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Geotechnical investigation and testing - Identification and classification of soil - Part 2: Principles for a classification

Reconnaissance et essais géotechniques - Identification et classification des sols - Partie 2: Principes pour une classification (ISO 14688-2:2017)

Geotechnische Erkundung und Untersuchung -Benennung, Beschreibung und Klassifizierung von Boden - Teil 2: Grundlagen für Bodenklassifizierungen (ISO 14688-2:2017)

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TÜRK STANDARDI

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Milli Önsöz

Bu standard, CEN/TC 341 "Geotechnical Investigation and Testing-Geoteknik Araştırma ve Test" Teknik Komitesi tarafından hazırlanmış, CEN tarafından 20.11.2017 tarihinde onaylanmış ve Türk Standardları Enstitüsü Teknik Kurulu'nun 19.03.2018 tarihli toplantısında Türk Standardı olarak kabul edilerek yayımına karar verilmiştir.

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Geotechnical investigation and testing - Identification and classification of soil - Part 2: Principles for a classification (ISO 14688-2:2017)

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European foreword

This document (EN ISO 14688-2:2018) has been prepared by Technical Committee ISO/TC 182 “Geotechnics” in collaboration with Technical Committee CEN/TC 341 “Geotechnical Investigation and Testing” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2018, and conflicting national standards shall be withdrawn at the latest by August 2018.

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

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Endorsement notice

The text of ISO 14688-2:2017 has been approved by CEN as EN ISO 14688-2:2018 without any modification.

INTERNATIONAL STANDARD

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Geotechnical investigation and testing — Identification and classification of soil —

Part 2: Principles for a classification

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 182, *Geotechnics*.

This second edition cancels and replaces the first edition (ISO 14688-2:2004), which has been technically revised. It also incorporates the Amendment ISO 14688-2:2004/Amd 1:2013.

A list of all parts in the ISO 14688 series can be found on the ISO website.

Introduction

This document gives the means by which soils can be classified into groups of similar composition and geotechnical properties based on the results of field and laboratory tests with respect to their suitability for geotechnical engineering purposes.

Prior to classification, ISO 14688-1 gives details of the procedures that should be followed in the identification and description of soils.

INTERNATIONAL STANDARD **ISO 14688-2:2017(E)**

Geotechnical investigation and testing — Identification and classification of soil —

Part 2: Principles for a classification

1 Scope

This document specifies the basic principles for classification of those material characteristics most commonly used for soils for engineering purposes. It is intended to be read in conjunction with ISO 14688-1, which gives rules for the identification and description of soils. The relevant characteristics could vary and therefore, for particular projects or materials, more detailed subdivisions of the descriptive and classification terms could be appropriate. Due to differences in local geological conditions, practices to enhance relevant classification criteria are used.

The classification principles established in this document allow soils to be classified into groups of similar composition and geotechnical properties, based on the results of field and laboratory tests with respect to their suitability for geotechnical engineering purposes.

This document is applicable to natural soil *in situ*, natural soil reworked artificially and synthetic materials. A more detailed classification specific to use in earthworks is given in EN 16907-2.

NOTE 1 Identification and description of rocks are covered by ISO 14689. Identification and description of materials intermediate between soil and rock are carried out using the procedures in ISO 14688-1, this document and ISO 14689, as appropriate.

NOTE 2 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 25177.

2 Normative references

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

ISO 14688-1:2017, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description*

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

ISO 17892-1, *Geotechnical investigation and testing — Laboratory testing of soil — Part 1: Determination of water content*

ISO 17892-2, *Geotechnical investigation and testing — Laboratory testing of soil — Part 2: Determination of bulk density*

ISO 17892-3, *Geotechnical investigation and testing — Laboratory testing of soil — Part 3: Determination of particle density*

ISO 17892-4, *Geotechnical investigation and testing — Laboratory testing of soil — Part 4: Determination of particle size distribution*

ISO 17892-5, *Geotechnical investigation and testing — Laboratory testing of soil — Part 5: Incremental loading oedometer test*

ISO 17892-6, *Geotechnical investigation and testing — Laboratory testing of soil — Part 6: Fall cone test*

ISO/TS 17892-7, *Geotechnical investigation and testing — Laboratory testing of soil — Part 7: Unconfined compression test on fine-grained soils*

ISO/TS 17892-8, *Geotechnical investigation and testing — Laboratory testing of soil — Part 8: Unconsolidated undrained triaxial test*

ISO/TS 17892-9, *Geotechnical investigation and testing — Laboratory testing of soil — Part 9: Consolidated triaxial compression test*

ISO/TS 17892-10, *Geotechnical investigation and testing —Laboratory testing of soil — Part 10: Direct shear tests*

ISO/TS 17892-11, *Geotechnical investigation and testing — Laboratory testing of soil — Part 11: Permeability tests*

ISO/TS 17892-12, *Geotechnical investigation and testing — Laboratory testing of soil — Determination of Atterberg limits*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14688-1 and the following apply.

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

— ISO Online browsing platform: available at www.iso.org/obp

— IEC Electropedia: available at www.electropedia.org

3.1
coefficient of curvature
C_C
ratio $(D_{30})^2/(D_{10} \times D_{60})$, where D_{60}, D_{30} and D_{10} are the particle diameters corresponding to 60 %, 30 % and 10 % finer on the cumulative particle size distribution curve, respectively

3.2
compression index
C_c
defined in accordance with the following relation:

$$C_c = -\frac{\Delta e}{\lg\left[(\sigma' + \Delta\sigma')/\sigma'\right]} = -\frac{\Delta e}{\Delta(\lg\sigma')}$$

Note 1 to entry: Δe is the change in void ratio (negative value when e decreases) for plastic deformation and is the change in void ratio Δe for a relative increase of effective stress from lgσ' to lg $(\sigma' + \Delta\sigma')$.

3.3
consistency index
I_C
numerical difference between the *liquid limit* (3.6) and the natural *water content* (3.16) expressed as a percentage ratio of the *plasticity index* (3.10)

$$I_C = (w_L - w)/I_P$$

3.4
density index
I_D
index for coarse soils (sands and gravels) dependent upon the *void ratio* (3.15) and the void ratios corresponding to the minimum density (e_{min}) and the maximum density (e_{max}), as measured in the laboratory

$$I_D = (e_{max} - e)/(e_{max} - e_{min})$$

3.5
dry density
ρ_d
mass of oven-dried soil per unit volume of the material

3.6
liquid limit
w_L
water content (3.16) at which a fine soil passes from the liquid to the plastic condition, as determined by the *liquid limit* (3.6) test

3.7
liquidity index
I_L
numerical difference between the natural *water content* (3.16) and the *plastic limit* (3.9) expressed as a percentage ratio of the *plasticity index* (3.10)

$$I_L = (w - w_P)/I_P$$

3.8
particle density
ρ_S
density of the soil particles

3.9
plastic limit
w_P
water content (3.16) at which a fine soil passes from the plastic to the semi-solid condition, as determined by the plastic limit test

3.10
plasticity index
I_P
numerical difference between the *liquid limit* (3.6) and *plastic limit* (3.9) of a fine soil

$$I_P = w_L - w_P$$

3.11
soil classification
assignment of soil into groups on the basis of certain behavioural characteristics, criteria and genesis

3.12
soil groups
soils of similar composition and geotechnical properties

3.13
undrained shear strength
c_u
shear resistance of soil in the undrained condition

3.14
uniformity coefficient
C_U
ratio D_{60}/D_{10}, where D_{60} and D_{10} are the particle sizes such that 60 % and 10 % of the particles by weight are smaller than those sizes

3.15
void ratio
e
ratio of the volume of voids to the volume of solids of a soil

3.16
water content
w
mass of water which can be removed from the soil, usually by drying, expressed as a percentage of the dry mass

4 Principles of soil classifications

4.1 General

Soils shall be classified in accordance with this document. The identification and description of soils and the identification, description and classification of rocks shall be carried out in accordance with ISO 14688-1 and ISO 14689, respectively.

Classification uses the results of laboratory tests. The classification of soils shall be based on tests carried out in accordance with ISO 17892-1 to ISO 17892-12.

Classification places soils into groups on the basis of their nature which is the composition only, irrespective of their water content or compactness, taking into account the following characteristics:

— particle size distribution (grading);

— plasticity;

— organic content;

— chemical constituents such as carbonate or sulfate;

— origin of the deposit (see ISO 14688-1:2017, 5.9).

This document describes general principles for a unique soil classification system. In a geotechnical investigation, soils shall be classified with the use of an adopted existing national requirement or one created for a specific project. Such a soil classification system should meet the following principles.

a) It will conform to this document and to ISO 14688-1 regarding terms, definitions and identification of the soil groups.

b) It will comprise a sufficient series of soil groups that will correspond to and cover the geotechnical conditions of the project.

c) It will comprise specific criteria for classifying soils into distinct groups.

Principles for soil classification, which correspond to the principles of identification given in ISO 14688-1, are given in Table 1.

Table 1 — Principles of soil classification

Soil group	Quantification	Denomination into soil groups			Further subdivision as appropriate by
		Primary fraction (symbol)	Composite fractions		
very coarse	>50 % of particles by mass ≥200 mm	Boulders (Bo)	BOULDERS BOULDERS with cobbles	BOULDERS with finer soils	Requires special consideration
	>50 % of particles by mass <200 mm and ≥63 mm	Cobbles (Co)	COBBLES COBBLES with boulders	COBBLES with finer soils	
coarse	>50 % of particles by mass <63 mm and ≥2 mm	Gravel (Gr)	GRAVEL with cobbles GRAVEL sandy GRAVEL with cobbles	Sandy GRAVEL GRAVEL with clay and silt	Particle size distribution, Shape of grading curve, Relative density/ density index, Permeability
	>50 % of particles by mass <2 mm and ≥0,063 mm	Sand (Sa)	Gravelly SAND SAND	SAND with clay or silt	Mineralogy, Particle shape
fine	low plasticity or non-plastic	Silt (Si)	sandy SILT	sandy gravelly SILT sandy clayey SILT	Plasticity, Water content, Strength, Sensitivity, Compressibility, Stiffness, Clay mineralogy
			clayey SILT, silty CLAY		
	plastic	Clay (Cl)	Sandy gravelly CLAY Organic SILT Organic CLAY		
organic		PEAT (Pt) GYTTJA (Gy) DY (Dy) HUMUS (Hu)	Sandy PEAT sandy clayey GYTTJA		Requires special consideration
Anthropogenic soil		Made Ground	Placed without control	Synthetic material or Reworked natural materials (such as crushed, graded or washed materials	Requires special consideration As for natural soils
		Fill	Placed with control		

Cases requiring special consideration should be classified in accordance with national or project requirements (see, for example, EN 16907 standards).

4.2 Particle size fractions

Soil is a mixture of materials of different particle sizes, which are grouped into particle size fractions as specified in ISO 14688-1.

Classification of coarse and very coarse soils shall be based on the particle size distribution alone (see 4.3), where the mass of soil samples available for the determination is representative (see EN 1997-2:2007, Annex L).

Classification of coarse and fine soils and composite mixtures shall be based both on the particle size and on plasticity (see 4.4), unless determination of plasticity is irrelevant or not feasible.

Classification of fine soil shall be based on either the grading (see 4.3) and/or on the plasticity (see 4.4). The basis of classification used shall be reported.

4.3 Particle size distribution (grading)

The particle sizes and their distribution in a soil should be determined by analysis carried out in accordance with ISO 17892-4 as follows:

— the separation of the coarser fractions by sieving;

— the determination of the finer fractions by, for example, sedimentation.

The results of the sieving and sedimentation process shall be plotted as a grading curve which gives the percentage by mass of each size fraction. Other methods, such as optical, can be used for determining the particle size fractions.

When designating the coarse fractions, a distinction can be drawn between uniformly, poorly, medium, well and gap graded particle size distributions. In this connection, the coefficient of curvature (C_C) and the uniformity coefficient (C_U) provide means for defining the shape of the grading curve. If certain grain sizes are absent, the term gap-graded is used (see Table 2). The median D50 of the grading curve, together with C_U and C_C may also be used to indicate the particle size grading.

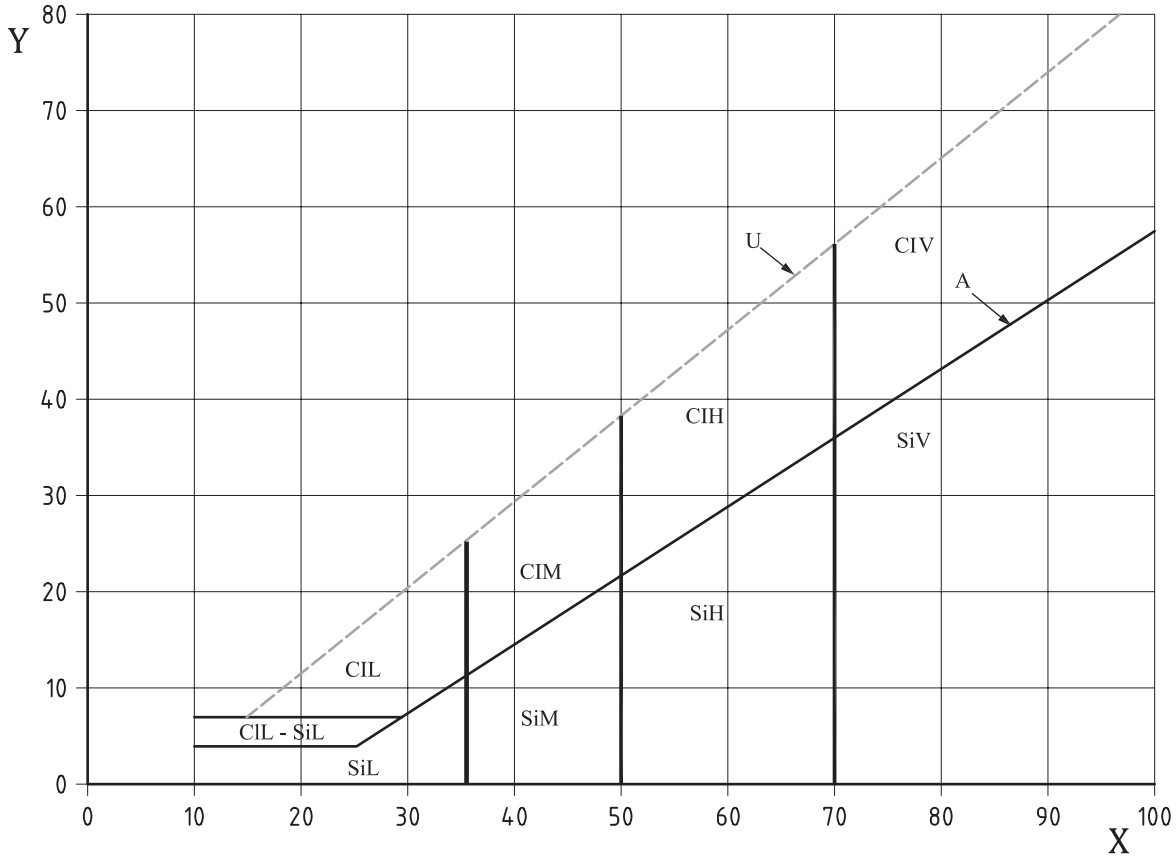
Table 2 — Shape of grading curve

Term	C_U	C_C
Uniformly graded	<3	<1
Poorly graded	3 to 6	<1
Medium graded	6 to 15	<1
Well graded	>15	1 to 3
Gap graded	>15	<0,5

4.4 Plasticity

The classification of fine soils or fine fractions in composite coarse soils should be made in accordance with their plasticity (liquid limit w_L and plastic limit w_P), which shall be determined by laboratory testing in accordance with ISO 17892-12.

The degree of plasticity of fine soils should be classified using the following terms shown on Figure 1.



Key

X liquid limit, w_L				Y plasticity index, I_P	
Soil type		Plasticity			
				Liquid limit	
Cl	Clay	L	Low	<35	
Si	Silt	M	Medium	35 to 50	
		H	High	50 to 70	
		V	Very high	>70	
		O	Organic	append to classification for organic material (e.g. ClHO)	
U line	$I_P = 0{,}9\ (w_L - 8)$			A line	$I_P = 0{,}73\ (w_L - 20)$

Figure 1 — Plasticity chart

Any test results that plot above or to the left of the U line should be carefully checked.

NOTE 1 The U line shown in Figure 1 is empirically determined to be an approximate upper limit for natural soils.

NOTE 2 Organic content of soils can affect the results of the plasticity tests, with greater impact on the liquid limit than the plasticity index, and so increasing the organic content moves soils to the right on Figure 1.

Other test methods, such as methylene blue, can be used to assess soil plasticity.

Alternative materials classifications may be used in particular geological settings.

4.5 Organic content

When soils with organic constituents are classified in accordance with their organic content, a distinction shall be made between organic soils (peat/humus/gyttja/dy; see ISO 14688-1) and mineral

soils with an organic content (see Table 3). The method used for determination of the organic content shall be reported.

Table 3 — Classification of soils with particle sizes ≤2 mm with organic constituents

Term	Organic content % of dry mass
Low-organic	2 to 6
Medium-organic	6 to 20
High-organic	>20
Peat/gyttja/ dy/humus	—

Classification of soils with particle sizes larger than 2 mm is based on the type of organic matter, the genetic origin and the degree of decomposition of the organic constituents.

4.6 Carbonate content

The classification of the carbonate content of soils can be made using the terms given in Table 4. The method used shall be reported.

Table 4 — Classification of carbonate content

Term	Carbonate content ($CaCO_3$) %
Non-calcareous	<1
Slightly calcareous	1 to 5
Calcareous	5 to 25
Highly calcareous	25 to 50
Very highly calcareous or Carbonate	>50

5 Other principles suitable for soil classification

5.1 General

There is a variety of quantifying terms which can be used to describe soils which include relative density, undrained shear strength and consistency index.

5.2 Correlations of relative density terms for coarse soils

Relative density can be classified on the basis of the density index, I_D, using the terms given in Table 5. The density index is measured in the laboratory (see 3.4).

Table 5 — Correlations to classify relative density using density index

Relative density term	Density index, I_D %
Very loose	0 to 15
Loose	15 to 35
Medium dense	35 to 65
Dense	65 to 85
Very dense	85 to 100

Field tests can also be used to assess relative density (see EN 1997-2).

5.3 Undrained shear strength of fine soils

The terms to be used for the designation of the undrained shear strength in accordance with the results of direct (but not derived) measurement by laboratory and field tests are given in Table 6. The laboratory determination of shear strength shall be carried out in accordance with ISO 17892-7 or ISO 17892-8 or as an index test in accordance with ISO 17892-6.

Table 6 — Undrained shear strength of fine soils

Term	Undrained shear strength c_u, kPa
Extremely low	<10
Very low	10 to 20
Low	20 to 40
Medium	40 to 75
High	75 to 150
Very high	150 to 300
Extremely high	>300

NOTE When making an immediate (field) examination, the strength can be measured by a simple field test, e.g. small (hand-held) vane apparatus.

Materials with a strength above 300 kPa should be described as rock (see ISO 14689).

5.4 Sensitivity

Fine soils may also be classified in accordance with their sensitivity, the ratio between the undisturbed and remoulded undrained shear strengths as given in Table 7.

Table 7 — Classification of sensitivity

Term	Sensitivity
Low	<8
Medium	8 to 30
High	>30

NOTE High sensitivity materials can be further classified as quick clay.

5.5 Consistency index

Terms to be used for the designation of the consistency index (I_C) of silts and clays, where appropriate, are given in Table 8. The determination of the Atterberg limits shall be carried out in accordance with ISO 17892-12.

Table 8 — Consistency index I_C of silts and clays

Term	Consistency index I_C
Very soft	<0,25
Soft	0,25 to 0,50
Firm	0,50 to 0,75
Stiff	0,75 to 1,00
Very stiff	>1,00

These subdivisions may be approximate, particularly in materials of low plasticity. Also, the strength of a clay may not be constant at a given consistency index. The liquidity index may be used as an alternative.

5.6 Other parameters

Some other parameters may be used for soil classification for specific purposes such as

— natural water content,

— dry density,

— clay activity,

— mineralogical composition,

— saturation index,

— permeability,

— compression index, C_c,

— swelling index, and

— collapse potential.

Bibliography

[1] ISO 22476-1, *Geotechnical investigation and testing — Field testing — Part 1: Electrical cone and piezocone penetration test*

[2] ISO 22476-2, *Geotechnical investigation and testing — Field testing — Part 2: Dynamic probing*

[3] ISO 22476-3, *Geotechnical investigation and testing — Field testing — Part 3: Standard penetration test*

[4] ISO 22476-4, *Geotechnical investigation and testing — Field testing — Part 4: Ménard pressuremeter test*

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[7] ISO 25177, *Soil quality — Field soil description*

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[9] EN 16907, *Earthworks*

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