CHAPTER 3

CLASSIFICATION TESTS

3.1 Determination of Moisture Content

3.1.1 General requirements

3.1.1.1 Scope. Water is present in most naturally occurring soils and has a profound effect in soil behaviour. A knowledge of the moisture content is used as a guide to the classification. It is also used as a subsidiary to almost all other field and laboratory tests of soil. The oven-drying method is the definitive method of measuring the moisture contents of soils. The sand-bath method is used, where oven drying is not possible, mainly on site.

3.1.1.2 Definition. The moisture content of a soil sample is defined as the mass of water in the sample expressed as a percentage of the dry mass, usually heating at 105^0C, i.e.

$$\text{moisture content, } w = \frac{M_W}{M_D} \times 100\ (\%)$$

where, M_W = mass of water

M_D = dry mass of sample

3.1.1.3 Sample requirements

3.1.1.3.1 Sample mass. The mass required for the test depends on the grading of the soil, as follows;

a) Fine-grained soils*, not less than 30 grams
b) Medium-grained soils*, not less than 300 grams
c) Coarse-grained soils*, not less than 3 kg

*Soils group
i) Fine-grained soils: Soils containing not more than 10% retained on a 2 mm test sieve.
ii) Medium-grained soils: Soils containing more than 10% retained on a 2 mm test sieve but not more than 10% retained on a 20 mm test sieve.
iii) Coarse-grained soils: Soils containing more than 10% retained on a 20 mm test sieve but not more than 10% retained on a 37.5 mm test sieve.

3.1.1.4 Accuracy of weighing. The accuracy of weighing required for test samples is as follows;

a) Fine-grained soils: within 0.01 g.
b) Medium-grained soils: within 0.1 g.
c) Coarse-grained soils: within 1g.

3.1.1.5 Safety aspects

a) Heat-resistant gloves and / or suitable tongs should be used to avoid personal injury and possible damage to samples.

b) If glass weighing bottles are used they should be placed on a high shelf away from heating elements.
c) A heat-insulated pad should always be used to place hot glassware of any description.

3.1.2 Oven-drying method (standard method)

3.1.2.1 Apparatus

1) Thermostatically controlled drying oven capable of operating to 105 ± 5^0C.
2) Glass weighing bottles or suitable metal containers (corrosion-resistant tins or trays).
3) Balance (to the required sensitivity).
4) Dessicator containing anhydrous silica gel.
5) Scoop, other small tools as appropriate.
   Optional: Test sieves - 2 mm, 20 mm, 37.5 mm (to check classification of sample, in order to confirm required sample size).

3.1.2.2 Test procedure

a) One clean container with the lid (if fitted) is taken and the mass in grams is recorded (m_1) together with container number.

   Note: The container plus lid or bottle plus stopper should have the same number and be used together.

b) The sample of wet soil is crumbled and placed in the container. The container with the lid on is weighed in grams (m_2).
c) The lid is removed and both lid and container are placed in the oven. The sample is then dried in a thermostatically controlled drying oven which is maintained at a temperature of 105 ± 5^0C. A period of 16 to 24 hours is usually sufficient, but this varies with soil type. It will also vary if the oven contains a large number of samples or very wet samples. The soil is considered dry when the differences in successive weighings of the cooled soil at 4 hour intervals do not exceed 0.1% of the original mass.

   Note. 1) For peats and soils containing organic matter a drying temperature of 60^0C is to be preferred to prevent oxidation of organic matter.
   2) For soils containing gypsum a maximum drying temperature of 80^0C is preferred. The presence of gypsum can be confirmed by heating a small quantity of soil on a metal plate. Grains of gypsum will turn white within a few minutes, but most other mineral grains will remain unaltered.

d) The container is removed from the oven. For medium and coarse-grained soils, the lid should be replaced (if fitted) and the sample allowed to cool. For fine-grained soils, the container and lid, or bottle and stopper if used, should preferably be placed in a dessicator and allowed to cool. After cooling, the lids or stoppers should be replaced and the container plus dry soil weighed in grams (m_3).

3.1.2.3 Calculation and expression of results

$$\text{Moisture content, } w = \frac{\text{mass of moisture}}{\text{mass of dry soil}} \text{ x } 100\%$$

$$= \frac{(\text{mass of container + wet soil}) - (\text{mass of container + dry soil})}{(\text{mass of container + dry soil}) - (\text{mass of container})} \text{ x } 100\%$$

i.e. $$w = \frac{m_2 - m_3}{m_3 - m_1} \text{ x } 100\%$$

For values up to 10% the moisture content should be expressed to two significant figures, e.g. 1.9%, 4.3%, 9.8%. For moisture contents above 10% express the result to the nearest whole number, e.g. 11%, 27%.

Note. If the moisture content is to be related to the Atterberg limits, e.g. for determining the liquidity index, and the soil contains material retained on a 425 mm sieve, the measured moisture content, w (in %), can be corrected to give the equivalent moisture content, w_a (in %), of the fraction passing the 425 mm sieve, using the equation :

$$w_a = w\left(\frac{100}{p_a}\right)$$

where, p_a is the percentage by dry mass of the portion of the soil sample passing the 425 μm test sieve.

If the particles retained on the 425 μm sieve are porous and absorb water, the amount of absorption should be determined and the value of water calculated from the equation.

$$w_a = \frac{100w}{p_a} - w_r\left(\frac{100 - p_a}{p_a}\right)$$

where; w_r, is the moisture content of the fraction retained on the 425 μm test sieve.

3.1.2.4 Report. The test report shall contain the following information:

a) the method of test used;
b) the moisture content;
c) the temperature at which the soil was dried, if less than 105^0C;
d) the comparison with Atterberg limits, if required (see Note to 3.1.2.3);
e) full details of the sample origin.

The operator should sign and date test sheet. An example of the calculations made is shown in Form 3.1.1.

3.1.3 Sand-bath (subsidiary method)

3.1.3.1 Apparatus

i) Strong metal heatproof tray or dish containing clean sand to a depth of at least 25mm (sand-bath).
ii) Moisture content containers for fine soils (excluding glass containers), as used for oven drying. For coarser soils heat-resistant trays 200-250 mm square and 50-70 mm deep, the size depending on the quantity of soil required for test.
iii) Heating equipment, such as a bottled gas burner or paraffin pressure stove, or electric hot plate if mains electricity is available.
iv) Scoop, spatula, appropriate small tools.

BANGLADESH ROAD RESEARCH LABORATORY

MOISTURE CONTENT DETERMINATION

Contract : *Jaflong-Sylhet Road*

Sample No. *1072*
Date of sample *10/11/96*

Description of soil : *Moist medium dense light-brown silty fine medium and coarse (FMC) Gravel*

Type / origin of sample : *Distarrbed TP 103, Km 10+500 o/s 15m LHS. Depth : 1.75-2.10m*

Method of drying : Oven / Sand bath
Drying temp. *10.5* ^{0}C

Container No.		52	69								
Position of sample											
Mass of wet soil + container (m_2)	g	5001	4931								
Mass of dry soil + container (m_3)	g	4690	4646								
Mass of moisture ($m_4 = m_2 - m_3$)	g	311	285								
Mass of container (m_1)	g	990	996								
Mass of dry soil ($m_5 = m_3 - m_1$)	g	3700	3650								
Moisture content $w = \frac{m_4}{m_5} \times 100$	%	8.4	7.8								
Average moisture content	%	8.1									

Date of test : *10/11/96*

Name and Designation		
Operator	Checked	Approved

Contract : *Jaflong-Sylhet Road*

Sample No. *1083*
Date of sample *10/11/96*

Description of soil : *Wet soft light grey silty CLAY with pocket of brown fibrous peat*

Type / origin of sample : *Distarrbed TP 104, Km 11+200 o/s 50m RHS.*

Method of drying : Oven / Sand bath
Drying temp. *80* ^{0}C

Container No.		34		49							
Position of sample											
Mass of wet soil + container (m_2)	g	89.00		74.21							
Mass of dry soil + container (m_3)	g	56.62		61.49							
Mass of moisture ($m_4 = m_2 - m_3$)	g	12.40		12.72							
Mass of container (m_1)	g	20.07		20.98							
Mass of dry soil ($m_5 = m_3 - m_1$)	g	36.55		40.57							
Moisture content $w = \frac{m_4}{m_5} \times 100$	%	33.90		31.40							
Average moisture content	%	33									

Date of test :

Name and Designation		
Operator	Checked	Approved

3.1.3.2 Test procedure

a) A clean dry container with the lid (if fitted) is weighed, in grams (m_1). The number of the container is recorded.
b) The sample of wet soil is crumbled, placed in the container and weighed in grams (m_2).
c) The sand-bath is placed on some form of heater such as a kerosene stove, a gas burner or an electric heater. The sample in its container is embedded in the surface of the sand in the sand-bath. Care should be taken to ensure that the container is not heated too much. The sample should be stirred and turned frequently so that the sample does not burn. Small pieces of white paper will act as an indicator and turn brown if over-heated. To check that the sample is completely dry it should be weighed and returned to the sand-bath for another 15 minutes. If the loss in mass after heating for a further period of 15 min does not exceed the following, the sample may be considered to be dry :

Fine-grained soils	0.1g
Medium-grained soils	0.5g
Coarse-grained soils	5g

d) After drying, the sample is removed from the sand-bath, the container lid (if fitted) is firmly secured in place and the sample is allowed to cool. When cool, the container and the dry soil is weighed in grams (m_3).

Note. Do not place hot trays onto the unprotected pan of a balance.

e) Normally, more than one determination of moisture content is made and the average value is taken.

3.1.3.3 Calculation and expression of results. Calculation and expression of results are identical to those for oven-drying method.

3.1.3.4 Report. Report is also identical to that for oven-drying method.

3.1.4 Speedy Moisture Test

3.1.4.1 General

3.1.4.1.1 Introduction. A rapid test method for determination of moisture in soils is by the use of a calcium carbide gas pressure moisture tester - commonly called the Speedy moisture tester. Soil samples are used in 6, 26 and 200 gram sizes.

3.1.4.1.2 Apparatus. The basic apparatus includes the moisture tester, a scale for weighing the sample, a cleaning brush, a scoop for measuring the calcium carbide reagent and a sturdy carrying case. For the 26 gm sample test, steel balls are used to break down cohesive materials.

Calcium carbide reagent is available in cans. This may be a finely pulverized material and should be of a grade capable of producing at least 2.25 cu.ft. of acetylene gas per pound of calcium carbide.

In performing the test, in the 26 gram sample unit, three scoops of reagent (approximately 24 grams) and two balls are placed in the large chamber of the tester.

When using the 6 gram sample tester, place on level scoopful (approximately 8 grams) of calcium carbide in the larger chamber of the tester. Steel balls are not used with the 6 gm sample tester.

Speed moisture tester is shown in Figure 3.1.1.

3.1.4.1.3 Preparation of the material. The speedy moisture test gives consistently accurate results in approximately 3 minutes. The material should be prepared for test as follows:

a) Sands and fine powders : No preparation necessary.
b) Clays, soils and other coarse materials: Use steel ball speedy moisture test.
c) Aggregates: No preparation necessary.

3.1.4.1.4 Pre-caution. Five rules should be noted before testing. Make sure that:

a) The body or cap, whichever is being used for the material, is perfectly clean and contains no active absorbent from a previous test.
b) The material is truly representative of the bulk and carefully weighed.
c) The material and the absorbent are kept separate until the cap is tightly secured to the body.
d) The material has been thoroughly prepared – ground or pulverized or mixed with sand (if necessary) so that the absorbent can act freely on the material.
e) Make sure that the steel ball pulverizes are used when testing clays, soils etc.

3.1.4.2 Procedure

a) Weight the desired 6, 26, or 200 gram test sample on the scale.
b) Place the soil sample in the cap of the tester. Then, with the pressure vessel in approximately horizontal position, insert the cap in the pressure vessel and seal the unit by tightening the clamp, taking care that no calcium carbide comes in contact with the soil sample until a seal is achieved.
c) Raise the moisture tester to a vertical position so that the soil in the cap falls into the pressure vessel.
d) Then shake the tester vigorously so that all the lumps will be broken up, permitting the calcium carbide to react with all the available free moisture. When steel balls are used in the tester, the instrument should be shaken with a rotating motion. This will prevent damage to the instrument and eliminate the possibility of soil particles becoming embedded in the orifice leading to the pressure diaphragm.
e) Continue shaking for approximately one minute for granular soils and up to three minutes for other soils, to allow for complete reaction between the calcium carbide reagent and free moisture. Time should be permitted to allow dissipation of the heat generated by the chemical reaction.
f) When the dial indicator stops moving, read the dial while holding the instrument in a horizontal position at eye level.
g) Record the sample weight and the dial reading.
h) With the cap of the instrument pointed away from the operator, slowly release the gas pressure. Empty the pressure vessel and examine the material for lumps. If the sample is not completely pulverized, the test should be repeated using a new sample.
i) The dial reading is the percent of moisture by wet weight and must be converted to dry weight percent.

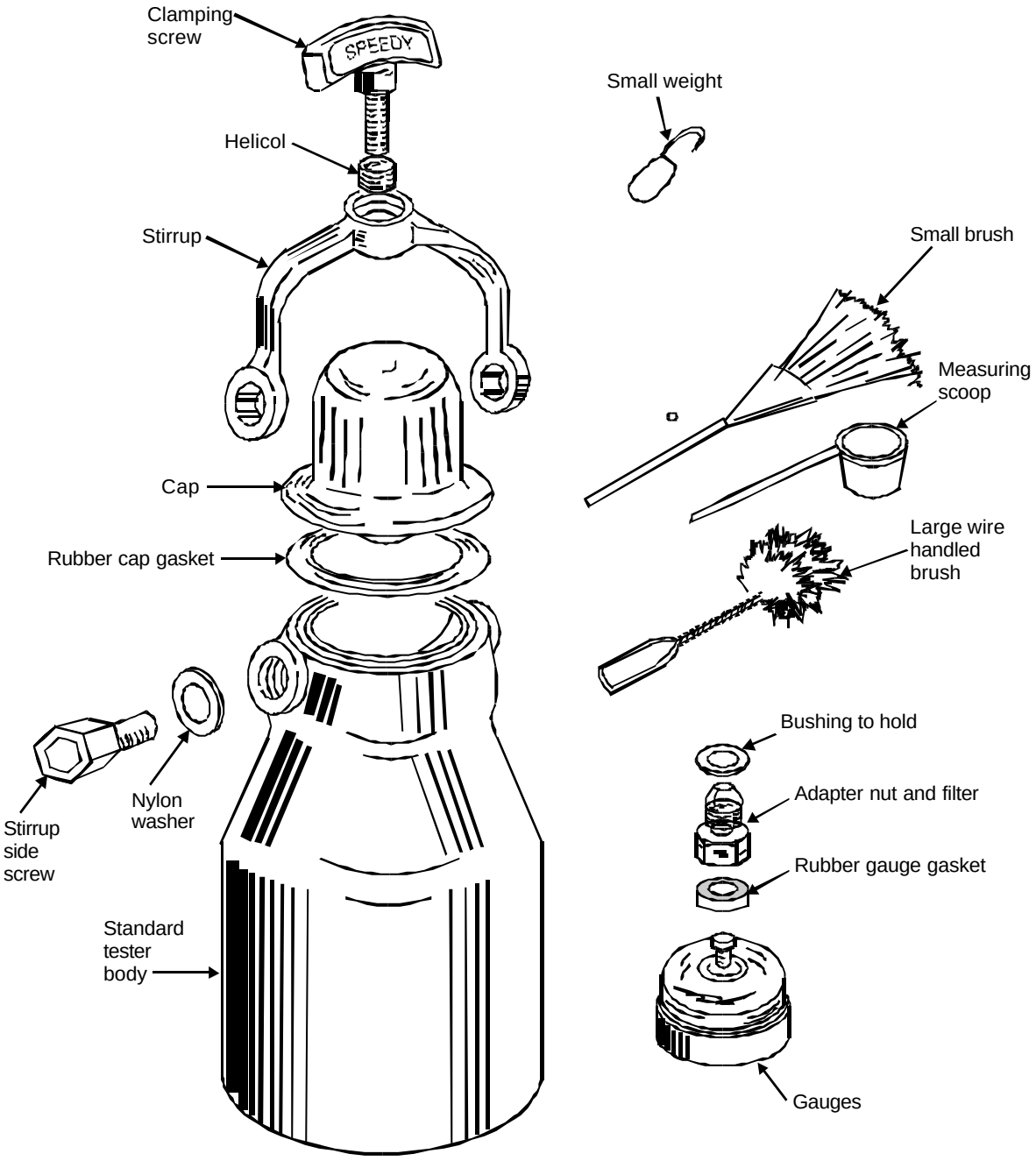


Figure 3.1.1 a) Speedy moisture tester

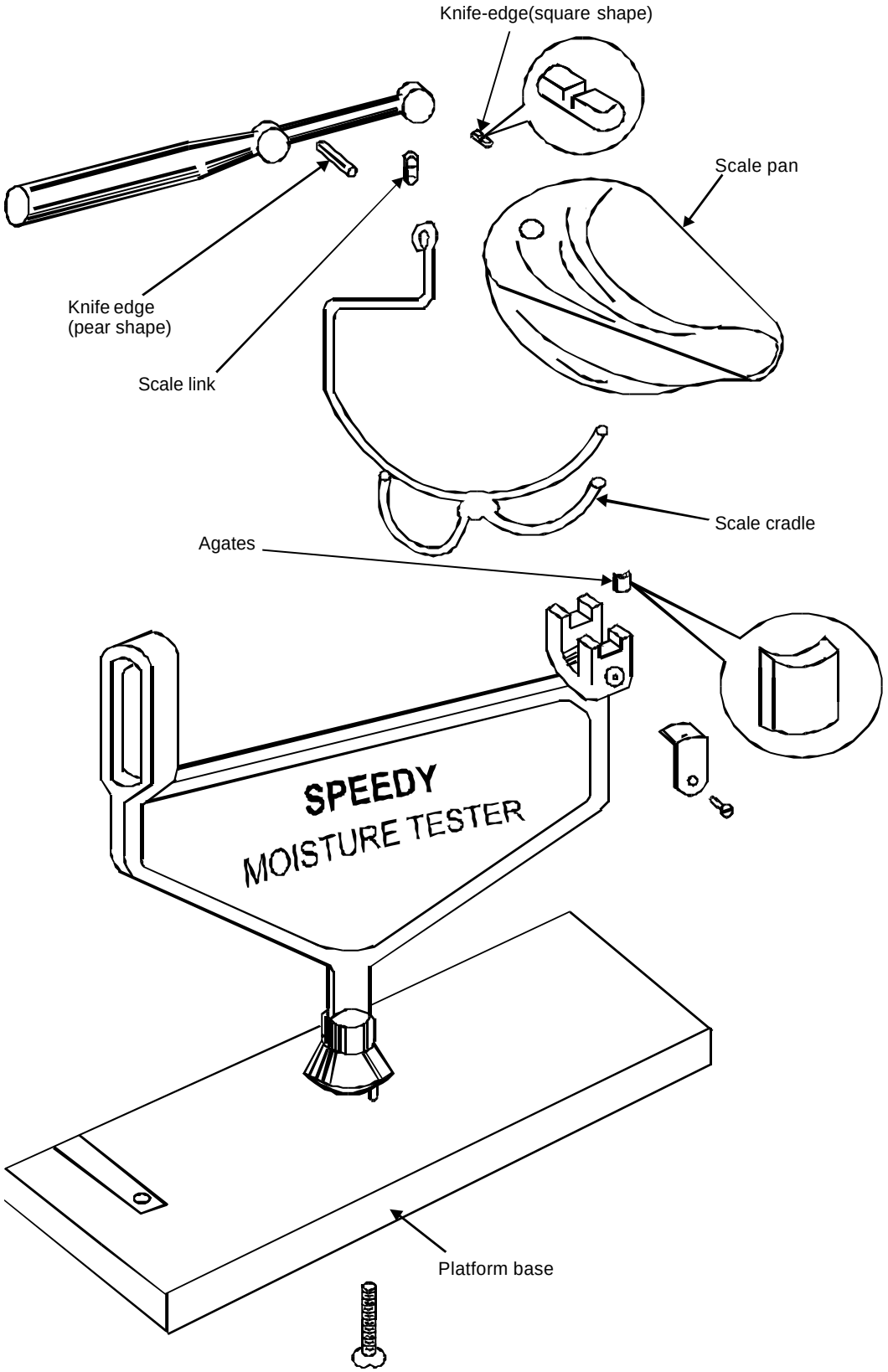


Figure 3.1.1 b) Speedy moisture tester

3.1.4.3 Expression of results and report

Moisture content should be expressed to two significant figures, e.g. 1.9%, 4.3%. Wet weight / dry weight conversion Chart (when steel ball pulverizes are not used) is presented in Table 3.1.1 and the conversion chart (when using steel ball pulverizes) is shown in Figure 3.1.2. The test report shall contain the following information:

a) Method of test used,
b) The moisture content
c) Full details of the sample origin.

Table 3.1.1

Wet Weight / Dry Weight Conversion Chart

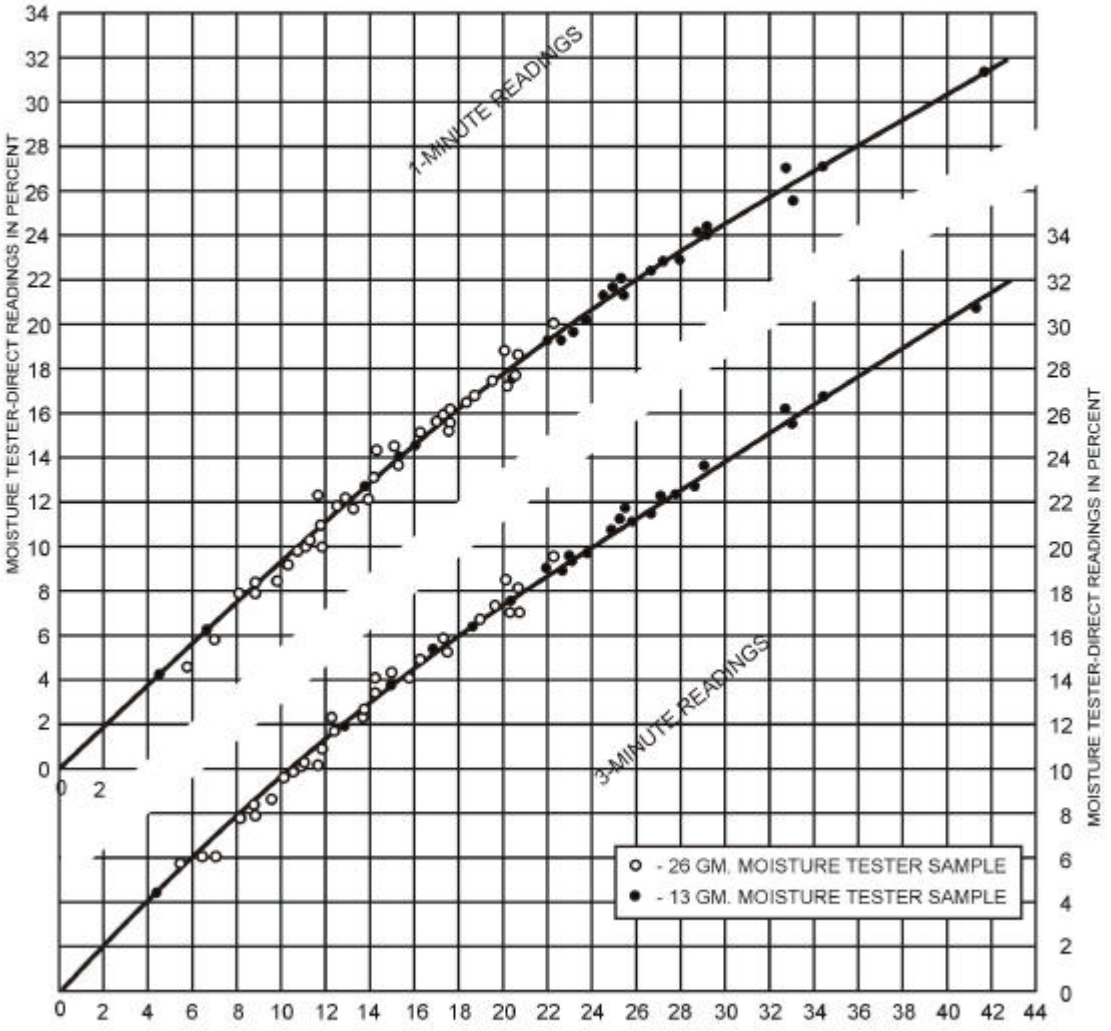
Not Applicable When Steel Ball Pulverizes Used – See Figure 3.1.2
With Calibration Curves on Reverse Side

SPEEDY READING		SPEEDY READING		SPEEDY READING	
Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight
1.0%	1.0%	20.5%	25.8%	35.5%	55.0%
2.0%	2.1%	21.0%	26.5%	36.0%	56.2%
3.0%	3.2%	21.5%	27.4%	36.5%	57.4%
4.0%	4.3%	22.0%	28.2%	37.0%	58.7%
5.0%	5.4%	22.5%	29.0%	37.5%	60.0%
6.0%	6.5%	23.0%	29.8%	38.0%	61.2%
7.0%	7.6%	23.5%	30.7%	38.5%	62.6%
8.0%	8.7%	24.0%	31.5%	39.0%	63.9%
9.0%	9.8%	24.5%	32.4%	39.5%	65.2%
10.0%	11.0%	25.0%	33.3%	40.0%	66.6%
10.5%	11.7%	25.5%	34.2%	40.5%	68.0%
11.0%	12.3%	26.0%	35.3%	41.0%	69.4%
11.5%	13.0%	26.5%	36.0%	41.5%	70.9%
12.0%	13.6%	27.0%	36.9%	42.0%	72.4%
12.5%	14.2%	27.5%	37.9%	42.5%	73.8%
13.0%	14.9%	28.0%	38.8%	43.0%	75.4%
13.5%	15.6%	28.5%	39.8%	43.5%	76.9%
14.0%	16.3%	29.0%	40.8%	44.0%	78.5%
14.5%	16.9%	29.5%	41.8%	44.5%	80.1%
15.0%	17.6%	30.0%	42.8%	45.0%	81.8%
15.5%	18.3%	30.5%	43.9%	45.5%	83.4%
16.0%	19.0%	31.0%	44.9%	46.0%	85.1%
16.5%	19.7%	31.5%	45.9%	46.5%	86.9%
17.0%	20.4%	32.0%	47.0%	47.0%	88.6%
17.5%	21.2%	32.5%	48.1%	47.5%	90.6%
18.0%	21.9%	33.0%	49.2%	48.0%	92.3%
18.5%	22.7%	33.5%	50.3%	48.5%	94.1%
19.0%	23.4%	34.0%	51.5%	49.0%	96.0%
19.5%	24.2%	34.5%	52.6%	49.5%	98.0%
20.0%	25.0%	35.0%	53.8%	50.0%	100.0%

Figure 3.1.2 Wet Weight / Dry Weight Conversion Graph

Calibration Curves for 1-and 3-Minute Tester Readings

When Using Steel Ball Pulverizers
Refer to This Graph for Dry-Weight Conversion



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