

Soil quality —

Part 5: Physical methods —

Section 5.4: Determination of particle size distribution in mineral soil material — Method by sieving and sedimentation

ICS 13.080

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Amendments issued since publication

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National foreword

This British Standard reproduces verbatim ISO 11277:1998 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee EH/4, Soil quality, to Subcommittee EH/4/5, Physical methods, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

BS 7755 is being published in a series of Parts subdivided into Sections and Subsections that will generally correspond to particular international standards. Other Parts of BS 7755 are, or will be, as follows.

- *Part 1: Terminology and classification;*
- *Part 2: Sampling;*
- *Part 3: Chemical methods;*
- *Part 4: Biological methods;*
- *Part 5: Physical methods.*

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

Textual error

The textual error set out below was discovered when adopting the text of the international standard. It has been reported to ISO in a proposal to amend the text of the international standard. Clause **B.2.8**, line 2. The cross reference should just read “**(8.2.2)**”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ISO title page, pages ii to iv, pages 1 to 27 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

INTERNATIONAL STANDARD

ISO
11277

First edition
1998-05-15

Soil quality — Determination of particle size distribution in mineral soil material — Method by sieving and sedimentation

*Qualité du sol — Détermination de la répartition granulométrique de la
matière minérale des sols — Méthode par tamisage et sédimentation*



Reference number
ISO 11277:1998(E)



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Descriptors: Soils, quality, tests, soil testing, determination, size classification, sieve analysis.

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11277 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 5, *Physical methods*.

Annex A and Annex B form an integral part of this International Standard. Annex C is for information only.

Introduction

The physical and chemical behaviour of soils is controlled in part by the amounts of mineral particles of different sizes in the soil. The subject of this International Standard is the quantitative measurement of such amounts (expressed as a proportion or percentage of the total mass of the mineral soil), within stated size classes.

The determination of particle size distribution is affected by organic matter, soluble salts, cementing agents (especially iron compounds), relatively insoluble substances such as carbonates and sulfates, or combinations of these. Some soils change their behaviour to such a degree upon drying, that the particle size distribution of the dried material bears little or no relation to that of the undried material encountered under natural conditions. This is particularly true of soils rich in organic matter, those developed from recent volcanic deposits, some highly weathered tropical soils, and soils often described as “cohesive” [6]. Other soils, such as the so-called “sub-plastic” soils of Australia, show little or no tendency to disperse under normal laboratory treatments, despite field evidence of a large clay content.

The procedures given in this International Standard recognize these kinds of differences between soils from different environments, and the methodology presented is designed to deal with them in a structured manner. Such differences in soil behaviour can be very important, but awareness of them depends usually on local knowledge. Given that the laboratory is commonly distant from the site of the field operation, the information supplied by field teams becomes crucial to the choice of an appropriate laboratory procedure. This choice can be made only if the laboratory is made fully aware of this background information.

All procedures in this International Standard should be carried out by competent, trained persons, with adequate supervision. Attention is drawn to certain known hazards, but it is essential that users follow safe working practices. If in any doubt, seek professional advice.

It is essential that users of this International Standard read all of it before commencing any operation, as failure to note certain points will lead to incorrect analysis, and could be dangerous.

1 Scope

This International Standard specifies a basic method of determining particle size distribution applicable to a wide range of mineral soil materials, including the mineral fraction of organic soils. It also offers procedures to deal with the less common soils mentioned in the introduction. This International Standard has been developed largely for use in the field of environmental science, and its use in geotechnical investigations is something on which professional advice might be required.

A major objective of this International Standard is the determination of enough size fractions to enable the construction of a reliable particle size distribution curve.

This International Standard does not apply to the determination of the particle size distribution of the organic components of soil, i.e. the more or less fragile, partially decomposed, remains of plants and animals. It should also be realized that the chemical pretreatments and mechanical handling stages in this International Standard could cause disintegration of weakly cohesive particles that, from field inspection, might be regarded as primary particles, even though such primary particles could be better described as aggregates. If such disintegration is undesirable, then this International Standard should not be used for the determination of the particle size distribution of such weakly cohesive materials.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 565:1990, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*.

ISO 3310-1:1990, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*.

ISO 3310-2:1990, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*.

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*.

ISO 11464:1994, *Soil quality — Pretreatment of samples for physico-chemical analyses*.

3 Terminology and symbols

3.1 Terminology

Particles within particular size ranges or classes are commonly described as cobbles, gravel, coarse sand, silt, etc. The meaning of such trivial names differs between countries, and in some cases there are no exact translations of such words from one language to another; for example, the Dutch word “zavel” has no equivalent in English. The only fraction for which there appears to be common agreement is clay, which is defined as material of less than 0,002 mm equivalent spherical diameter [1, 6]. Such trivial names shall not be used in describing the results of particle size determination according to this International Standard. Phrases such as “...passing a 20 mm aperture sieve...” or “...less than 0,063 mm equivalent spherical diameter...” shall be used instead. If trivial names must be used, for example to cross-reference to another (inter-)national standard, then the trivial name should be defined explicitly, so as to remove any doubt as to the meaning intended, e.g. silt (0,063 mm to 0,002 mm equivalent spherical diameter) (clause 4 and, for example, [3]). Further, it is common to use the word “texture” to describe the results of particle size distribution measurements, e.g. “the particle size of this soil is of clay texture”. This is incorrect as the two concepts are different, and the word “texture” shall not be used in the test report (clause 10) to describe the results obtained by use of this International Standard.

It is common to refer to sieves as having a particular mesh-size or mesh number. These are not the same as the sieve aperture, and the relationship between the various numbers is not immediately obvious. The use of mesh numbers as a measurement of particle size is difficult to justify, and shall not be used in reporting the results of this International Standard.

3.2 Symbols

The following symbols are found throughout the text and, where appropriate, units and quantities are as given below (SI convention is followed for common units e.g. g = gram; m = metre; mm = millimetre; s = second, etc.).

Mg megagram (10^6 g)

mPa millipascal

t is the settling time, in seconds, of a particle of diameter d_p ;

η is the dynamic viscosity of water at the test temperature (see Table B.2), in millipascals per second;

h is the sampling depth, in centimetres;

ρ_s is the mean particle density, in megagrams per cubic metre (taken as 2,65; note in clause 4);

ρ_w is the density of the liquid containing the soil suspension, in megagrams per cubic metre (taken as 1,00; note in clause 4);

g is the acceleration due to gravity, in centimetres per second squared (taken as 981);

d_p is the equivalent spherical diameter of the particle of interest, in millimetres;

4 Principle

Particle size distribution is determined by a combination of sieving and sedimentation, starting from air-dried soil [6] (see note below). A method for undried soil is given in Annex A. Particles not passing a 2 mm aperture sieve are determined by dry sieving. Particles passing such a sieve, but retained on a 0,063 mm aperture sieve, are determined by a combination of wet and dry sieving, whilst particles passing the latter sieve are determined by sedimentation. The pipette method is preferred. A hydrometer method is given in Annex B. A combination of sieving and sedimentation enables construction of a continuous particle size distribution curve.

The key points in this procedure are summarized as a flow chart in Figure 2. This International Standard requires that the proportions of fractions separated by sedimentation and sieving be determined from the masses of such fractions obtained by weighing. Other methods of determining the mass of such fractions rely on such things as the interaction of particles with electromagnetic radiation or electrical fields [1]. There are often considerable difficulties in relating the values obtained by different methods, one to another, for the same sample. It is one of the intentions of this International Standard that close adherence to its details should help minimize interlaboratory variation in the determination of the particle size distribution of mineral soils. Therefore the proportions of fractions shall be determined only by weighing. If this is not the method used, then compliance with this International Standard cannot be claimed in the test report (clause 10).

Both the pipette and hydrometer methods assume that the settling of particles in the sedimentation cylinder is in accordance with Stokes' Law [1, 6, 9], and the constraints that this implies, namely:

- a) the particles are rigid, smooth spheres;
- b) the particles settle in laminar flow i.e. the Reynolds Number is less than about 0,2. This constraint sets an upper equivalent spherical particle diameter (below) slightly greater than 0,06 mm for Stokesian settling under gravity [1];
- c) the suspension of particles is sufficiently dilute to ensure that no particle interferes with the settling of any other particle;
- d) there is no interaction between particle and fluid;
- e) the diameter of the suspension column is large compared to the diameter of the particle, i.e. the fluid is of "infinite extent";
- f) the particle has reached its terminal velocity;
- g) the particles are of the same relative density.

Thus, the diameter of a particle is defined in terms of the diameter of a sphere whose behaviour in suspension matches that of the particle. This is the concept of *equivalent spherical diameter*. It is the principle upon which the expression of the diameter of particles, as derived from sedimentation, is based in this International Standard.

Stokes' Law can be written, for the purposes of this International Standard, in the form:

$$t = 18 \eta h / [(\rho_s - \rho_w) g d_p^2]$$

where

- t is the settling time, in seconds, of a particle of diameter d_p (below);
- η is the dynamic viscosity of water at the test temperature (Table B.2), in millipascals per second;
- h is the sampling depth, in centimetres;
- ρ_s is the mean particle density, in megagrams per cubic metre (taken as 2,65; see note);
- ρ_w is the density of the liquid containing the soil suspension, in megagrams per cubic metre (taken as 1,00; see note);
- g is the acceleration due to gravity, in centimetres per second squared (taken as 981);
- d_p is the equivalent spherical diameter of the particle of interest, in millimetres;

NOTE It is realized that there are considerable differences between the densities of soil particles, but for the purposes of this International Standard it is assumed that the mean particle density is that of quartz, i.e. 2,65 Mg/m³ [10], as this is the commonest mineral in a very wide range of soils. The density of water is 0,9982 Mg/m³ and 0,9956 Mg/m³ at 20 °C and 30 °C, respectively [8]. Given the effect of the addition of a small amount of dispersant (8.3.2), the density of water is taken as 1,0000 Mg/m³ over the permitted temperature range of this International Standard (8.2.2). Further, for routine use, it is recommended that the sampling times be converted to minutes and/or hours, as appropriate, to lessen the risk of error (Table 3).