
**Soil quality — Determination of dry
bulk density**

Qualité du sol — Détermination de la masse volumique apparente sèche

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Test procedures	2
4.1 Core method	2
4.1.1 Principle	2
4.1.2 Apparatus	2
4.1.3 Sampling and drying	2
4.1.4 Calculation	3
4.2 Excavation method	3
4.2.1 Principle	3
4.2.2 Apparatus	3
4.2.3 Field procedure	4
4.2.4 Laboratory procedure	4
4.2.5 Calculation	5
4.3 Substitute methods	6
4.4 Clod method	7
4.4.1 Principle	7
4.4.2 Apparatus	7
4.4.3 Procedure	8
4.4.4 Calculation	8
4.4.5 Unified reference temperature	9
5 Test report	9
Annex A (informative) Volume measurement using plastic balls	10
Annex B (normative) Density of water at different temperatures	11
Bibliography	14

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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This second edition cancels and replaces the first edition (ISO 11272:1998), which has been technically revised.

Introduction

The dry bulk density is used together with the particle density (see ISO 11508) for the calculation of the solids content and porosity of soil for the evaluation of soil structure and conversion of concentrations of substances in soil from mass/volume to mass/mass and vice versa.

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Soil quality — Determination of dry bulk density

1 Scope

This document specifies three methods for the determination of dry bulk density of soils calculated from the mass and the volume of a soil sample. The methods involve drying and weighing a soil sample, the volume of which is either known [core method (see 4.1)] or determined [excavation method (see 4.2) and clod method (see 4.4)].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM D1556, *Standard test method for density and unit weight of soil in place by sand-cone method*

ASTM D2167, *Standard test method for density and unit weight of soil in place by the rubber balloon method*

ASTM D4914, *Standard test methods for density of soil and rock in place by the sand replacement method in a test pit*

ASTM D5030, *Standard test methods for density of soil and rock in place by the water replacement method in a test pit*

DIN 18125-2, *Soil investigation and testing — Determination of density of soil — Part 2: Field tests*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

dry bulk density

ratio of the oven-dry mass of the solids to the volume of the soil

Note 1 to entry: The bulk volume includes the volume of the solids and of the pore space.

Note 2 to entry: The preferred SI unit of measurement is kilograms per cubic metre ($\text{kg} \cdot \text{m}^{-3}$), but grams per cubic centimetre ($\text{g} \cdot \text{cm}^{-3}$) is also very common. Note that $x \text{ g} \cdot \text{cm}^{-3} = 1\,000 x \text{ kg} \cdot \text{m}^{-3}$.

4 Test procedures

4.1 Core method

4.1.1 Principle

This method is applicable to stoneless and slightly stony soils. Core samples of known volume are taken with a metal sampling tool. The sample is dried in an oven and weighed, and the dry bulk density is calculated.

4.1.2 Apparatus

4.1.2.1 Core sample holders, thin-walled metal cylinders with a volume of 100 cm³ to 400 cm³, a steel cap for driving into the soil, and a driver.

4.1.2.2 Oven, heated and ventilated, capable of maintaining a temperature of (105 ± 2) °C.

4.1.2.3 Desiccator, sealed chamber in which the air is kept dry with the aid of silica gel or other desiccant.

4.1.2.4 Laboratory balance, capable of weighing to an accuracy of 1/1 000 of the measured value.

4.1.3 Sampling and drying

Press or drive a core sample holder (4.1.2.1) of known volume without deflection and compaction into either a vertical or horizontal soil surface far enough to fill the sampler. Carefully remove the sample holder and its contents to preserve the natural structure, and trim the soil extending beyond each end of the sample holder with a straight-edged knife or sharp spatula. The soil sample volume is thus equal to the volume of the sample holder. Take at least six core samples from each soil layer. Place the holders containing the samples in an oven (4.1.2.2) at 105 °C until constant mass is reached.

NOTE 1 In most cases, constant mass is reached after 48 h drying.

Remove the samples from the oven and allow them to cool in the desiccator (4.1.2.3). Weigh the samples on the balance (4.1.2.4) immediately after removal from the desiccator (m_T). Control mass is reached when the differences in successive weighings of the cooled sample, at intervals of 4 h, do not exceed 0,01 % of the original mass of the sample.

Swell/shrink soils (especially clays, muds and peats) change their bulk density with changing water content. Such soils should be sampled first in a moist state (i.e. field capacity); in addition, they should be sampled in a wetter state (water saturation) and in a drier state (i.e. wilting point). If the dry soil is too hard to be sampled, the bulk density of the soil can be determined according to 4.3, and the total soil volume according to 4.2.3.

NOTE 2 If bulk density (and water content) is the only parameter of interest, it is not necessary to keep the samples in their holders when taking them back to the laboratory. After the sample has been obtained and trimmed, the soil can be extracted from the holder, without loss, in order to be stored for transportation either in a metal box or in a heat-resistant plastic bag.

It is normally worthwhile to combine a measurement of the water content with a measurement of the bulk density; in that case it is necessary to transport the samples without allowing loss of water by evaporation, and to begin the laboratory operations by weighing the fresh sample.

4.1.4 Calculation

The dry bulk density is calculated using [Formula \(1\)](#) and [Formula \(2\)](#):

$$\rho_{b,s} = \frac{m_d}{V} \quad (1)$$

$$m_d = m_t - m_s \quad (2)$$

where

$\rho_{b,s}$ is the bulk density, dry, in grams per cubic centimetre, g/cm³;

m_d is the mass of the sample dried at 105 °C, in grams, g;

V is the volume of the sample holder, in cubic centimetres, cm³;

m_s is the mass of the empty sample holder, in grams, g;

m_t is the mass of the sample holder together with the soil sample dried at 105 °C, in grams, g.

4.2 Excavation method

4.2.1 Principle

Bulk density is determined by excavating a quantity of soil, drying and weighing it, and determining the volume of the excavation by filling it with sand. This procedure is applicable to soils containing gravel and/or stones.

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4.2.2 Apparatus

4.2.2.1 Earth-digging equipment, such as a spade, with a long sharp-edged straight blade.

4.2.2.2 Sampling equipment, flat-bladed spade, knife (for hard or stony soil), pick, spade chisel, hammer.

4.2.2.3 Equipment for collecting and cleaning, such as plastic sheet, brush, heat-resistant plastic bags or canisters.

4.2.2.4 Plastic film, thin, flexible, but stable.

4.2.2.5 Equipment for spreading sand, including funnel with a gauging rod (the falling height beneath the funnel mouth should be 5 cm), graduated cylinder of 1 dm³ capacity.

4.2.2.6 Dry, graded sand of known volume, with a particle diameter between 500 µm and 700 µm.

4.2.2.7 Balance, capable of weighing to an accuracy of 0,1 g.

4.2.2.8 Oven, heated and ventilated, capable of maintaining a temperature of (105 ± 2) °C.

4.2.2.9 Vacuum desiccator with self-indicating desiccant.

4.2.2.10 Sieve, with 2 mm apertures.

4.2.2.11 Straight metal blade.

4.2.3 Field procedure

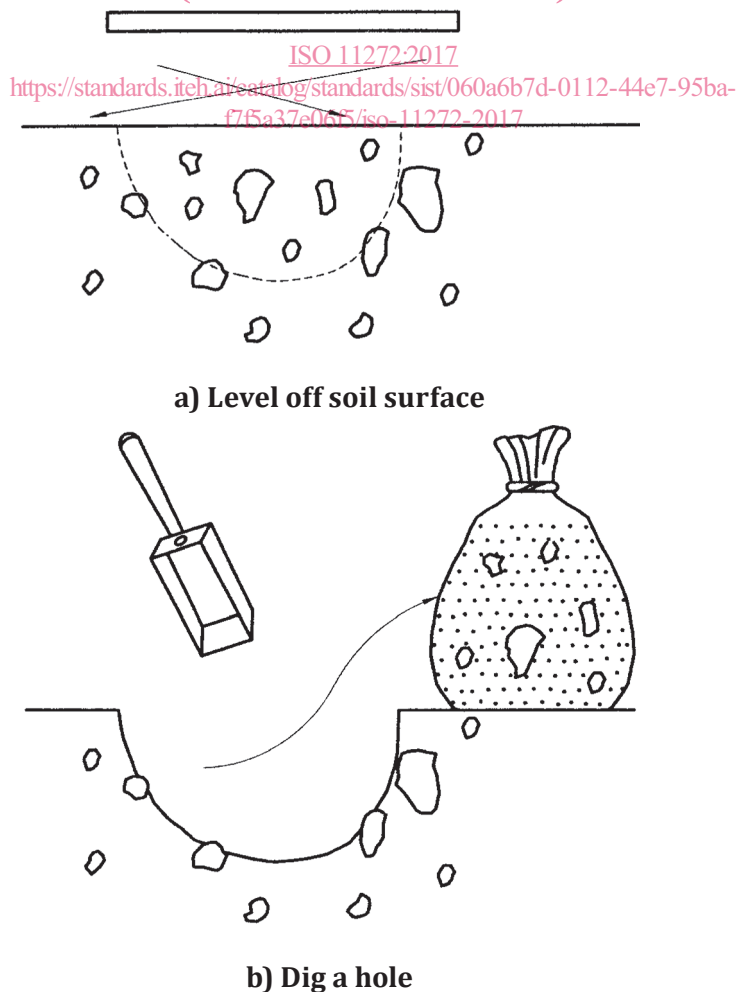
Level off the soil surface with the straight metal blade (4.2.2.11) [Figure 1 a)]. Dig a hole in the levelled soil having a representative content of larger gravel and stones according to visual inspection. Avoid compaction of the soil on the sides [Figure 1 b)]. Put the excavated soil in bags (4.2.2.3) for laboratory analysis. Large nonporous stones such as granite pieces may be separated in the field, cleaned with a stiff brush, putting the fine material into the bags. Weigh the large nonporous stone(s) on a field balance and include it in the mass of gravel and stones.

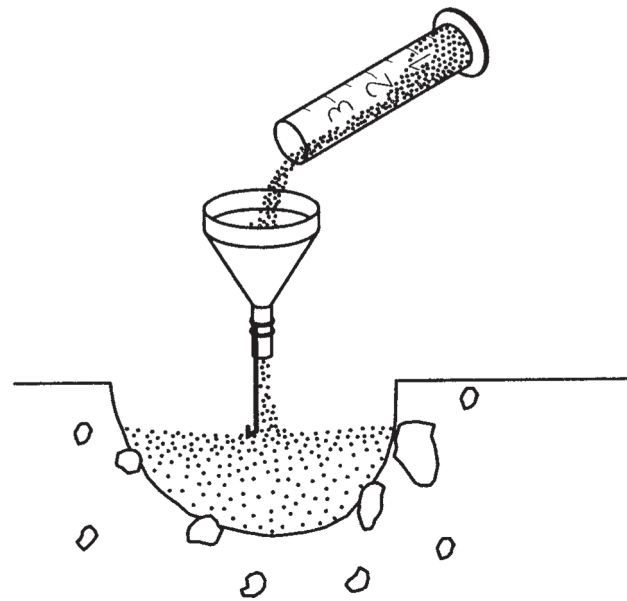
Line the hole with the plastic film (4.2.2.4). Using the funnel (4.2.2.5), fill the hole to excess with a known volume of sand (4.2.2.6) from a height of 5 cm [Figure 1 c)]; then, level the surface with the blade without packing down. Replace the excess sand into the graduated measuring cylinder (4.2.2.5), and read the volume [Figure 1 d)]; the difference from the initial volume of sand is the volume V of the hole.

4.2.4 Laboratory procedure

Determine the mass, in grams, of the moist excavated soil with a balance (4.2.2.7) (m_{pw}). Separate the stones and gravel from the fine soil with the sieve (4.2.2.10) (clean any dirty pieces with a cloth or a stiff brush), and weigh them on the laboratory balance (m_{xw}). Dry the stones and gravel in the oven (4.2.2.8) at $(105 \pm 2)^\circ\text{C}$ and after cooling weigh them, in grams, on the laboratory balance (m_x).

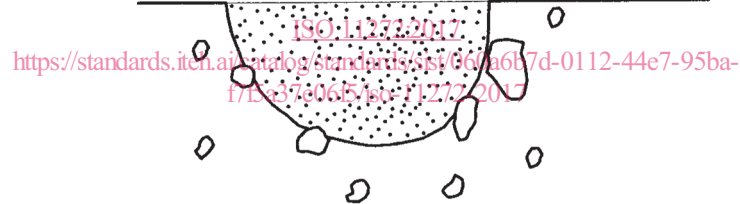
Determine the water content of the fine soil ($<2,0$ mm diameter) by drying a representative sample (5 g to 10 g) of known mass in the oven at $(105 \pm 2)^\circ\text{C}$ until constant mass is reached. Remove the sample from the oven and allow to cool in the desiccator. Weigh the sample on the laboratory balance. Calculate the water content (w) as a mass ratio of the moist sample.





c) Fill with sand

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d) Remove the excess sand and measure its volume

Figure 1 — Excavation method — Field procedure

4.2.5 Calculation

The dry bulk density of the soil layer is calculated using [Formula \(3\)](#) to [Formula \(6\)](#):

$$\rho_{b,s} = \frac{m_x + m_{fp}}{V} \quad (3)$$

$$m_{fp} = m_{pw} - m_{xw} - m_w \quad (4)$$

$$m_w = w \cdot m_{fw} \quad (5)$$

$$m_{fw} = m_{pw} - m_{xw} \quad (6)$$

where