BS 8601:2013

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Specification for subsoil and requirements for use

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This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 24, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2013. It was prepared by Technical Committee AW/20, *Topsoil, other growing media and turf.* A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

This British Standard is intended to complement BS 3882 which specifies topsoil.

Information about this document

Test laboratory accreditation. Users of this British Standard are advised to consider the desirability of selecting test laboratories that are accredited to BS EN ISO/IEC 17025 by a national or international accreditation body.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with the *Rules for the structure and drafting of UK standards,* subclause **J.1.1**, which states, "Requirements should be expressed using wording such as: 'When tested as described in Annex A, the product shall ...'". This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the Environmental Protection Act 1990 [1].

Introduction

The subsoil is an essential component of most soil profiles. Only soil that is shallow over rock lacks a subsoil layer. Subsoil provides storage of moisture, transmits rainfall to deeper layers or watercourses and enables deep rooting by trees, shrubs, grasses and other plants. It controls the waterlogging of surface layers, helps vegetation and crops to withstand summer droughts and provides anchorage for trees.

Subsoil plays an important role in reducing the amount and speed of surface water runoff, reduces the risk of erosion and flooding and consequently is an integral part of sustainable drainage systems.

Subsoil can be both naturally-occurring and manufactured. Naturally-occurring subsoil is the product of dynamic chemical, physical and (to a lesser extent) biological processes acting on weathered mineral matter. Subsoil can be manufactured by combining mineral ingredients to provide a medium that can develop properties similar to naturally-occurring subsoil.

Soil is a dynamic and fragile material, which when managed appropriately fulfils its function, but is easily damaged by mishandling. It is important that soil is lifted, transported, stored and spread carefully. Damage during handling can result in a rapid deterioration in the functions soil provides.

NOTE 1 Transporting soil involves mechanical handling, i.e. excavation, loading, transport and distribution on site. Not all naturally-occurring soils would survive such handling and retain the ability to develop into an acceptable soil in a reasonable time at the new site, even though in their undisturbed, naturally-occurring condition they might be very productive and capable of sustaining plant growth over long periods of time. For example, clay textured soil could be very productive in situ but its structure might suffer damage during stripping (or other handling activities) that could only be reversed by years of careful management.

NOTE 2 In the context of soil profile construction, the subsoil is also an important medium for root growth since it provides reserves of water and available plant nutrients and mechanical anchorage.

1 Scope

This British Standard specifies requirements for the classification, composition and use of subsoils that are moved or traded for creating soil profiles intended to support plant growth. The standard is not applicable to topsoil, or to subsoil that is to remain in situ. It is not intended to preclude the use of subsoil that is already on site and suitable for its intended purpose. This standard specifies requirements for multipurpose subsoil, which is fit for the majority of needs, and also specific purpose subsoils that are acidic or calcareous, for specialist use where acidic or calcareous soil profiles are required. It also specifies requirements for sampling and analysis of subsoil.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7755-5.6:1999 (ISO 11272:1998), *Soil quality – Part 5: Physical methods – Section 5.6: Determination of dry bulk density*

BS EN 12579:2000, *Soil improvers and growing media – Sampling*

BS EN ISO 3696:1995, *Water for analytical laboratory use – Specification and test methods*

BS ISO 10390:2005, *Soil quality – Determination of pH*

BS ISO 11277:2009, *Soil quality – Determination of particle size distribution in mineral soil material – Method by sieving and sedimentation*

BS ISO 16729:2013, *Soil quality – Digestion of nitric acid soluble fractions of elements*

3 Terms and definitions

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

3.1 topsoil

top layer of soil, darker in colour and with more organic matter than the layer below (subsoil), or manufactured soil with similar properties

3.2 subsoil

soil layer extending between the topsoil and the little weathered parent material below, or material that functions in the same way in a constructed soil profile and on to which topsoil can be spread

NOTE Usually subsoil has a lower concentration of organic matter and available plant nutrients than topsoil.

3.3 soil texture

proportion by mass of sand, silt and clay sized particles in the mineral fraction of the <2 mm fraction of soil, see Figure 1 (sand: 2 mm to 0.063 mm; silt: 0.063 mm to 0.002 mm; clay <0.002 mm equivalent spherical diameter particles)

*NOTE Modified from BS 3882:2007, **3.5**.*

3.4 soil structure

arrangement formed by aggregation of primary soil particles (mineral and organic) into larger units

NOTE It is the spaces (pores) between these larger units (aggregates) that allow the flow of air and water, and root penetration.

[BS 3882:2007, **3.6**]

3.5 soil pH value

measure of the acidity or alkalinity of soil

[BS 3882:2007, **3.8**]

NOTE pH 7 is neutral, values less than 7 are acid, values greater than 7 are alkaline.

3.6 potentially phytotoxic element

element which, when present in excess, has the potential to inhibit plant growth or kill plants

3.7 other contaminant

undesirable, potentially injurious foreign object discernible by the naked eye

NOTE Examples include asbestos containing material, metal objects, plastics, treated wood, textiles and sharp fragments of ceramics and glass.

3.8 sharp

inorganic soil contaminant such as a glass fragment, nail or needle that can cause physical injury to the hands of a user of subsoil when handling it without protective gloves

[BS 3882:2007, **3.14**]

NOTE At some future date, subsoil might be brought to the surface, for example when planting holes are dug or when a pipeline is routed through a site.

3.9 coarse fragment

particle of greater than 2 mm diameter that is not a sharp or other contaminant

3.10 soil source

location from which a subsoil is obtained

3.11 supplier

person or organization supplying subsoil from within or outside the site where it is to be used

3.12 incremental sample

quantity of material taken from one sampling point

[BS EN 12579:2000, **3.5**]

4 Subsoil classification and characteristics

4.1 Classification

The subsoil shall be classified as multipurpose subsoil or specific purpose subsoil. Specific purpose subsoil shall be further classified as acidic or calcareous.

NOTE 1 If correctly handled, and managed appropriately (including attention to drainage), subsoil is capable of providing adequate rooting, drainage, aeration and runoff attenuation (see Clause ***6****). Some natural subsoils, especially clayey and silty subsoils, might not be able to survive the handling involved with trading subsoil.*

NOTE 2 Multipurpose subsoil is natural subsoil or manufactured subsoil. This is the grade suited to most situations where subsoil is required; however, there can be situations where specific purpose subsoil is required (see NOTE 3).

NOTE 3 Specific purpose subsoil is natural or manufactured subsoil. It comprises subsoils with characteristics appropriate for specialist applications, e.g. supporting the growth of certain plants or plant communities where acidic or calcareous soils are required.

NOTE 4 Specific purpose subsoils might not be appropriate for general landscaping projects.

NOTE 5 When specifying multipurpose or specific purpose subsoil, suppliers, specifiers and users of subsoil should take into account the intended use of the site at which the subsoil is to be deployed so that the particular properties are fit for the intended planting.

4.2 Characteristics

The subsoil shall be sampled in accordance with Clause **5**. The samples shall be reduced and prepared in accordance with Annex A and tested in accordance with the methods listed in Table 1. The characteristics of the samples shall be as specified in Table 1 and Figure 1.

NOTE 1 Attention is drawn to Schedule 9 of the Wildlife and Countryside Act 1981 [2] which lists plants that it is prohibited to release, allow to escape or cause to grow in the wild.

NOTE 2 Attention is drawn to the Environmental Protection Act 1990 [1] (EPA) and to the National Planning Policy Framework (NPPF) [3], under which there is a requirement for subsoil to contain no concentrations of chemical contaminants that would cause a significant risk to human health and the environment.

NOTE 3 Attention is drawn to the possibility that Site Specific Assessment Criteria (SSAC) or Generic Assessment Criteria (GAC) might have been set for the intended recipient site under the EPA or NPPF. Further guidance is given in Contaminated Land Exposure Assessment (CLEA) model (EA/DEFRA:2009) Soil Guideline Values *[4] and Chartered Institute of Environmental Health (CIEH)/Land Quality Management (LQM)* Generic assessment criteria for human health risk assessment *(2nd Edition, 2009) [5].*

NOTE 4 If the subsoil is classed as a waste under the Waste Management Licensing Regulations 1994 (as amended) [6] the supplier has a legal obligation to supply it in accordance with those Regulations and to inform the customer that the subsoil has been classified as waste under those Regulations. The Waste Management Licensing Regulations [6] also place legal obligations on the storage and use of such subsoil in most contexts. In addition, the Definition of waste: Development industry code of practice *(Guidance Bulletin GB 03, CL:AIRE, 2011) [7] gives guidance on assessing on a site-specific basis whether excavated soils are classified as waste or not and, if they are, when they can cease to be a waste when put to a particular use.*

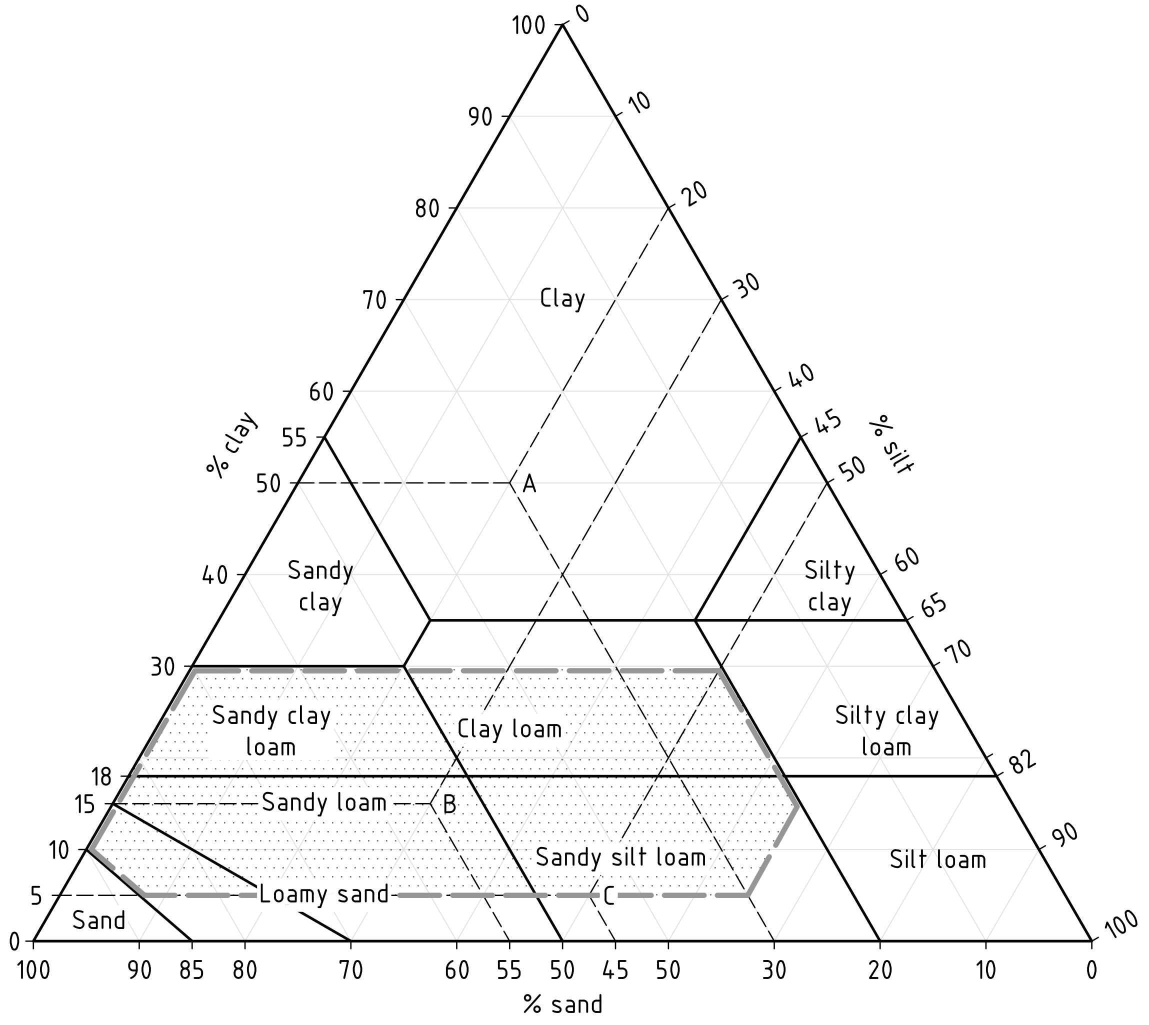
Table 1 **Subsoil characteristics**

Parameter	**Multipurpose subsoil**	**Specific purpose subsoil**		**Method of test**
		Acidic	**Calcareous**	
Soil texture <2 mm fraction % *m/m*	See area of permitted soil textural classes in Figure 1			BS ISO 11277:2009
Mass loss on ignition	Maximum 2%			Annex B
Maximum coarse fragment content % *m/m* (see **3.9**)				BS ISO 11277:2009 1 kg sample minimum
>2 mm	40			
>20 mm	20			
>75 mm	0			
Soil pH (measured in water)	5.5 to 8.5	3.5 to 5.5	7.5 to 8.5	BS ISO 10390:2005
Carbonate % *m/m*	—	—	>1	Annex C
Exchangeable sodium percentage (ESP) % Need not measure if soil electrical conductivity $<2\,800\ \mu S \cdot cm^{-1}$	<15			Annex D, Annex E and Annex F
Electrical conductivity [A], [B]	Value to be measured and recorded (see ESP)			Annex F
Potentially phytotoxic elements (by soil pH) (mg/kg dry solids)	**Multipurpose and specific purpose subsoils**			BS ISO 16729:2013
	Soil pH <6.0	**Soil pH 6.0 to 7.0**	**Soil pH >7.0**	
Zn (Nitric acid extractable)	<200	<200	<300	
Cu (Nitric acid extractable)	<100	<135	<200	
Ni (Nitric acid extractable)	<60	<75	<110	
Other contaminants % *m/m* (air-dried soil)				Annex G
>2 mm	<0.5			
of which plastics	<0.25			
sharps	zero in 1 kg air-dried soil			

[A] The electrical conductivity is related to the concentration of soluble ionic constituents, particularly ammonium, calcium, chloride, magnesium, nitrate, phosphate, potassium, sodium and sulfate. A discussion of the importance of soil electrical conductivity, soil salinity and ESP is given in Annex H.

[B] A high soil electrical conductivity might indicate a detrimentally high level of salinity.

Figure 1 **Textural classification (limiting percentages of sand, silt and clay sized particles for the mineral texture class) and the area of textures that are acceptable within BS 8601:2013**



Key

▨ Area within which the texture of subsoil is required to fall

NOTE Examples of textural classification are as follows.

- *Soil A with 30% sand, 20% silt and 50% clay is in the "clay" textural class.*
- *Soil B with 55% sand, 30% silt and 15% clay is in the "sandy loam" textural class.*
- *Soil C with 45% sand, 50% silt and 5% clay is in the "sandy silt loam textural class.*

5 Sampling of subsoil

NOTE Any source of subsoil (including soils to be retained on site), whether natural or manufactured, should be investigated carefully with respect to its suitability for the intended use. The supplier should consult the customer regarding the intended use of the subsoil.

If natural subsoil is to be supplied, the subsoil shall be sampled before stripping to the full depth that is intended to be stripped. Sampling patterns shall be based on a rectilinear grid or a W-pattern. Before sampling, a specialist soil resource survey shall be carried out. A geotechnical or geo-environmental survey shall not be used for this purpose. A separate subsoil sample shall be taken from each of the different soil areas delineated by the survey and from any sub-areas of differing land use within them. To ensure accurate representation of each sampling area, a minimum of 10 incremental samples shall be taken across each and mixed together to create one composite sample (minimum 2 kg) for analysis.

From stockpiles, incremental samples shall be taken at regular intervals both from the surface 1 m and from the core in accordance with BS EN 12579:2000 and mixed together to create a composite sample for analysis. One composite sample (minimum 2 kg) shall represent no more than 5 000 m^3 of subsoil.

The samples shall be reduced and prepared in accordance with Annex A.

6 Stripping, handling and trafficking of subsoil

*COMMENTARY ON CLAUSE **6***

Soils generally lose strength and become less resistant to damage as they become wetter; therefore, it is essential that they are stripped, handled and trafficked only in the appropriate conditions of weather and soil moisture, and with suitable machinery. If sustained heavy rainfall (e.g. >10 mm in 24 h) occurs during soil stripping operations, work should be suspended and not restarted until the ground has had at least one dry day or until a suitable moisture content has been reached. A soil can be considered to have a suitable moisture content for stripping and handling if the whole thickness of the subsoil layer being stripped and/or handled is at a moisture content below the plastic limit as determined in accordance with BS 1377-2:1990 (incorporating Amendment No. 1).

Machinery should be selected and routed to minimize soil compaction.

6.1 General

Subsoil shall not be stripped, handled or trafficked:

- in a waterlogged condition;
- when the ground is frozen or covered by snow; or
- when there are pools of water on the ground surface.

To minimize risks of damage to the soil structure, whenever possible, soil shall be moved directly from where it is stripped or manufactured to the receptor land.

NOTE 1 Multiple handling of soil materials increases the risk of damage to the soil structure.

Before commencing work on a site, subsoil from all areas that are to be disturbed by construction activities or driven over by vehicles shall be stripped.

NOTE 2 Stripping should be done by earthmoving plant that is appropriate to the size of the site, the volume of soil to be stripped and the haul distances.

NOTE 3 The selection of appropriate equipment and work practices is also important because mishandling subsoil can have an adverse effect on its properties, especially the permeability, which can result in waterlogging of the topsoil, reduce recharge of underlying aquifers, and increase the risk of flooding and off-site discharges which can breach water discharge consents.

The operation shall follow a detailed stripping plan showing soil units to be stripped, haul routes and the phasing of vehicle movements. The soil units shall be identified on the site with information to distinguish types and layers, and ranges of thickness.

NOTE 4 It is essential that the stripping is adequately supervised to ensure that the stripping plan is adhered to.

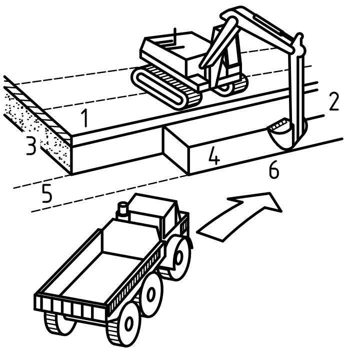
Subsoil and topsoil shall be stripped separately and they shall be kept separate. Subsoils of different quality shall also be kept separate from each other.

NOTE 5 Figure 2 shows the preferred method of soil stripping. Within each soil unit the soil layers above the base/formation layer are removed in sequential strips that can be up to 6 m wide (the reach of a 360° excavator). Using an excavator bucket with teeth is preferable to using one without. Where there is a cover of topsoil, that layer is removed first before stripping subsoil to the specified depth. The soil transport vehicle runs on the layer beneath the subsoil, not on the subsoil.

NOTE 6 Alternative stripping methods that can be shown to afford the same degree of soil protection are acceptable.

NOTE 7 An archaeological watching brief might have to be accommodated during subsoil stripping.

Figure 2 **Preferred method of stripping subsoil**



Key

1 Topsoil
2 Progressive removal
3 Next strips
4 Subsoil
5 Current strip
6 Basal layer

6.2 Storing subsoil

COMMENTARY ON ***6.2***

Subsoil often has to be stripped or excavated during a construction process. In order to enable its reuse on site at a later stage, the subsoil needs to be stored in temporary stockpiles to minimize the surface area occupied, and to prevent damage from the weather and other construction activities.

The stockpiling of subsoils shall be avoided whenever possible.

NOTE 1 If subsoil loses physical quality, diffusion of oxygen and permeability are reduced.

Where stockpiling is unavoidable, heaps shall be tipped loosely and the surface firmed and shaped to shed water.

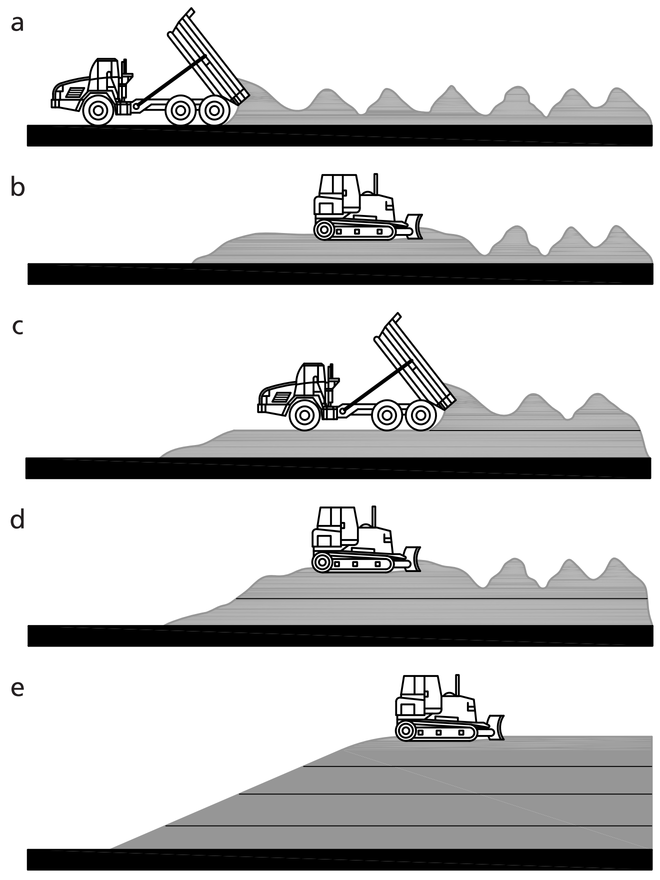
NOTE 2 Figure 3 illustrates a preferred method of stockpiling stripped subsoil.

Stockpiles shall be sited so as to avoid any risk that muddy water could run off directly or indirectly into watercourses.

The site of a stockpile shall be prepared thoroughly in advance by grading and by removing rubbish etc. Topsoil and subsoil shall be removed from sites designated for stockpiling subsoil. Subsoil shall be stockpiled separately from topsoil and other excavated materials.

NOTE 3 Stockpiles left in situ for long periods should be managed to prevent seeding, especially from adjacent land.

Figure 3 **Preferred method of stockpiling dry non-plastic subsoil**



Key

a	Placing first layer
b	Levelling first layer
c	Placing second layer
d	Levelling second layer
e	Levelling top layer

6.3 Depths of subsoil and topsoil on a landscaped site

On a landscaped site, the combined minimum depth of subsoil and topsoil placed shall be 450 mm for grass, 600 mm for shrubs and 900 mm for trees.

NOTE The depth of topsoil spread should not normally exceed 300 mm.

6.4 Preparation of the receiving area and spreading of subsoil

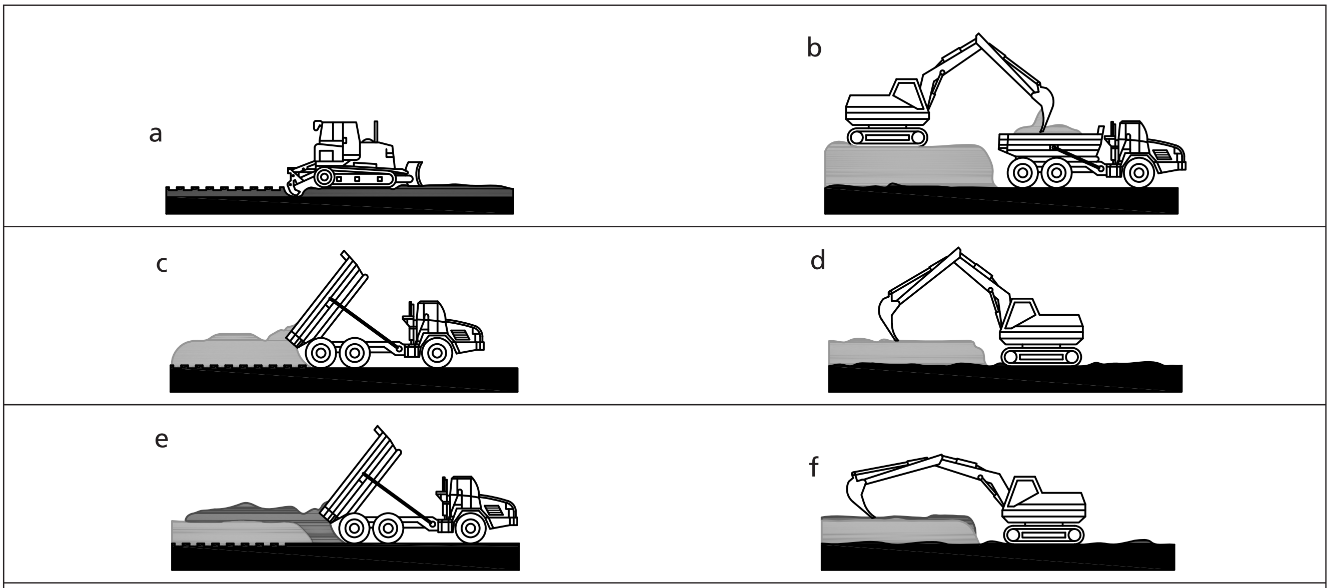
*COMMENTARY ON **6.4***

The functioning of subsoil within a landscape depends not only on the quality of the subsoil but also on the care given to the preparation of the receiving area, which will often have been compacted by the passage of vehicles or storage of materials.

Prior to spreading subsoil, the receiving area shall be decompacted to increase permeability.

NOTE 1 It is particularly important that the subsoil is not over-compacted during spreading. Over-compaction prevents plant root growth and function, and reduces water attenuation and the ability of excess water to drain away through the subsoil. It is one of the most common reasons for plant failures in landscape schemes, and it increases the risk of erosion and runoff. Placement of soil by tracked hydraulic excavators working in strips from ground not yet loosened (the "loose-tipping" method) is a way to avoid this. This method is illustrated in Figure 4.

Figure 4 **The loose-tipping method for placing subsoil and topsoil, including substrate loosening**



Key

a Loosening of the substrate of the ground that will receive the subsoil
b Loading of subsoil from stockpile
c Backtipping subsoil onto receiving ground
d Levelling subsoil (light use of a low pressure dozer can help to consolidate subsoil if dry)
e Backtipping topsoil
f Spreading topsoil over subsoil by excavator working on substrate

NOTE 2 If sustained heavy rainfall (e.g. >10 mm in 24 h) occurs during soil spreading and levelling operations, work should be suspended and not restarted until the ground has had at least one dry day or until a suitable moisture content has been reached. A soil can be considered to have a suitable moisture content for spreading and levelling if the whole thickness of the subsoil layer being spread and levelled is at a moisture content below the plastic limit as determined in accordance with BS 1377-2:1990 (incorporating Amendment No. 1).

If over-compaction of subsoils occurs they shall be loosened using ripping equipment before receiving topsoil; ripping shall only be done when the subsoil is sufficiently dry that it shatters. In small confined areas, such as in gardens and narrow landscaping strips, the use of a small tracked excavator with a "tine attachment", or hand cultivation, shall be used.

NOTE 3 Care should be taken to avoid overworking soils, especially with inappropriate machinery, as this can damage soil structure and increases the risk of erosion and runoff.

All stones and other objects larger than 75 mm brought to the subsoil surface by ripping shall be removed from the prepared surface.

NOTE 4 Further guidance on the management, preparation and handling of soils is provided in the Defra publication Construction code of practice for the sustainable use of soils on construction sites *[8].*

6.5 Determination of subsoil bulk density post placement

If excessive compaction, insufficient loosening or insufficient permeability of the subsoil are suspected, the bulk density of the subsoil shall be measured in accordance with BS 7755-5.6:1999. If the bulk density exceeds 1.6 g/cm^3 loosening/de-compaction shall be undertaken.

NOTE Examination by a soil scientist might be necessary.

7 Information to be provided by the supplier to the purchaser

The supplier shall provide the following information to the purchaser of the subsoil prior to supply of the subsoil:

a) number and date of this British Standard, i.e. BS 8601:2013 [1];

b) soil source (see **3.10**):

    1) for natural subsoil: description of location including previous and current land use, and ordnance survey grid reference (minimum two letters, six figures);

    2) for manufactured subsoil: name of producer;

c) the designation of the subsoil, i.e. multipurpose or specific purpose acidic or specific purpose calcareous (see Clause **4**);

d) the supplier's understanding of the intended use of the site where the subsoil will be used;

e) details of the laboratory that performed the subsoil analysis;

f) date the subsoil was sampled;

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[1] Marking BS 8601:2013 on or in relation to a product represents a manufacturer's or supplier's declaration of conformity, i.e. a claim by or on behalf of the manufacturer or supplier that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

g) date the sample was received by the laboratory;

h) date the laboratory reported the results;

i) soil texture class (see **3.3**) presented on a three axis triangular diagram of the form shown in Figure 1, and the contents of sand, silt and clay;

j) soil organic matter content;

k) content of coarse fragments (see **3.9**) classified as >2 mm, >20 mm and >75 mm;

l) pH of the subsoil (see **3.5**) measured in water;

m) for specific purpose calcareous subsoil, the carbonate content;

n) subsoil electrical conductivity;

o) exchangeable sodium percentage if the subsoil electrical conductivity >2 800 $\mu S \cdot cm^{-1}$

p) content of potentially phytotoxic elements (see **3.6**), i.e. nitric acid extractable zinc, copper and nickel;

q) content of other contaminants >2 mm (see **3.7**):

    1) plastics;

    2) sharps (see **3.8**).

Annex A (normative) Method of sample reduction and preparation

A.1 Sample reduction and identification

The sample shall be mixed thoroughly and subdivided by quartering, riffling or another suitable method to produce a reduced sample of not less than 1 kg. The reduced sample shall be labeled clearly.

A.2 Sample preparation

The reduced sample shall be transferred to a suitable tray to form a layer approximately 20 mm deep. If necessary, any clods shall be broken between the fingers into pieces not exceeding 25 mm in any direction. The sample shall be dried by placing the tray in a current of air at a temperature of (30 ± 2) °C. The process shall be continued until the sample feels dry.

The air-dried sample shall be weighed and shall then be sieved through a 2 mm aperture sieve.

The material retained on the sieve shall be used for analysis of coarse fragment content and other contaminants.

The material passing through the sieve shall be used for the determination of soil texture and for chemical analysis.

NOTE It is recommended that a portion of air-dried sample be retained for at least 12 months.

Annex B (normative) Determination of mass loss on ignition

B.1 General

This annex describes the determination of the mass loss on ignition of soil over a specified temperature range. It is a measure of the content of soil organic matter. None of the soil organic matter methods is definitive; mass loss on ignition over the temperature range 125 °C to 440 °C is deemed adequate for the purposes of this standard.

B.2 Principle

Air-dried soil is dehydrated at (125 ± 5) °C then ashed at (440 ± 10) °C. The mass loss on ignition is expressed as a percentage of the mass of the dehydrated sample.

NOTE The drying temperature of 125 °C has been chosen to allow for the relatively large loss of mass that results because of the loss of "bound" water which occurs between the more common drying temperature of 105 °C and 125 °C. Combustion of soil organic matter can be expected to occur in the range 125 °C to 440 °C. A temperature of 440 °C has been chosen to avoid mass loss due to decarboxylation of carbonates, combustion of fossil carbon or water loss from the crystal structures of minerals.

B.3 Apparatus

B.3.1 *Drying oven*, capable of maintaining a temperature of (125 ± 5) °C.

B.3.2 *Electric muffle furnace*, capable of maintaining temperatures of (440 ± 10) °C and (550 ± 10) °C.

B.3.3 *Basin*, made from fused silica or quartz, of shallow form with a flat bottom, capable of holding a 5 g sample.

NOTE Typical dimensions are 70 mm width and 20 mm height.

B.3.4 *Desiccator*, containing a suitable desiccant.

B.4 Procedure

B.4.1 Preparation of the basin

Heat the basin (**B.3.3**) for 16 h in the muffle furnace (**B.3.2**) at (550 ± 10) °C. Cool in the desiccator (**B.3.4**). After cooling, weigh to the nearest 0.001 g. Note the mass of the basin, M_0.

B.4.2 Determination

Spread evenly over the surface of the basin (**B.3.3**) approximately 5 g of the test sample prepared in accordance with **A.2** and dry in the oven (**B.3.1**) at a temperature of (125 ± 5) °C for 16 h. Allow the basin and contents to cool to room temperature in the desiccator (**B.3.4**) and weigh to the nearest 0.001 g. Note the mass of the basin and dehydrated sample, M_1. Place the basin and contents into the cool muffle furnace (**B.3.2**) and raise the temperature to (440 ± 10) °C. Maintain this temperature for 4 h. Allow the basin and contents to cool to room temperature in the desiccator (**B.3.4**) and weigh to the nearest 0.001 g. Place the basin and contents into the muffle furnace maintained at (440 ± 10) °C for a further 1 h. Allow the basin and contents to cool to room temperature in the desiccator (**B.3.4**) and weigh to the nearest 0.001 g. Repeat the operations of heating, cooling and weighing until the difference between two successive weighings is less than 0.01 g. Note the mass of the basin and sample after ignition, M_2.

B.5 Calculation and expression of results

Calculate the mass loss on ignition (LOI), expressed as a percentage by mass of the dehydrated sample [after drying at (125 ± 5) °C for 16 h], using the following equation:

$$\%\mathrm{LOI} = [(M_1 - M_2)/(M_1 - M_0)] \times 100$$

where

M_0 is the mass of the basin, in grams (g);

M_1 is the mass of the basin and dehydrated sample, in grams (g);

M_2 is the mass of the basin and sample after ignition, in grams (g).

B.6 Test report

The test report shall include the following:

a) a complete identification of the sample;

b) a reference to this British Standard, i.e. BS 8601:2013;

c) the results expressed in accordance with **B.5**;

d) any unusual features noted during the determination;

e) any operation not included in this method or regarded as optional.

Annex C (normative) Determination of mineral carbonate content of soil (as calcium carbonate)

C.1 General

This annex gives a method for the determination of the mineral carbonate content of soil (expressed as calcium carbonate). It is applicable to all soils that have not had free lime applied within the previous 3 months.

C.2 Principle

A weighed portion of soil is allowed to react with an excess of standardized hydrochloric acid. After clarification, the excess acid is back-titrated with standard alkali.

C.3 Reagents

Only reagents of recognized analytical grade and water conforming to grade 3 of BS EN ISO 3696:1995 shall be used.

NOTE All reagents listed below can be purchased commercially.

C.3.1 *Sodium carbonate solution, 2.0 mol/L*. Dry solid sodium carbonate at 260 °C for 30 min; allow to cool to room temperature in a desiccator. Dissolve 13.25 g of the dried sodium carbonate in water and dilute to 250 ml in a standard volumetric flask.

C.3.2 *Indicator solution, methyl orange-indigo carmine*. Dissolve 1 g of methyl orange and 2.5 g of pure indigo carmine in 1 L of water. Filter the solution and store in a dark bottle.

C.3.3 *Hydrochloric acid, approximately 1 mol/L.* Dilute 90 ml of 36% (*m*/*m*) (1.18 g/L) HCl to 1 L. Standardize with 2.0 mol/L sodium carbonate solution (**C.3.1**) using the methyl orange-indigo carmine indicator (**C.3.2**) (end point neutral grey). Calculate the concentration factor, f_1.

C.3.4 *Hydrochloric acid, approximately 4 mol/L*. Dilute 360 ml of 36% *(m/m)* (1.18 g/L) HCl to 1 L. Standardize with 2.0 mol/L sodium carbonate solution (**C.3.1**) using the methyl orange-indigo carmine indicator (**C.3.2**) (end point neutral grey). Calculate the concentration factor, f_2.

C.3.5 *Sodium hydroxide, 1 mol/L.* Quickly weigh out 20 g NaOH and dilute to 500 ml with water. Store in an air-tight plastics bottle. Standardize against 1 mol/L hydrochloric acid (**C.3.3**). Calculate the concentration factor, f_3.

C.3.6 *Indicator solution, screened methyl orange*.

C.4 Apparatus

C.4.1 *Conical flasks*, of capacity 150 ml.

C.4.2 *Filter paper*, 120 mm diameter.

NOTE Whatman™ filter paper GF/A has been found to be suitable [2].

C.4.3 *Volumetric flasks*, marked at 100 ml.

C.5 Preparation of test sample

Prepare the test sample in accordance with **A.2**.

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[2] Whatman™ is a trade mark owned by GE Healthcare Companies and is an example of a suitable product available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by BSI of this product.

C.6 Procedure

Weigh to the nearest 0.1 g, approximately 25 g of the test sample (see **C.5**) and transfer into a conical flask (**C.4.1**). Pipette 20 ml of approximately 1 mol/L hydrochloric acid (**C.3.3**) into the flask. If a vigorous reaction is observed, add (cautiously) by pipette a further 20 ml of approximately 4 mol/L hydrochloric acid (**C.3.4**) to the flask. Allow to stand, swirling occasionally until there is no further visible effervescence and then for a further 10 min.

Filter through a 120 mm filter paper (**C.4.2**) and wash with water until at least 70 ml of filtrate has been collected. Dilute to 100 ml in a volumetric flask (**C.4.3**) (see Note). Pipette 50 ml of the clear filtrate into a clean 150 ml conical flask (**C.4.1**). Add a few drops of screened methyl orange indicator solution (**C.3.6**) to the filtrate and titrate with sodium hydroxide solution 1 mol/L (**C.3.5**) (colour change is from violet to green). If the titre is less than 5 ml or greater than 50 ml repeat the determination using more suitable volumes of hydrochloric acid.

NOTE In some cases it might be necessary to centrifuge the suspension in order to obtain a clear solution. If filtration is slow, repeat the test with less soil or by diluting the acid digest with water to 100 ml and centrifuging without the filtration step. If the solution is highly coloured and it is impossible to see the end point, titrate to pH 7.0 ± 0.2 using a calibrated pH meter and electrode.

C.7 Calculation of result

Calculate the mineral carbonate content, expressed as a percentage by mass of calcium carbonate in air-dried soil using the following equation:

$$\%\mathrm{CaCO_3} = \{[(V_1 f_1 + 4V_2 f_2 - V_3 f_3)\ (a/b)\ 0.05]/w\} \times 100$$

where:

V_1	is the volume of 1 mol/L HCl;
f_1	is the concentration factor for 1 mol/L HCl;
V_2	is the volume of 4 mol/L HCl;
f_2	is the concentration factor for 4 mol/L HCl;
V_3	is the volume of 1 mol/L sodium hydroxide;
f_3	is the concentration factor for 1 mol/L sodium hydroxide;
a	is the total volume of filtered extract;
b	is the volume taken for titration;
0.05	is the mass equivalent in grams (g) of calcium carbonate per 1 ml of 1 mol/L HCl;
w	is the mass of the test sample in grams (g).

Annex D (normative) Extraction of the exchangeable cations in soil for determining exchangeable sodium percentage

D.1 General

This annex gives a method for extracting exchangeable (which approximates to plant-available) cations from the cation exchange sites in soil. It is applicable to the determination of extractable potassium, magnesium, calcium and sodium content of soil, for calculating the exchangeable sodium percentage in accordance with Annex E.

D.2 Principle

The cations are extracted from a soil sample by exchanging them with ammonium ions from an ammonium nitrate solution.

D.3 Reagents

Only reagents of recognized analytical grade and water conforming to grade 3 of BS EN ISO 3696:1995 shall be used.

D.3.1 *Ammonium nitrate solution*, 80 g/L.

D.4 Apparatus

D.4.1 *Bottles,* (200 ± 25) ml capacity, wide mouth with closure.

D.4.2 *Filter paper.*

NOTE Whatman™ No. 2 filter paper 125 mm diameter has been found to be suitable [3]*.*

D.4.3 *Shaking machine*, reciprocating, approximately 275 strokes/min and length of travel 25 mm.

D.5 Preparation of test sample

Prepare the test sample in accordance with **A.2**.

D.6 Procedure

D.6.1 Preparation of extract from test sample

Weigh approximately 5 g of the test sample (see **D.5**) and record the mass to the nearest 0.001 g. Transfer this into a bottle (**D.4.1**) and add 50 ml of the ammonium nitrate solution (**D.3.1**). Cap the bottle and shake on the shaking machine (**D.4.3**) for 30 min. Filter immediately through a filter paper (**D.4.2**) and retain the filtered extract for the determination of cations.

NOTE 1 The extract can be stored for up to 24 h in cool conditions. A refrigerator maintained at a temperature of (4 ± 2) °C has been found to be suitable for this purpose.

NOTE 2 The extract can be used for the determination of potassium, calcium or magnesium, and also of sodium if the determination is carried out immediately or the sample extract is stored in a sodium-free bottle.

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D.6.2 Blank extraction

Carry out a blank extraction, in parallel with the extraction in accordance with **D.6.1**, omitting the test sample.

D.7 Measurement and expression of results

Measure the concentrations of cations in the filtered extract (**D.6.1**). Calculate the exchangeable cation content of the soil sample, expressed in milligrams per kilogram of air-dried soil, from the machine calibration graph using the sample and blank determinations and multiplying the result by the extraction and dilution ratios. Incorporate the dilution factor into the calculation if the original sample extract has been diluted with the extracting solution prior to examination.

D.8 Test report

The test report shall include the following information:

a) a complete identification of the test sample;

b) a reference to this British Standard, i.e. BS 8601:2013;

c) the results expressed in accordance with **D.7**;

d) any unusual features noticed during the determination;

e) any operation not included in this method or regarded as optional.

Annex E (normative) Calculation of exchangeable sodium percentage of soil

E.1 General

This annex gives a method for the calculation of the concentration of exchangeable sodium as a percentage of the sum of the extractable potassium, calcium, magnesium and sodium in a soil sample analysed in accordance with Annex D.

E.2 Calculation and expression of results

Convert each of the exchangeable cation contents in milligrams per kilogram obtained from the analysis given in Annex D (see **D.7**) to an exchangeable cation content in milliequivalents per kilogram (me/kg) using the following equation:

$$C_{exch} = C_{ext} \times V/A \qquad (E.1)$$

where:

C_{exch}	is the exchangeable cation concentration (in me/kg);
C_{ext}	is the extractable cation concentration (in mg/kg) determined by the extraction method given in Annex D;
V	is the valency of the cation;
A	is the relative atomic mass of the cation.

Calculate the exchangeable sodium percentage (ESP) from the following equation:

$$\text{ESP} = [\text{Na}/(\text{K} + \text{Ca} + \text{Mg} + \text{Na})] \times 100 \tag{E.2}$$

using the exchangeable cation concentrations, in me/kg, calculated using equation (E.1).

Annex F (normative) Determination of the specific electrical conductivity of a calcium sulfate extract of soil

F.1 General

This annex describes the determination of the specific electrical conductivity of a calcium sulfate extract of soil in order to determine whether measurement of exchangeable sodium percentage is necessary (see Table 1 and Annex E).

F.2 Principle

Air-dried soil is extracted with saturated calcium sulfate solution at (20 ± 1) °C [extraction ratio 2:5 (*m*/*m*)]; the specific conductivity of the filtered extract is measured.

F.3 Reagents

Only reagents of recognized analytical grade and water conforming to grade 2 of BS EN ISO 3696:1995 shall be used.

F.3.1 *Potassium chloride stock standard volumetric solution,* c(KCl) = 0.02 mol/L. Dissolve 1.492 g of potassium chloride, previously dried at (102 ± 1) °C for at least 2 h, in water in a 1 000 ml one-mark volumetric flask and dilute to the mark. The specific conductivity of this solution at 20 °C is 2 501 $\mu\text{S}\cdot\text{cm}^{-1}$.

F.3.2 *Calcium sulfate solution.* Shake 7 g of calcium sulfate ($CaSO_4.2H_2O$) with 2 L of water at 20 °C for 2 h. Check that the temperature of the suspension is 20 °C and filter through a filter paper (**F.4.3**). The specific conductivity of the filtrate should be approximately 1 960 $\mu\text{S}\cdot\text{cm}^{-1}$ at 20 °C. Store the solution at 20 °C.

F.4 Apparatus

F.4.1 *Conductivity bridge and cell*, capable of measuring specific conductivity in the range 1 000 $\mu\text{S}\cdot\text{cm}^{-1}$ to 6 000 $\mu\text{S}\cdot\text{cm}^{-1}$.

F.4.2 *Constant temperature bath*, capable of maintaining a temperature of (20 ± 0.5) °C.

F.4.3 *Filter paper*.

NOTE Whatman No. 2 filter paper 125 mm diameter has been found to be suitable [4]*.*

F.4.4 *Shaking machine*, reciprocating, approximately 275 strokes/min and length of travel 25 mm.

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[4] Whatman™ is a trade mark owned by GE Healthcare Companies and is an example of a suitable product available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by BSI of this product.

F.5 Test samples

F.5.1 Preparation of test sample

Weigh 20 g of air-dried sample prepared in accordance with **A.2** to the nearest 0.001 g, transfer to a bottle and add 50 ml of the calcium sulfate solution (**F.3.2**). Cap the bottle and shake on the shaking machine (**F.4.4**) at 20 °C for 30 min. Filter through a filter paper (**F.4.3**) into a bottle and retain the filtrate for the determination of soil electrical conductivity.

F.5.2 Preparation of blank test sample

Prepare a blank test sample using the test sample procedure and the same quantities of the reagents as used for the determination but omitting the air-dried test sample.

F.6 Procedure

F.6.1 Determination of cell constant

Measure the conductivity of the potassium chloride solution (**F.3.1**) using the conductivity bridge (**F.4.1**) according to the manufacturer's instructions. Transfer approximately 50 ml of the potassium chloride solution into a bottle. Cap the bottle and, using the constant temperature bath (**F.4.2**), bring its temperature to, and maintain it at, (20 ± 0.5) °C. Place the conductivity cell into the solution and record the conductivity of the solution, in $\mu S \cdot cm^{-1}$. Calculate the cell constant, *J,* using the following equation:

$$J = S/C_{KCl}$$

where:

S	is the standard specific conductivity (in $\mu S \cdot cm^{-1}$);
C_{KCl}	is the conductivity of the potassium chloride solution (**F.3.1**) at 20 °C (in $\mu S \cdot cm^{-1}$).

NOTE 1 The measured values can be influenced by poisoning of the electrodes. Poisoning is difficult to recognize except as an influence on the cell constant. Variation of the cell constant should be investigated.

NOTE 2 It is important to check that the temperature setting of the conductivity bridge is 20 °C as some instruments are factory set to different temperatures.

F.6.2 Determination of conductivity

Cap the bottle containing the filtered extract (**F.5.1**) and, using the constant temperature bath (**F.4.2**), bring its temperature to, and maintain it at, (20 ± 0.5) °C. Place the conductivity cell into the solution and record the conductivity of the filtered extract, *c*, in $\mu S \cdot cm^{-1}$.

Repeat this procedure with the blank (**F.5.2**) and record the conductivity of the blank, *b*, in $\mu S \cdot cm^{-1}$.

F.7 Calculation and expression of results

Calculate the specific conductivity of the soil, C, in μS·cm^{-1}, using the following equation:

$$C = J(c - b)$$

where:

c	is the conductivity of the soil solution (from **F.6.2**) at 20 °C (in μS·cm^{-1});
b	is the conductivity of the blank (from **F.6.2**) at 20 °C (in μS·cm^{-1});
J	is the cell constant determined in accordance with **F.6.1**.

F.8 Test report

The test report shall include the following:

a) a complete identification of the sample;

b) a reference to this British Standard, i.e. BS 8601:2013;

c) the results calculated in accordance with **F.7**;

d) any unusual features noted during the determination;

e) any operation not included in this method or regarded as optional.

Annex G (normative) Method for determining other contaminants

NOTE This method is based on that in PAS 100:2005.

G.1 Test samples

Samples retained on the sieves after measurement of the coarse fragment content (see Table 1) shall be used. For determination of sharps, the portion that has passed the 2 mm aperture sieve shall also be used.

G.2 Procedure

From the material retained on sieves with apertures 2 mm or larger, pick over and remove “other contaminants” (**3.7**) for weighing. Weigh and record the mass of other contaminants.

Pick over the other contaminants (**3.7**) and remove plastics for weighing. Weigh and record the mass of plastics.

Pick over the other contaminants and the portion that has passed the 2 mm aperture sieve for sharps (**3.8**). Weigh and record the mass of sharps.

G.3 Test report

The test report shall include the following:

a) a reference to this British Standard, i.e. BS 8601:2013;

b) a complete identification of the original sample;

c) mass of the original sample

d) the % (*m*/*m*) of other contaminants in the sample;

e) the % (*m*/*m*) of plastics in the sample;

f) the mass of sharps in 1 kg of the sample;

g) any operation not included in this method or regarded as optional.

Annex H (normative) Importance of soil electrical conductivity, soil salinity and exchangeable sodium percentage (ESP)

H.1 Soil electrical conductivity and salinity

Soil electrical conductivity (EC) is relatively easy to measure, albeit there are different methods, but interpreting the result is not straightforward. EC is determined by the concentration of dissolved ions (charged atoms and molecules) in the medium being measured. EC can be measured in soil made into a saturated paste or in an extract from soil with a defined soil to extractant volume ratio; the extractant could be distilled water or saturated calcium sulfate solution. The latter has been chosen for this standard because it suppresses solubilization of constituents that were not dissolved in the original sample.

The most common soluble constituents are fertilizer constituents (ammonium, potassium, calcium, magnesium, sulfate and nitrate) and sodium and chloride from sea-water flooding. Excessive sodium is problematic in soils that contain clay because it destabilizes soil structure. Chloride is potentially toxic.

High EC gives rise to three possible causes for concern: an osmotic effect on root activity (i.e. water uptake is reduced); a toxicity effect; and (as above) a soil structural stability effect (see also Loveland, 1990 [9] for further discussion of electrical conductivity and salinity). The effects of EC on plants are also affected by soil texture. Plants growing in lighter soils are more susceptible to elevated EC.

Climate and irrigation also influence salinity tolerance. As soil dries, salts become concentrated in the soil solution, increasing salt stress. Therefore, salt problems are more severe under hot, dry conditions than under cool, humid conditions. Increasing irrigation frequency and applying water in excess of plant demand might be required during hot, dry periods to minimize salinity stress.

Different plant species display a range of tolerances to the soluble salts present, as measured by soil electrical conductivity. However, a low soil electrical conductivity is not necessarily a guide to the absence of sodium-related structural problems. In most cases the EC decreases when rainfall or irrigation is sufficient to leach soluble salts out of the soil.

In summary, EC is easy to measure but interpreting the result is difficult and very dependent upon the method used. It is a useful screening test to trigger investigation of whether there is some potential problem that needs to be addressed and that is how it is used in this standard.

H.2 Exchangeable sodium percentage (ESP)

The exchangeable sodium percentage (ESP) is a measure of the exchangeable sodium ions relative to the total exchangeable ions. If the soil electrical conductivity is greater than 2 800 $\mu S \cdot cm^{-1}$, the ESP needs to be measured. An ESP of up to 15% is acceptable where the clay content is less than 35% (and up to 10% when clay is >50%). Gypsum can be applied to ameliorate structural instability due to excessive sodium; replacing exchangeable sodium with exchangeable calcium reduces clay dispersion and thus improves soil structure and drainage (leaching).

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