portions of the material as practical using random locations that will best represent the moisture condition. Combine all the portions for the test specimen.

(3) Intact samples, such as block, tube, split barrel, and the like, obtain the test specimen by one of the following methods depending on the purpose and potential use of the sample.

(3.1) Using a knife, wire saw, or other sharp cutting device, trim the outside portion of the sample a sufficient distance to see if the material is layered and to remove material that appears more dry or more wet than the main portion of the sample. If the existence of layering is questionable, slice the sample in half. If the material is layered, see No. (3.3).

(3.2) If the material is not layered, obtain the specimen meeting the mass requirements in No. (2) under the Section “Test Specimen” by: (1) taking all or one-half of the interval being tested; (2) trimming a representative slice from the interval being tested; or (3) trimming the exposed surface of one-half or from the interval being tested.

Note 1—Migration of moisture in some cohesionless soils may require that the full section be sampled.

(3.3) If a layered material (or more than one material type) is encountered, select an average specimen, or individual specimens, or both. Specimens must be properly identified as to location or what they represent and appropriate remarks entered on the test data forms or test data sheets.

**PROCEDURE**

Determination of moisture content of soil is actually quite simple. As indicated by Eq. (3–1), it is necessary only to determine the (1) mass of water in the soil sample and (2) mass of soil solids in the same sample. This is easily done by determining the mass of the moist soil sample, drying the sample to remove moisture, and then measuring the mass of the remaining oven-dried sample. The mass of the remaining oven-dried sample is, of course, the mass of soil solids in the sample. The difference between that mass and the mass of the original moist sample is the mass of water in the original sample. Substituting these values into Eq. (3–1) will give the desired moisture content of the soil.
The actual step-by-step procedure is as follows (ASTM D 2216-98 [1]):

(1) Determine and record the mass of the clean and dry specimen container (and its lid, if used).

(2) Select representative test specimens in accordance with "Test Specimen Selection."

(3) Place the moist test specimen in the container and, if used, set the lid securely in position. Determine the mass of the container and moist material using a balance selected on the basis of the specimen mass. Record this value.

Note 2—To prevent mixing of specimens and yielding of incorrect results, all containers and lids, if used, should be numbered and the container numbers shall be recorded on the laboratory data sheets. The lid numbers should match the container numbers to eliminate confusion.

Note 3—To assist in the oven-drying of large test specimens, they should be placed in containers having a large surface area (such as pans) and the material broken up into smaller aggregations.

(4) Remove the lid (if used) and place the container with moist material in the drying oven. Dry the material to a constant mass. Maintain the drying oven at 110 ± 5°C unless otherwise specified. The time required to obtain constant mass will vary depending on the type of material, size of specimen, oven type and capacity, and other factors. The influence of these factors generally can be established by good judgment and experience with the materials being tested and the apparatus being used.

Note 4—In most cases, drying a test specimen overnight (about 12 to 16 h) is sufficient. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the change in mass after two successive periods (greater than 1 h) of drying is an insignificant amount (less than about 0.1%). Specimens of sand may often be dried to constant mass in a period of about 4 h when a forced-draft oven is used.

Note 5—Since some dry materials may absorb moisture from moist specimens, dried specimens should be removed before placing moist specimens in the same oven. However, this would not be applicable if the previously dried specimens will remain in the drying oven for an additional time period of about 16 h.
(5) After the material has dried to constant mass, remove the container from the oven (and replace the lid if used). Allow the material and container to cool to room temperature or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by convection currents and/or its being heated. Determine the mass of the container and oven-dried material using the same balance as used in (3). Record this value. Tight-fitting lids shall be used if it appears that the specimen is absorbing moisture from the air prior to determination of its dry mass.

Note 6—Cooling in a desiccator is acceptable in place of tight-fitting lids since it greatly reduces absorption of moisture from the atmosphere during cooling, especially for containers without tight-fitting lids.

**DATA**

Data collected in this test should include the following:

- Mass of container, $M_c$
- Mass of container and wet specimen, $M_{cw}$
- Mass of container and oven-dried specimen, $M_{cs}$

Calculate the water content of the material as follows:

$$w = \left(\frac{M_{cw} - M_c}{M_{cs} - M_c}\right) \times 100 = \frac{M_w}{M_s} \times 100$$  \hspace{1cm} (3-2)

where:
- $w$ = water content, %
- $M_{cw}$ = mass of container and wet specimen, g
- $M_{cs}$ = mass of container and oven-dried specimen, g
- $M_c$ = mass of container, g
- $M_w$ = mass of water ($M_w = M_{cw} - M_{cs}$), g
- $M_s$ = mass of solid particles ($M_s = M_{cs} - M_c$), g

**NUMERICAL EXAMPLE**

A laboratory test was conducted according to the procedure described previously. The following data were obtained:

- Mass of container, $M_c = 59.85$ g
- Mass of container and wet specimen, $M_{cw} = 241.25$ g
- Mass of container and oven-dried soil, $M_{cs} = 215.43$ g

Note: The data above are shown in boldface type to differentiate them from other values that are not collected during the test. In other words, boldface numbers indicate data collected during the test; all other numbers appear in regular type. This distinction is observed in the numerical examples throughout this book.
\[ M_w = M_{cws} - M_{cs} \]
\[ M_w = 241.25 - 215.43 = 25.82 \text{ g} \]
\[ M_s = M_{cs} - M_c \]
\[ M_s = 215.43 - 59.85 = 155.58 \text{ g} \]

Equation (3-1) can now be used to determine the desired moisture content.

\[ w = \frac{M_w}{M_s} \times 100 \]

\[ w = \frac{25.82}{155.58} \times 100 = 16.6\% \]

These results, together with the initial data, are summarized in the form on the following page. At the end of the chapter, two blank copies of this form are included for the reader’s use.

**REFERENCE**

Soils Testing Laboratory
Moisture Content Determination

Sample No. 15  Project No. SR2828
Boring No. B-7  Location Newell, N.C.
Depth 4 ft

Description of Sample Brown silty clay

Tested by John Doe  Date 1/15/02

<table>
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<th>Determination No.</th>
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<th>2</th>
<th>3</th>
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<tr>
<td>Container (can) no.</td>
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<tr>
<td>Mass of container + wet specimen, $M_{cw}$ (g)</td>
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<tr>
<td>Mass of container + oven-dried specimen, $M_{cs}$ (g)</td>
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<tr>
<td>Mass of container, $M_{c}$ (g)</td>
<td>59.85</td>
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<tr>
<td>Mass of water, $M_{w}$ (g)</td>
<td>25.82</td>
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<tr>
<td>Mass of solid particles, $M_{s}$ (g)</td>
<td>155.58</td>
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</tr>
<tr>
<td>Moisture content, $w$ (%)</td>
<td>16.6</td>
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</tbody>
</table>
Soils Testing Laboratory
Moisture Content Determination

Sample No. ____________________  Project No. ____________________

Boring No. ____________________  Location ____________________

Depth ____________________

Description of Sample ____________________

Tested by ____________________  Date ____________________

<table>
<thead>
<tr>
<th>Determination No.:</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
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<tbody>
<tr>
<td>Container (can) no.</td>
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</tr>
<tr>
<td>Mass of container + wet specimen, $M_{\text{wss}}$ (g)</td>
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<tr>
<td>Mass of container + oven-dried specimen, $M_{\text{ods}}$ (g)</td>
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<tr>
<td>Mass of container, $M_c$ (g)</td>
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<tr>
<td>Mass of water, $M_w$ (g)</td>
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</tr>
<tr>
<td>Mass of solid particles, $M_s$ (g)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Moisture content, $w$ (%)</td>
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