

Australian Standard™

AS 1289.5.7.1—2006

Methods of testing soils for engineering purposes

Method 5.7.1: Soil compaction and density tests—Compaction control test—Hilf density ratio and Hilf moisture variation (rapid method)

1 SCOPE

This Standard sets out a rapid method for determining compaction control parameters for soils. The method involves relating converted wet density (*CWD*) of the laboratory-compacted soil to added moisture (*Z*) without the need to determine moisture content.

The test is based on standard compactive effort in accordance with AS 1289.5.1.1. If modified compactive effort in accordance with AS 1289.5.2.1 is used, experimental data must initially be accumulated for that particular soil in order for the moisture variation to be reliably assessed (see Note to Clause 4.2(h)).

Because this is a rapid method, there may be minor differences between results obtained by this procedure and results obtained by the method of compaction control given in AS 1289.5.4.1.

This procedure is applicable to the portion of soil that passes a 37.5 mm sieve. Corrections can be made to values determined by this method for soil with up to 20% oversize material. Soil that passes a 19.0 mm sieve is compacted in a 105 mm diameter mould. Soil that contains more than 20% of material retained on a 19.0 mm sieve is compacted in a 152 mm diameter mould.

Because of the omission of proper curing, this method might not be reliable for soils that are much wetter or drier than the optimum moisture content.

Further, because of the empirical basis for the calculation of moisture variation, the method is limited to added moisture values (*Z*) between -4% and $+6\%$ (see Figure 1).

This method may be used for checking material before placement to ensure that the moisture content is within specified limits (see Note to Clause 4.2(h)).

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1152	Specification for test sieves
1289	Methods of testing soils for engineering purposes
1289.1.1	Method 1.1: Sampling and preparation of soils—Preparation of disturbed soil samples for testing
1289.5.1.1	Method 5.1.1: Soil compaction and density tests—Determination of the dry density/moisture content relation of a soil using standard compactive effort

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- 1289.5.2.1 Method 5.2.1: Soil compaction and density tests—Determination of the dry density/moisture content relation of a soil using modified compactive effort
- 1289.5.3.1 Method 5.3.1: Soil compaction and density tests—Determination of the field density of a soil—Sand replacement method using a sand-cone pouring apparatus
- 1289.5.3.2 Method 5.3.2: Soil compaction and density tests—Determination of the field dry density of a soil—Sand replacement method using a sand pouring can, with or without a volume displacer
- 1289.5.3.5 Method 5.3.5: Soil compaction and density tests—Determination of the field dry density of a soil—Water replacement method
- 1289.5.4.1 Method 5.4.1: Soil compaction and density tests—Compaction control test—Dry density ratio, moisture variation and moisture ratio
- 1289.5.8.1 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

3 APPARATUS

The following apparatus is required:

- (a) A cylindrical metal mould appropriate to the size of material as described in AS 1289.5.1.1 or AS 1289.5.2.1.
- (b) A steel rammer, or an alternative mechanical compaction device, as described in AS 1289.5.1.1 or AS 1289.5.2.1.
- (c) A level rigid foundation on which to compact the specimen, e.g., a sound concrete floor approximately 100 mm or more in thickness, or a concrete block of at least 100 kg mass.
- (d) A balance of suitable capacity with a limit of performance not greater than ± 5 g.
- (e) Sieves, 37.5 mm and 19.0 mm, complying with AS 1152.
- (f) A strong spatula or a suitable knife.
- (g) A steel straightedge, approximately 250 mm long, 25 mm wide and 3 mm thick, and preferably with one bevelled edge.
- (h) Miscellaneous mixing apparatus, such as pan or bowl, spoon, trowels and water spray, suitable for thoroughly mixing increments of water with the soil.
- (i) A rule graduated in millimetres or a layer depth gauge.
- (j) Sealable containers suitable for curing moistened soil samples.
- (k) A siphon can and a calibrated volumetric measuring cylinder.
- (l) A sample extractor, such as a jack, lever, frame or other device, suitable for extruding compacted soil specimens from the mould (optional).
- (m) A soil grater for fine-grained materials (optional).

4 PROCEDURE

4.1 Sampling and preparation

The validity of the method depends upon the field-in-place moisture content and the moisture content of the split compaction samples (prior to wetting or drying) being substantially the same; therefore, considerable care should be taken to ensure that moisture loss is minimized during the sampling, preparation and compaction procedures.

The procedure shall be as follows:

- (a) Determine the field wet density of the soil (ρ) using the method described in AS 1289.5.3.1, AS 1289.5.3.2, AS 1289.5.3.5 or AS 1289.5.8.1.
- (b) Obtain a bulk sample of the soil for the compaction test from the material excavated during the in situ density test. If this material is insufficient for the bulk sample, obtain additional material immediately after completion of the field density test by enlarging the density hole laterally to a depth approximately equal to but not exceeding the depth of the field density test hole. The sides of any excavation made to recover the required bulk sample of material shall be reasonably vertical. For sites for which the field density has been determined by a nuclear surface moisture-density gauge, obtain the bulk sample by excavating a hole centred between the nuclear source and the detector in the gauge. The depth of the excavation shall be equal to the depth of insertion of the source rod during the field density test. The sides of any excavation made to recover the required bulk sample of material shall be reasonably vertical. Collect, transport and store samples in sealable containers.
- (c) Prepare the sample in accordance with AS 1289.1.1.
- (d) Determine the total mass (m) of the wet material. Screen the prepared sample over a 19.0 mm sieve. Determine the wet mass (m_o) of the material retained on the 19.0 mm sieve.

Calculate the percentage of oversize material using the equation—

$$P_o = \frac{100 m_o}{m} \quad \dots 4.1$$

where

P_o = the percentage of material by mass retained on sieve, based on the wet mass of the total material and the oversize material

m_o = the wet mass of oversize material, in grams

m = the wet mass of the total sample before screening, in grams

If more than 20% of the material is retained on the 19.0 mm sieve, screen this material over a 37.5 mm sieve. When material is retained on this sieve, determine its wet mass and calculate the percentage of oversize material on the wet mass basis, as above.

- (e) If oversize material is present, determine the volume (V_o) of the oversize material by methods such as measuring its displacement of water using a siphon can or a calibrated volumetric measuring cylinder.
- (f) Select the size fraction and mould size to be used in the compaction test using the criteria in Table 1.

Record the mould used as type A or B.

When necessary, recombine the material passing the 37.5 mm sieve and that passing the 19.0 mm sieve and thoroughly mix.

- (g) Split out three or more representative portions of the screened soil, each of sufficient quantity to produce a compacted volume in excess of the volume of the mould.

NOTE: For material compacted in a 105 mm diameter mould, a mass of 2.5 kg will be adequate for most soils. Gravel may require up to 3 kg, while it may be possible to use as little as 2 kg of heavy clay. For material compacted in a 152 mm diameter mould, about 2.5 times the material required for a 105 mm diameter mould will be required. Sample sufficient soil in case three points are not adequate. Generally, 15 kg of soil when using a 105 mm diameter mould, and 40 kg of soil when using a 150 mm diameter mould, should be adequate.

- (h) If required, determine the field moisture content (w_f) of a representative portion of the sample.

TABLE 1
SIZE FRACTION AND MOULD TYPE

Percent retained		Test mould type	Portion to be tested
37.5 mm sieve	19.0 mm sieve		
>20			Not testable using this method
≤20	>20	B	All material passing 37.5 mm sieve
	≤20	A	All material passing 19.0 mm sieve

4.2 Compaction

The samples shall be compacted in the following manner:

- (a) Take a portion of the screened soil as prepared in Clause 4.1(g). Add or remove moisture, or leave as is, so that the soil is at the optimum moisture content. Record the amount of moisture added or removed.

NOTES:

- 1 Increments of 2% are usually suitable for cohesive soils; however, in some cases more compaction points or different moisture increments may be needed. In particular, for non-cohesive soils the moisture increments may need to be 0.5% to 1.0%.
 - 2 Dry out soil samples that are wetter than the optimum moisture content. To accelerate the drying process, a special sample drier may be used. This usually consists of a 450 mm diameter 425 µm sieve supported by a coarser mesh mounted over a fan-heater with a small metal cone between them. Alternatively, infra-red lights or a fan that blows air across the soil may be used. The soil should be turned from time to time to assist evaporation.
 - 3 It is important that moisture not be lost from the sample portions during preparation and testing.
- (b) Thoroughly mix the portion to ensure uniform distribution of moisture through the soil. Compact the portion of soil as described in AS 1289.5.1.1 or AS 1289.5.2.1 and calculate the wet density of the compacted specimen.
- (c) Calculate the corresponding converted wet density for the specimen using the equation—

$$CWD = \rho_w / (1 + Z/100) \quad \dots 4.2(1)$$

where

CWD = converted wet density, in tonnes per cubic metre

ρ_w = wet density of the compacted specimen, in tonnes per cubic metre

Z = the added moisture based on the original mass of wet soil, in percent