Australian Standard®

Methods of testing soils for engineering purposes

Method 5.8.1: Soil compaction and density tests—Determination of field density and field moisture content of a soil using a nuclear surface moisture–Density gauge—Direct transmission mode

1 SCOPE

This Standard sets out the method for determining the field density of a soil using a nuclear surface moisture-density gauge in the direct transmission mode of operation. It describes the method for determining the field moisture content of a soil using the same device, but other methods of moisture content determination may also be used. Gauges determine the gross mass per unit volume (field wet density) of the soil and the mass of water per unit volume (field water content) of the soil. Field dry density and moisture content can be calculated from these values.

This method is applicable to soils having not more than 20% by mass of particles retained on the 37.5 mm sieve. Some soils containing variable percentages of chemically bound water or other neutron moderators or absorbers may require the moisture content of the material to be determined in accordance with AS 1289.2.1.1 or one of the subsidiary methods, AS 1289.2.1.2, AS 1289.2.1.4, AS 1289.2.1.5 or AS 1289.2.1.6.

Because of the variety of gauges available, this method does not detail the operation of the gauge but refers the operator to the manufacturer's handbook.

When nuclear gauges are used for density or moisture measurement, the volume of material being assessed is not precisely known; however, reference to the manufacturer's handbook and current literature may indicate the likely volume. The zone of influence for the nuclear moisture function of a gauge is normally restricted to less than 150 mm below the base of the gauge.

A nuclear gauge gives an indirect measure of field density and field moisture content and hence requires calibration in accordance with AS 1289.5.8.4. Regular checks on the operation and the calibration of the gauge are also required (see Clause 5). When the moisture content is measured using the gauge, the intercept of the moisture calibration equation needs to be determined for each material being tested.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS		
1289	Methods of testing soils for engineering purposes	
1289.2.1.1	Method 2.1.1:	Soil moisture content tests—Determination of the moisture content of a soil—Oven drying method (standard method)
1289.2.1.2	Method 2.1.2:	Soil moisture content tests—Determination of the moisture content of a soil—Sand bath method (subsidiary method)
1289.2.1.4	Method 2.1.4:	Soil moisture content tests—Determination of the moisture content of a soil—Microwave-oven drying method (subsidiary method)
1289.2.1.5	Method 2.1.5:	Soil moisture content tests—Determination of the moisture content of a soil—Infrared lights method (subsidiary method)
1289.2.1.6	Method 2.1.6:	Soil moisture content tests—Determination of the moisture content of a soil—Hotplate drying method
1289.2.3.1	Method 2.3.1:	Soil moisture content tests—Establishment of correlation—Subsidiary method and the standard method (AS 1289.2.1.1)
1289.5.4.1	Method 5.4.1:	Soil compaction and density tests—Compaction control test—Dry density ratio, moisture variation and moisture ratio
1289.5.4.2	Method 5.4.2:	Soil compaction and density tests—Compaction control test—Assignment of maximum dry density and optimum moisture content values
1289.5.8.4	Method 5.8.4:	Soil compaction and density tests—Nuclear surface moisture-density gauges—Calibration using standard blocks

3 SAFETY PRECAUTIONS

The equipment used in this method utilizes radioactive materials, which may be hazardous to health unless proper precautions are taken. Therefore, it is essential that operators receive instruction on potential hazards and precautions, together with routine safety check procedures such as the use of personal radiation monitors, source leak testing and use of radiation survey meters. Statutory regulations cover the use, transport and storage of radioactive substances in the State or Territory in which the gauge is to be used.

4 APPARATUS

The following items of apparatus are essential for the correct performance of the test (additional items may be required for the correct usage of a particular model of gauge):

(a) Nuclear surface moisture-density gauge calibrated in accordance with AS 1289.5.8.4, logbook, manufacturer's handbook for the gauge, and the manufacturer's reference block for standard counts that were used for the calibration of the gauge.

The maximum uncertainty of the predicted density of the nuclear gauge, at the 95% confidence limits, for the calibration equation for the depth being used for the test shall not exceed 0.06 t/m^3. The maximum uncertainty of the predicted water content, at the 95% confidence limits, from the calibration equation (as defined in AS 1289.5.8.4) shall not exceed 0.07 t/m^3.

(b) Scraper plate, shovel and brush.

(c) Rotary hammer drill or drill rod capable of forming a hole at least 16 mm in diameter.

NOTE: In order to reduce distortion of the surface of the compacted soil, the shaft of the drill rod may be tapered 1 in 100 over its length.

(d) Secondary block of naturally occurring stone or concrete of minimum size 500 mm long by 300 mm wide by at least 50 mm greater than the greatest depth at which the gauge density system consistency checks will be carried out, or a standard density block as defined in AS 1289.5.8.4.

NOTE: Concrete secondary blocks may be used provided they have been allowed to dry to a stable state following manufacture, and are kept in a stable moisture condition.

(e) A fine density sand of one size (passing 0.600 μm) of the material under test.

5 GAUGE CALIBRATION AND OPERATIONAL CHECKS

Nuclear surface moisture-density gauges shall be calibrated at each probe position of interest in accordance with AS 1289.5.8.4 and shall be recalibrated at least once every two years or after any major repair or component replacement. Regular checks on the operation and calibration of the gauges shall be made as follows:

(a) Standard count checks, as detailed in Paragraph A1 of Appendix A, shall be made on each day of use.

(b) Gauge function checks, as detailed in Paragraph A2 of Appendix A, shall be made at least once per month.

(c) Density system consistency checks, as detailed in Paragraph A3 of Appendix A, shall be made at least once per month.

(d) Moisture intercepts for each material shall be determined as detailed in Appendix B and redetermined—

(i) if the time between the use of the value and the determination of the value is greater than three months; or

(ii) if the maximum dry density as determined in accordance with AS 1289.5.4.2 has been reassigned.

6 PROCEDURE

The procedure shall be as follows:

(a) At the works site, obtain and record the field standard counts, with the manufacturer's reference block placed on the material to be tested, in accordance with the procedure specified for the gauge by the manufacturer. The field standard counts are valid for testing of material on which they were determined, for that test lot only.

NOTE: The gauge should not be used near any vertical projection that is within 150 mm of the short side of the gauge and 600 mm of the long side of the gauge. When a gauge is used within these distances, the effects of reflected radiation has to be taken account of by performing a separate field standard count for each density and moisture count. When used in a trench, the gauge should be placed in the trench so that the longitudinal axis of the gauge is parallel to the structure or the walls of the trench. If the material to be tested is overlying a pipe, the end of the probe should be at least 50 mm above the pipe.

(b) Select a test site on which density and moisture contents are to be determined and ensure that—

(i) loose material is swept or cleared off the surface; and

(ii) the surface is essentially flat and essentially free of cracks and depressions.

NOTE: Cracking in the surface of the soil should not adversely affect the test results provided the gauge is so positioned that no crack extends from the source directly to the detector tubes and provided the soil integrity has not been affected.

(c) Using the scraper plate as a guide, drill or drive a direct transmission access hole to a depth at least 25 mm greater than the required test depth.

NOTES:

1 When testing a layer(s) of soil, the required test depth is the maximum depth that allows both the probe to be located in the testing position and the probe to remain in the layer(s) being tested.

2 The surface of the compacted soil should be flat after the removal of the drill rod.

(d) Place the gauge on the test site, checking that it is firmly seated. It is permissible to use small quantities of fines of the material under test or a fine sand to fill small surface voids, taking care to avoid placing fines in the hole. This material shall not form an added layer.

(e) Insert the probe into the hole to the required test depth. Move the gauge longitudinally so that the side of the probe nearest to the density detector is in contact with the side of the hole.

(f) Follow the gauge manufacturer's instructions to obtain at least one density reading with a count time of not less than 60 s. Record the field wet density (ρ), and the corresponding density count.

If the moisture content of the soil is to be determined using the gauge, follow the gauge manufacturer's instructions to obtain at least one moisture reading with a count time of not less than 60 s. Record field water content of the soil (W) or field moisture content of the soil (w) and the corresponding moisture count.

NOTES:

1 When using gauges with in-built data processing circuitry that enables direct reading of density and moisture content, it is important for traceability to record the counts as well as the direct readings from the gauge for each set of readings.

2 Gauge calibration data may be in the form of calibration constants stored in the gauge microprocessor, calibration constants to be used in association with an electronic calculator, calibration charts or count ratio versus density tables.

3 Some gauges are not fitted with a microprocessor, while other gauges may be fitted with a microprocessor but require the use of a different and incompatible form of calibration equation than that supplied by the manufacturer. Such gauges require recording of the counts only.

4 Nuclear surface moisture-density gauges determine field moisture content using backscatter and field density using direct transmission. Therefore, the volume of material being assessed when measuring field density can differ from that to which moisture measurements apply.

5 Some gauge models make an in-built correction to wet density to take into account the effect of gamma mass attenuation of water. Users should satisfy themselves that this correction does not significantly affect the accuracy of the wet density reading.

(g) If the moisture content of the soil is to be determined using a method other than the gauge, remove any fines or fine sand placed on the surface and obtain a sample of soil from the test site by excavating a hole with vertical sides to the depth at which the probe was located during the tests. The centre of the hole shall be at the centre of the gauge base. Determine the moisture content of the soil in accordance with AS 1289.2.1.1, AS 1289.2.1.2, AS 1289.2.1.4, AS 1289.2.1.5, or AS 1289.2.1.6.

NOTES:

1 If oversize material is present, a sample should be taken to determine the percentage by mass of the material retained on the 19.0 mm or 37.5 mm sieve, as detailed in AS 1289.5.4.1.

2 Methods AS 1289.2.1.2, AS 1289.2.1.4, AS 1289.2.1.5 or, AS 1289.2.1.6 may only be used if a satisfactory correlation of the method for the soil being tested has been determined in accordance with AS 1289.2.3.1.

7 CALCULATIONS

The following calculations shall be carried out as appropriate:

(a) If applicable, calculate the field density count ratio and, if required, the field moisture count ratio, by dividing the appropriate count by its corresponding field standard count.

(b) If applicable, calculate field wet density (ρ), in tonnes per cubic metre, at the test site, from the calibration coefficients, or read these values from the calibration charts or tables.

(c) If applicable, calculate the field water content (W) (mass of water per unit volume) from the following equation:

$$W = d(MCR) + c \qquad \ldots 7(1)$$

where

W = field water content of the soil, in tonnes per cubic metre

d = moisture slope constant determined in accordance with AS 1289.5.8.4

MCR = moisture content ratio

c = moisture intercept as detailed in Appendix B

(d) When required, calculate the field dry density (ρ_d) from the following equation:

$$\rho_d = \rho - W \qquad \ldots 7(2)$$

where

ρ_d = field dry density of the soil, in tonnes per cubic metre

ρ = field wet density of the soil, in tonnes per cubic metre

W = field water content of the soil, in tonnes per cubic metre

or, when field moisture content (w) has been determined from a field sample obtained in accordance with Clause 6 (g), calculate the field dry density (ρ_d) from the following equation:

