BS 1377-2: 1990

Incorporating Amendment No. 1

Methods of test for

# Soils for civil engineering purposes —

**Part 2: Classification tests** 





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# Foreword

This Part of BS 1377 has been prepared under the direction of the Road Engineering Standards Policy Committee. It is a revision of clause **2** of BS 1377:1975 which is superseded by amendment.

BS 1377:1975 which has now been with drawn is replaced by the following Parts of BS 1377:1990:

- Part 1: General requirements and sample preparation;
- Part 2: Classification tests;
- Part 3: Chemical and electro-chemical tests;
- Part 4: Compaction-related tests;
- Part 5: Compressibility, permeability and durability tests;

*— Part 6: Consolidation and permeability tests in hydraulic cells and with pore pressure measurement;* 

- Part 7: Shear strength tests (total stress);
- Part 8: Shear strength tests (effective stress);
- Part 9: In-situ tests.

Reference should be made to Part 1 for further information about each of the Parts.

The principal changes to the classification tests as described in the 1975 edition are as follows.

a) Additions

Determination of the saturation moisture content of chalk.

Determination of the liquid limit by a one-point cone penetration test.

Determination of shrinkage limit.

Determination of bulk density by direct measurement of an undisturbed sample.

Determination of particle density using a large pyknometer (preserving jar).

b) Deletion

The alcohol and sand bath methods for the determination of moisture content.

c) Significant changes

Use of the ISO recommended series of sieve aperture sizes has been introduced as an alternative to existing sieve aperture sizes.

Procedures for fine particle size analysis by sedimentation have been amended. Pretreatment is not now mandatory, and the need for several corrections to test observations has been eliminated.

The term "particle density" replaces "specific gravity".

For most of the tests the normal requirement is to use the soil in its natural state without the need for drying before testing.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

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 1 to 64, an inside back cover 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.

### 1 Scope

This Part of BS 1377 specifies methods of test for the classification of soil and for the determination of basic physical properties.

Most of these tests are required for the classification of soils in accordance with BS 5930:1981.

Some of the properties determined by these tests are required for tests described in other Parts of this standard.

Reference should be made to Part 1 of this standard for general requirements that are relevant to all Parts of this standard, and for methods of preparation of samples for testing.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

## **2 Definitions**

For the purposes of this Part of BS 1377 the definitions given in BS 1377-1 apply.

### **3 Determination of moisture content**

#### 3.1 General

Water is present in most naturally occurring soils. The amount of water, expressed as a proportion by mass of the dry solid particles, known as the moisture content, has a profound effect on soil behaviour. In this context a soil is "dry" when no further water can be removed at a temperature not exceeding 110 °C.

Moisture content is required as a guide to classification of natural soils and as a control criterion in recompacted soils and is measured on samples used for most field and laboratory tests. The oven-drying method is the definitive procedure used in standard laboratory practice.

NOTE In some situations, for example in the field control of earthworks, a rapid method of measurement of moisture content may be required and a number of rapid methods are available, e.g. the sand bath method, the microwave oven-drying method and the calcium carbide method. It should not be assumed that these methods are appropriate for all soil types and when they are used on a particular soil some tests should also be carried out using the oven-drying method as a check.

A procedure for determining the moisture content at full saturation of chalk is described.

#### 3.2 Oven-drying method

**3.2.1** *General.* This method covers the determination of the moisture content of a specimen of soil as a percentage of its dry mass.

The requirements of Part 1 of this standard, where appropriate, shall apply to this test method.

#### 3.2.2 Apparatus

**3.2.2.1** A drying oven, capable of maintaining a temperature of 105 °C to 110 °C.

NOTE A microwave oven should not be used for the determination of moisture content by the definitive method for soils containing clay or organic matter because of the difficulty of ensuring that the temperature of the soil does not exceed 110 °C before all the water is removed. Higher temperatures than this can alter the properties of clay material.

#### 3.2.2.2 For fine-grained soils

**3.2.2.2.1** A glass weighing bottle, fitted with a ground glass stopper or cap, or a suitable airtight corrosion-resistant metal container.

**3.2.2.2.2** A balance readable to 0.01 g.

**3.2.2.2.3** *A desiccator* containing anhydrous silica gel.

NOTE It is preferable to use self-indicating silica gel as the desiccant. Calcium chloride should not be used as it is known that many clays when oven dry are capable of absorbing water from it.

**3.2.2.3** For medium-grained soils

**3.2.2.3.1** A corrosion-resistant container of about 500 g capacity.

**3.2.2.3.2** *A balance* readable to 0.1 g.

**3.2.2.3.3** *A scoop* of suitable size.

**3.2.2.4** For coarse-grained soils

**3.2.2.4.1** *A corrosion-resistant container* of about 4 kg capacity.

**3.2.2.4.2** A balance readable to 1 g.

**3.2.2.4.3** *A scoop* of suitable size.

#### 3.2.3 Procedure

#### 3.2.3.1 For fine-grained soils

**3.2.3.1.1** Clean and dry the weighing bottle or metal container and weigh it to the nearest 0.01 g  $(m_1)$ . Take a sample of at least 30 g of soil, crumble and place loosely in the container or weighing bottle, and replace the lid or stopper. Then weigh the container or bottle and contents to the nearest 0.01 g  $(m_2)$ .

**3.2.3.1.2** Remove the lid or stopper, and place the container or bottle with its lid and contents in the oven and dry at 105 °C to 110 °C. The period required for drying will vary with the type of soil and the size of sample but the sample shall be deemed to be dry when the differences in successive weighings of the cooled sample (see **3.2.3.1.3** and **3.2.3.1.4**) at intervals of 4 h do not exceed 0.1 % of the original mass of the sample. Do not replace the lid or stopper while the sample is in the oven.

NOTE 1 Certain soils contain gypsum which on heating loses its water of crystallization. The moisture content determined by this method will be affected by approximately 0.2 % for each 1 % of gypsum. If it is suspected that gypsum is present in the soil the mosture content samples should be dried at no more than 80 °C and possibly for a longer time. The presence of gypsum can be identified by heating a small quantity of soil on a metal plate. Grains of gypsum will turn white within a few minutes, whereas most other mineral grains remain unaltered.

NOTE 2 Between 16 h and 24 h is usually a sufficient length of time for drying most soils, but certain soil types and large or very wet samples will require longer. The drying time will also depend on the amount of material in the oven and may be confirmed by trial tests.

**3.2.3.1.3** After drying, remove the container or bottle and contents from the oven and place the whole in the desiccator to cool.

NOTE If the lids of the containers fit well and it is unlikely that the samples are to be left for a considerable time before weighing, the samples need not be placed in the desiccator to cool, unless glass weighing bottles with ground glass stoppers have been used.

**3.2.3.1.4** Replace the lid and then weigh the container or bottle and contents to the nearest 0.01 g ( $m_3$ ).

#### 3.2.3.2 For medium-grained soils

**3.2.3.2.1** Clean and dry the container and weigh it to the nearest 0.1 g  $(m_1)$ . Take a sample of at least 300 g of soil, crumble and place loosely in the container, and replace the lid. Then weigh the container and contents to the nearest 0.1 g  $(m_2)$ .

**3.2.3.2.2** Remove the lid and place the container and contents in the oven and dry at 105 °C to 110 °C (see note 1 to **3.2.3.1.2**). The period required for drying will vary with the type of soil, the size of sample and the number of samples in the oven but the sample shall be deemed to be dry when the differences in successive weighings of the cooled sample (see **3.2.3.2.3** and **3.2.3.2.4**) at intervals of 4 h do not exceed 0.1 % of the original mass of the soil (see note 2 to **3.2.3.1.2**). Do not replace the lid while the sample is in the oven.

**3.2.3.2.3** After drying, replace the lid and allow the whole to cool.

**3.2.3.2.4** Weigh the container and contents to the nearest 0.1 g  $(m_3)$ .

#### 3.2.3.3 For coarse-grained soils

**3.2.3.3.1** Clean and dry the container and weigh it to the nearest 1 g  $(m_1)$ . Take a sample of at least 3 kg of soil, place loosely in the container and replace the lid. Weigh the container and contents to the nearest 1 g  $(m_2)$ .

**3.2.3.3.2** Remove the lid and place the container and contents in the oven and dry at 105 °C to 110 °C (see note 1 to **3.2.3.1.2**). The period for drying will vary with the type of soil and the size of the sample but the sample shall be deemed to be dry when the differences in successive weighings of the cooled sample (see **3.2.3.3.3** and **3.2.3.3.4**) at intervals of 4 h do not exceed 0.1 % of the original mass of the soil (see note 2 to **3.2.3.1.2**). Do not replace the lid while the sample is in the oven.

**3.2.3.3.3** After drying, replace the lid and allow the whole to cool.

**3.2.3.3.4** Weigh the container and contents to the nearest 1 g  $(m_3)$ .

# **3.2.4** Calculations and expression of results (See form 2.A of appendix A.)

Calculate the moisture content of the soil specimen, *w*, as a percentage of the dry soil mass to the nearest 0.1 %, from the equation:

$$w = \left(\frac{m_2 - m_3}{m_3 - m_1}\right) 100 \ (\%)$$

where

 $m_1$  is the mass of container (in g);

 $m_2$  is the mass of container and wet soil (in g);

 $m_3$  is the mass of container and dry soil (in g).

NOTE 1 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  $\mu m$  sieve, the measured moisture content, w (in %), can be corrected to give the equivalent moisture content,  $w_{\rm a}$  (in %), of the fraction passing the 425  $\mu m$  sieve, using the equation:

$$w_{\rm a} = w \left(\frac{100}{p_a}\right)$$

where

 $P_a$  is the percentage by dry mass of the portion of the soil sample passing the 425  $\mu$ m test sieve, determined as specified in 4.2.4 and 4.2.5.

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

$$w_{a} = \frac{100 w}{p_{a}} - w_{r} \left(\frac{100 - p_{a}}{p_{a}}\right)$$

where

 $w_{\rm r}$  is the moisture content of the fraction retained on the 425  $\mu m$  test sieve.

NOTE 2 The presence of dissolved salts in saline water gives an incorrect value of moisture content. For these soils the "fluid content" is more appropriate, i.e. the mass of pore fluid (water plus salts) per unit dry mass of soil particles. This can be calculated from the measured moisture content, w (in %), by the following two ways.

a) If the proportion by mass of salt in the fluid is known (*p* parts per thousand (ppt), i.e. *p* in mg of salt per g of fluid), the fluid content,  $w_{\rm f}$  (in %), by mass is calculated from the equation:

$$w_{\rm f} = \frac{1000 \ w}{1000 - p \left(1 + \frac{w}{100}\right)}$$

b) If the salt content is known in terms of volume (q in g of salt per litre of fluid), the density of thre fluid, r<sub>f</sub> (in Mg/m<sup>3</sup>), also needs to be known. The fluid content (in %) by volume can then be calculated from the equation:

$$w_{\rm f} = \frac{1000 \ w}{1000 - \frac{q}{r_{\rm f}} \left(1 + \frac{w}{100}\right)}$$

In sea water having a density of  $1.024 \text{ Mg/m}^3$  and containing a salt concentration of 35 ppt by mass, the difference between the fluid content and the conventional moisture content, expressed as a percentage, is about 3 %. The difference increases with increasing moisture content.