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Geotechnical investigation and testing — Identification and classification of soil —

Part 1: Identification and description

Recherches et essais géotechniques — Identification et classification des sols —

Partie 1: Identification et description

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 14688 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14688-1 was prepared by Technical Committee ISO/TC 182, *Geotechnics*, Subcommittee SC 1, *Geotechnical investigation and testing*.

ISO 14688 consists of the following parts, under the general title *Geotechnical investigation and testing — Identification and classification of soil*:

— *Part 1: Identification and description*

— *Part 2: Classification principles and quantification of descriptive characteristics*

Geotechnical investigation and testing — Identification and classification of soil —

Part 1: Identification and description

1 Scope

This part of ISO 14688, together with ISO 14688-2, establishes the basic principles for the identification and classification of soils on the basis of those material and mass characteristics most commonly used for soils for engineering purposes. The relevant characteristics may vary and therefore, for particular projects or materials, more detailed subdivisions of the descriptive and classification terms may be appropriate.

The general identification and description of soils is based on a flexible system for immediate (field) use by experienced persons, covering both material and mass characteristics by visual and manual techniques.

Details are given of the individual characteristics for identifying soils and the descriptive terms in regular use, including those related to the results of tests from the field.

This part of ISO 14688 is applicable to natural soils *in situ*, similar man-made materials *in situ* and soils redeposited by man. The identification and description of rocks is covered by ISO 14689.

The identification and classification of soil for pedological purposes, as well as in the framework of measurements for soil protection and for remediation of contaminated areas, is covered by ISO 11259.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14688. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14688 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 11259, *Soil quality — Simplified soil description*

ISO 14688-2, *Geotechnical investigation and testing — Identification and classification of soil — Part 2: Classification principles and quantification of descriptive characteristics*

ISO 14689, *Geotechnical investigation and testing — Identification and description of rock*

3 Terms and definitions

For the purposes of this part of ISO 14688, the following terms and definitions apply.

3.1
soil
assemblage of mineral particles and/or organic matter in the form of a deposit but sometimes of organic origin, which can be separated by gentle mechanical means and which includes variable amounts of water and air (and sometimes other gases)

NOTE 1 The term is also applied to made ground consisting of replaced natural soil or man-made materials exhibiting similar behaviour, e. g. crushed rock, blast-furnace slag, fly-ash.

NOTE 2 Soils may have rock structures and textures may exist but soils are usually of lower strength than rocks.

3.2
identification of soil
naming and description of a soil on the basis of its grading, type of material and characteristics of mineral and/or organic constituents and plasticity

3.3
geological structure
variation in composition including bedding and discontinuities

3.4
discontinuities
bedding planes, joints, fissures, faults and shear planes

3.5
organic matter
matter consisting of plant and/or animal organic materials, and the conversion products of those materials, e.g. humus

NOTE Organic matter usually has a very high water content.

3.6
grading
measure of the particle sizes of a soil and their distribution

3.7
fraction
part of a soil that can be distinguished on the basis of defined particle sizes

3.8
plasticity
property of a cohesive soil to change its mechanical behaviour with change of water content

3.9
volcanic soils
pyroclastic materials produced and formed by explosive volcanic eruption; e.g. pumice, scoria, volcanic ash

4 Identification of soil

4.1 General

Subclauses 4.2 to 4.10 give soil characteristics that generally permit soil to be identified with adequate accuracy for general (or preliminary) characterization. A more accurate identification and classification based on grading, plasticity or organic content can be achieved by laboratory tests. In addition to identifying soils, the condition in which a soil is encountered, any particular secondary constituents, other features of a soil, such as carbonate content, particle shape, surface roughness of particles, odour, any common names and the geological classification should all be indicated. For the identification and description, methods and additional tests shall be carried out according to clause 5. The identification and description of soils generally follows the flow chart in Figure 1.

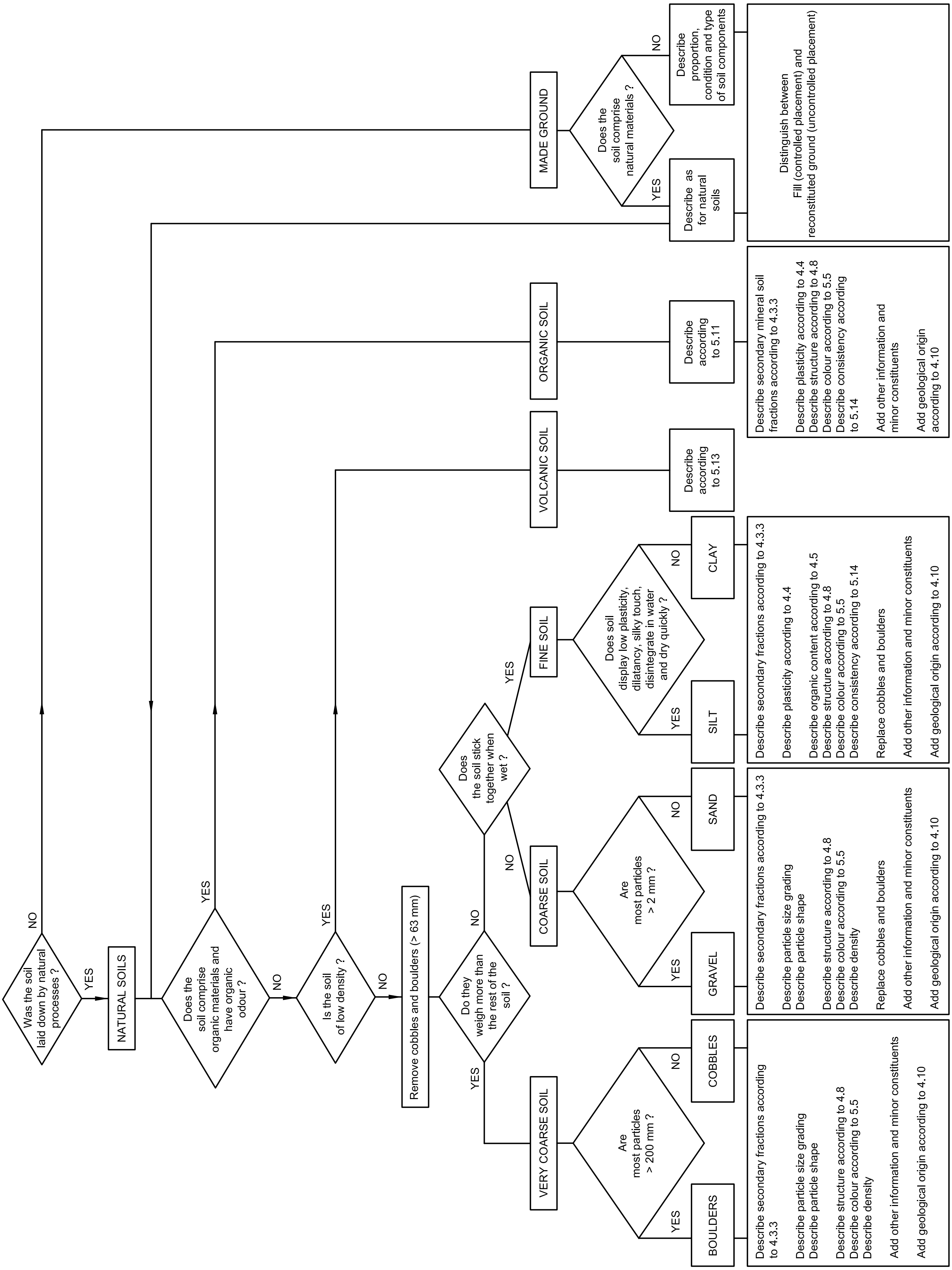

Figure 1 — Flow chart for the identification and description of soils

4.2 Particle size

Particle size is the fundamental basis for designating mineral soils using particle fractions to distinguish the soil mechanical behaviour. Table 1 shows the terms to be used for each soil fraction and its sub-fractions, together with the corresponding chosen range of particle sizes.

Basic soils are soils with uniform grading (i.e. they consist of particles of only one size range) as specified in Table 1 (e.g. gravel Gr, fine sand FSa, coarse silt CSi). The first letter of the abbreviation of the soil fraction is a capital.

Table 1 — Particle size fractions

Soil fractions	Sub-fractions	Symbols	Particle sizes mm
Very coarse soil	Large boulder	LBo	$>$ 630
	Boulder	Bo	$>$ 200 to 630
	Cobble	Co	$>$ 63 to 200
Coarse soil	Gravel	Gr	$>$ 2,0 to 63
	Coarse gravel	CGr	$>$ 20 to 63
	Medium gravel	MGr	$>$ 6,3 to 20
	Fine gravel	FGr	$>$ 2,0 to 6,3
	Sand	Sa	$>$ 0,063 to 2,0
	Coarse sand	CSa	$>$ 0,63 to 2,0
	Medium sand	MSa	$>$ 0,2 to 0,63
	Fine sand	FSa	$>$ 0,063 to 0,2
Fine soil	Silt	Si	$>$ 0,002 to 0,063
	Coarse silt	CSi	$>$ 0,02 to 0,063
	Medium silt	MSi	$>$ 0,006 3 to 0,02
	Fine silt	FSi	$>$ 0,002 to 0,006 3
	Clay	Cl	$\leqslant$ 0,002

4.3 Composite soils

4.3.1 General

Most soils are composite and consist of principal and secondary fractions. They are designated by a noun (main term) describing the principal fraction and by one or more adjectives (qualifying terms) describing the secondary fractions (e.g. sandy gravel saGr, gravelly clay grCl).

Composite soil terms shall be written with small letters.

Interlayered soils can be written in small underlined letters following the principal soil fraction (e.g. gravelly clay interbedded with sand grCl<u>sa</u>).

4.3.2 Principal fraction

The principal fraction in terms of mass determines the engineering properties of the soil. It may be given in capital letters for clarity.

In the case of very coarse soils, the principal fraction is the relevant very coarse soil fraction predominating in terms of mass. The very coarse fraction should be separated from the sample before identifying the fine and coarse fractions.

In the case of coarse soils, the principal fraction is the relevant coarse soil fraction predominating in terms of mass. Composite coarse soils include a fines fraction (silt and/or clay) that does not determine the engineering properties of the soil.

NOTE 1 The fines fraction is not regarded as determining the characteristics of a composite soil if the soil exhibits no, or only very low, dry strength in the test described in 5.6 or if, when tested in accordance with 5.8, it exhibits a very low plasticity.

In both cases, the name shall be based on the subfraction into which coarse soil is identified, cf. 4.2 e.g. gravel, sand, medium gravel, fine sand.

In the case of fine soils, the principal fraction is the relevant fine soil type determining the engineering properties of the soil.

In the case of composite fine soils, the fines fraction determines the engineering properties of the soil.

NOTE 2 The fines fraction is regarded as determining the characteristics of a composite soil if this is of at least medium dry strength as determined in the test described in 5.6, or exhibits a certain degree of plasticity as determined in the test described in 5.8.

In both cases, the soil shall be termed either “clay” or “silt”, depending on the plasticity of the fines fraction and not on the grading. The identification shall be based on 5.6, 5.7, 5.8 and 5.9.

NOTE 3 The minimum size of soil sample required for accurate identification increases with maximum particle size.

4.3.3 Secondary fractions

Secondary and further fractions do not determine but will affect the engineering properties of the soil.

The secondary fractions as adjectives shall be placed with the term describing the principal fraction in the order of their relevance, as shown in the following examples:

— sandy gravel (saGr),

— coarse sandy fine gravel (csaFGr),

— medium sandy silt (msaSi),

— fine gravely coarse sand (fgrCSa),

— silty fine sand (siFSa),

— fine gravelly, coarse sandy silt (fgrcsaSi),

— medium sandy clay (msaCl).

If coarse secondary fractions are present in a particularly small or particularly large proportion, the term “slightly” or “very” shall precede the qualifying term.

If it is a fine soil, the properties of which are determined by fines fractions, a soil can be identified as “silt” or “clay” by checking for the presence of fine secondary constituents on the basis of its plasticity properties using the tests described in 5.6, 5.7, 5.8 and 5.9.

If, in the case of coarse soils, two soil fractions are present in approximately equal proportions, an oblique shall be placed between the relevant terms, e.g. gravel/sand (Gr/Sa)or fine/medium sand (FSa/MSa).

4.4 Plasticity

Soils that are subjected to the test described in 5.8 and permit their consistency limits to be determined, may be identified as exhibiting plastic properties.

NOTE Such soils are also referred to as cohesive soils.

Assessment of the plasticity and identification of a soil as either silt or clay shall be carried out by testing as specified in 5.6, 5.7, 5.8 and 5.9. This permits the soil to be qualified as being of

— low plasticity, or

— high plasticity.

An exact determination can only be made by establishing the liquid limit w_L and the plastic limit, w_P, in laboratory tests.

4.5 Organic content

Small quantities of dispersed organic matter in a soil can produce a distinctive odour (see 5.11) and colours. The intensity of odour and colour indicates the proportion of organic matter and should be described.

4.6 Peat and other organic soils

The designation for soils consisting principally of organic matter are summarized in Table 2. Peats are generally of low density and have a distinctive odour (see 5.11).

Peat is identified and described according to the degree of decomposition, this being determined in the wet state by squeezing (see Table 5), and according to its fibre content.

In the case of organic soils with mineral constituents, these should be described by qualifying terms, e.g. fine sandy peat.

Table 2 — Identification and description of organic soil

Term	Description
Fibrous peat	Fibrous structure, easily recognizable plant structure, retains some strength
Pseudo-fibrous peat	Recognizable plant structure; no strength of apparent plant material
Amorphous peat	No visible plant structure, mushy consistency
Gyttja	Decomposed plant and animal remains; may contain inorganic constituents
Humus	Plant remains, living organisms and their excretions together with inorganic constituents, form the topsoil.

4.7 Volcanic soils

Generally, particles of volcanic soils are vesicular and the density of the soils is relatively low. The soils possess a characteristic colour depending on the property of their host magma or rock. Volcanic soil as a principal fraction is identified and described according to the particle size, structure and colour (see Table 3).

Table 3 — Identification and description of volcanic soils

<table>
<tr><th colspan="2">Term</th><th>Particle sizes
mm</th><th>Description</th></tr>
<tr><td colspan="2">Volcanic cobble</td><td>> 63</td><td>—</td></tr>
<tr><td rowspan="3">Lapilli</td><td>—</td><td rowspan="3">$> 2,0 < 63$</td><td>—</td></tr>
<tr><td>Pumice</td><td>Particles are vesicular and white.</td></tr>
<tr><td>Scoria</td><td>Particles are vesicular and black.</td></tr>
<tr><td rowspan="2">Volcanic ash</td><td>Volcanic sand</td><td rowspan="2">$\leqslant 2,0$</td><td>The soil shows particular geotechnical characteristics in each area.</td></tr>
<tr><td>Tuff</td><td>In most cases, the soil has its local name</td></tr>
</table>

4.8 Discontinuities and bedding

The term discontinuity is used to describe surfaces in the soil which separate soils of different types or form planes of weakness within the soil. Most discontinuities in soil fall into one of two broad groups. These are as follows.

a) “Depositional” discontinuities, which result from the way in which the soil was deposited or formed, such as bedding planes, which are commonly parallel but may show sedimentary structures such as cross-bedding or graded bedding. Such features may not be mechanical breaks, and shall be described by the thickness of units between the bedding planes.

b) “Mechanical” discontinuities, which include mechanical breaks in the soil as a consequence of shrinkage, ice unloading or tectonic stress. Fissures, faults and shears are examples of such discontinuities and are most common in over-consolidated soils. Fissures and shears may also be a consequence of previous landsliding in a soil.

Discontinuities may significantly affect the engineering behaviour of the soil and their frequency of occurrence is expressed by noting their spacing; quantification of the range of actual spacings can also be given. If discontinuities occur, they may be described by methods according to ISO 14689.

4.9 Interbedding and mixed soils

Interbedding is a sequence of different soil layers of variable thickness and extent which are summarized for practical reasons (thin laminae, rapid change). The properties of single layers shall be described; also very thin layers shall be considered. The bedding may be mixed by processes (roots, burrows, cryoturbination), so that mixed soils develop e.g. solifluction soils.

4.10 Origin of deposit

The description of the soil should be concluded, where possible, with the geological origin of the soil, usually in brackets. This also indicates some properties and mineral composition before test results become available.

5 Methods for identification and description of soil

5.1 Determination of particle size distribution

To determine the particle size distribution, the soil sample shall be spread out on a flat surface or on the palm of the hand. The particle sizes of the sample shall be compared with those of a grading standard comprising sections containing material of different particle size ranges according to Table 1.

As the individual particles of silt and clay are not visible to the naked eye, the methods given in 5.4, 5.6, 5.7 and 5.9 shall be used in determining the characteristics of such soil.

5.2 Determination of particle shape

In the case of coarse fractions, the particle shape is described by reference to the angularity of the particles (which indicates the degree of rounding at edges and corners), their general form and their surface characteristics. Terms to be used for these aspects, usually only applied to gravel size or larger, are given in Table 4. It is usual practice to estimate mean angularity or roundness using a standard set of charts.

Table 4 — Terms for the designation of particle shape

Parameter	Particle shape
Angularity/roundness	Very angular Angular Subangular Subrounded Rounded Well rounded
Form	Cubic Flat Elongate
Surface texture	Rough Smooth

5.3 Determination of mineral composition

The mineral composition of the individual particles of a soil is identified according to geological science. The names of the minerals present, together with any coatings, shall be included in the description of the soil. When making a field examination of the coarse fraction, a hand lens is often necessary.

NOTE Gravel particles are usually rock fragments, e.g. sandstone, limestone, flint. Sand and finer particles are generally individual mineral particles; quartz, mica, feldspar and clay minerals. Gravel and sand particles may be coated with mineral matter, including calcite, or iron oxide. Crystals, for example gypsum in clay and pyrite in chalk, may be present.

5.4 Determination of fines content

For identifying composite soils, the fines fraction of a small sample quantity shall be washed out and the coarse residue described on the basis of the particle size and shape, type of material and any special constituents. The duration and thoroughness of the washout process and examination of the product indicate the type and the percentage of fines.

5.5 Determination of soil colours

The colour of a soil, although dependent upon local conditions, will often characterize the composition of the material content and its distribution. Colour facilitates the distinction between mineral and organic soils. Reference to the colour of organic soils and peat is given in 4.6.

It is important to identify the colour of a freshly cut surface in full daylight because some soils change their colour very quickly in air. An example of this is fine soil containing iron oxide compounds which, in the fresh-water saturated condition, often has an olive green colour but which rapidly oxidizes to red on exposure to air. Colour changes such as those due to oxidation or desiccation should always be recorded.

A colour chart provides a useful aid, particularly to improve the consistency between descriptions by different persons.

5.6 Determination of dry strength

The dry strength provides information on the plasticity of a soil and thus on its behaviour and identification as silt or clay.

To establish the dry strength, a soil sample shall be dried. Its resistance to being crumbled or powdered between the fingers is a measure of the dry strength of the soil, which is governed by the type and percentage of fines. The following strengths are distinguished:

a) low dry strength: dried soil disintegrates under light to moderate finger pressure;

b) medium dry strength: dried soil disintegrates only under substantial finger pressure into pieces which still show cohesion

c) high dry strength: dried soil can no longer be made to disintegrate by finger pressure but can only be broken.

NOTE A low dry strength characterizes silt. A high dry strength characterizes clay, if not caused by cementation. A mixture of clay and silt has a medium dry strength in general.

5.7 Determination of dilatancy

The behaviour of cohesive soils when shaken indicates the content of silt and clay.

A moistened sample of 10 mm to 20 mm size shall be shaken from hand to hand. The sample becomes shiny by the appearance of water on the surface of the sample. When the sample is pressed with the fingers, the water disappears. The content of silt and clay can be estimated according to the time taken for water to appear and disappear during shaking and pressing.

NOTE The water appears and disappears rapidly for silt. Shaking and pressing has no effect on the sample condition of clay. The slower the appearance of water on the sample surface, the lower the content of silt and the higher the content of clay.

5.8 Determination of plasticity

To establish the plasticity (toughness), a moistened soil sample shall be rolled on a smooth surface to produce threads about 3 mm in diameter moulded together, and rolled again until it cannot be rolled out any longer because of loss of water, but only moulded. The plastic limit has been reached.

a) Low plasticity: a sample having cohesion but cannot be rolled to threads of about 3 mm in diameter.

b) High plasticity: the sample can be rolled to thin threads.

NOTE A low plasticity characterizes a high content of silt, while a high plasticity corresponds to a high clay content.

5.9 Determination of sand, silt and clay content of soils

To check a soil for the presence of sand, silt and clay, a small soil sample shall be rubbed between the fingers, if necessary under water. The proportion of the sand fraction can be determined from the degree to which the material feels gritty. Coarse silt may also feel gritty but the individual particles cannot be seen with the naked eye.

NOTE A clayey soil feels soapy and sticks to the fingers and cannot be removed without washing, even when in the dry state. Silty soils feel smooth to the touch, the dry soil particles that stick to the fingers can be easily blown away or removed by clapping the hands.

To check a soil for the presence of clay or silt, a sample in its naturally moist state shall be cut with a knife. A shiny cut surface indicates the presence of clay, while a dull sample surface is characteristic of silt or of clayey sandy silt of low plasticity. For a rapid assessment, the sample surface may be scored with a fingernail or smoothed.

5.10 Determination of carbonate content

The carbonate content is determined by the application of droplets of dilute hydrochloric acid (HCl) (3:1 or 10 %). The following characteristics could be distinguished:

a) carbonate-free (O) if the addition of HCl produces no effervescence;

b) calcareous (+) if the addition of HCl produces clear, but not sustained, effervescence;

c) highly calcareous (++) if the addition of HCl produces strong and sustained effervescence.

It should be noted that, in wet or moist clayey soils, the effervescence usually occurs with some delay.

NOTE A high dry strength is often the result of carbonate acting as a cementing agent.

WARNING — Hydrochloric acid can produce poisonous gases when applied to chemically contaminated soils.

5.11 Methods for identification and description of organic soil

The odour of a soil gives an indication of whether it is of inorganic or organic nature. Fresh, moist organic soils generally have a mouldy odour which can be intensified by heating a moist sample. Putrefying, rotten organic components in soil can be recognized by their odour typical of hydrogen sulfide, which can be intensified by pouring dilute hydrochloric acid on the sample. Dry inorganic clays have an earthy odour after being moistened.

5.12 Determination of the degree of decomposition of peat

The degree of decomposition of peat can be established by squeezing a wet sample in the hand (see Table 5). If squeezing is not effective because the peat is too dry, the peat shall be assessed on the basis of its appearance, substantial fractions of well-maintained plant remains being recognizable in undecomposed to moderately decomposed peat and no plant remains in highly or completely decomposed peat.

Table 5 — Degree of decomposition of wet peat as determined by squeezing

Term	Decomposition	Remains	Squeeze
Fibrous	Not	Clearly recognizable	Only water No solids
Pseudo-fibrous	Moderate	Recognizable	Turbid water $<$ 50 % solids
Amorphous	Full	Not recognizable	Paste $>$ 50 % solids

5.13 Methods of identification and description of volcanic soils

Soil located in the distribution area of volcanic soil can be identified as volcanic by the existence of pumice and scoria. Another method is to measure the volume of volcanic glass obtained by washing out the soils. If a more accurate identification is requested, it will be necessary to analyse the physical and chemical properties of the mineral constituents of the soil.

5.14 Determination of consistency

The consistency of a cohesive soil shall be determined in a manual test, permitting the following identification and description:

a) a soil is to be identified as **very soft** if it exudes between the fingers when squeezed in the hand;

b) a soil is to be identified as **soft** if it can be moulded by light finger pressure;

c) a soil is to be identified as **firm** if it cannot be moulded by the fingers, but rolled in the hand to 3 mm thick threads without breaking or crumbling;

d) a soil is to be identified as **stiff** if it crumbles and breaks when rolled to 3 mm thick threads but is still sufficiently moist to be moulded to a lump again;

e) a soil is to be identified as **very stiff** if it has dried out and is mostly light coloured. It can no longer be moulded but crumbles under pressure. It can be indented by the thumbnail.

These subdivisions may be approximate, particularly in materials of low plasticity.

6 Report

The symbols of ISO 710-1 and ISO 710-2 should be used to represent soils on bore hole legends or on engineering geological maps.

It shall be clearly stated that the descriptions are based on visual and manual identification.

The description of any soil shall contain at least the following information:

— author's name;

— date of description;

— details of origin of samples;

— condition of described soil;

— principal soil type;

— secondary fractions;

— colour;

— legend of symbols and additional terms used.

Following the previous items, any appropriate descriptions shall be added according to this part of ISO 14688.

Bibliography

[1] ISO 710-1, *Graphical symbols for use on detailed maps, plans and geological cross-sections — Part 1: General rules of representation*

[2] ISO 710-2, *Graphical symbols for use on detailed maps, plans and geological cross-sections — Part 2: Representation of sedimentary rocks*

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