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Geotechnical investigation and testing — Laboratory testing of soil —

Part 10: Direct shear tests

Reconnaissance et essais géotechniques — Essais de laboratoire des sols —

Partie 10: Essai de cisaillement direct

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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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, *Geotechnical Investigation and Testing*, in collaboration with ISO Technical Committee ISO/TC 182, *Geotechnics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces ISO/TS 17892-10:2004, which has been technically revised. It also incorporates the Technical Corrigendum ISO/TS 17892-10:2004/Cor 1:2006.

The main changes compared to the previous edition are as follows:

— general revision of the text and figures and addition of specimen preparation procedures;

— inclusion of two types of ring shear apparatus; Type A wherein failure occurs at the depth in the specimen defined by the split specimen container and Type B wherein the location of the failure surface is not defined by the apparatus;

— addition of Annex A on calibration, maintenance and checks;

— addition of Annex B on additional calculations for effective strength parameters.

A list of all the parts in the ISO 17892 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides laboratory test methods for the determination of the effective shear strength of soils by direct shear within the international field of geotechnical engineering.

The tests have not previously been standardized internationally. It is intended that this document presents broad good practice and significant differences with national documents are not anticipated. It is based on international practice (see Reference [1]).

This document specifies two methods for the determination of the effective shear strength of soils under consolidated drained conditions using either a shearbox or a ring shear device.

The shearbox test is generally used for the determination of peak effective shear strength parameters of soils. The ring shear test is generally used for the determination of residual effective shear strength parameters of fine grained soils. Residual effective shear strength parameters can also be obtained from shearbox tests and peak effective shear strength parameters can also be obtained from ring shear tests.

The test method consists of placing the test specimen in the direct shear device, applying a pre-determined vertical stress, providing for draining (and wetting if required) of the test specimen, consolidating the specimen under vertical stress and then shearing the specimen. This shearing is imposed by displacing one part horizontally, relatively with respect to the other part of the specimen at a constant rate of shear-deformation. The shearing force and the horizontal and vertical displacements are measured as the specimen is sheared. Shearing is applied slowly enough to allow excess pore pressures to dissipate by drainage so that effective stresses are equal to total stresses.

Geotechnical investigation and testing — Laboratory testing of soil —

Part 10: Direct shear tests

1 Scope

This document specifies two laboratory test methods for the determination of the effective shear strength of soils under consolidated drained conditions using either a shearbox or a ring shear device.

This document is applicable to the laboratory determination of effective shear strength parameters for soils in direct shear within the scope of geotechnical investigations.

The tests included in this document are for undisturbed, remoulded, re-compacted or reconstituted soils. The procedure describes the requirements of a determination of the shear resistance of a specimen under a single vertical (normal) stress. Generally three or more similar specimens from one soil are prepared for shearing under three or more different vertical pressures to allow the shear strength parameters to be determined in accordance with Annex B.

Special procedures for preparation and testing the specimen, such as staged loading and pre-shearing or for interface tests between soils and other materials, are not covered in the procedure of this document.

NOTE This document fulfils the requirements of the determination of the drained shear strength of soils in direct shear for geotechnical investigation and testing in accordance with EN 1997-1 and EN 1997-2.

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

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

ISO 386, *Liquid-in-glass laboratory thermometers — Principles of design, construction and use*

3 Terms and definitions

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

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

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

— IEC Electropedia: available at https://www.electropedia.org/

3.1
direct shear test
test whereby a specimen of soil is laterally restrained and sheared along a mechanically induced horizontal plane while subjected to a vertical stress applied normal to that plane

3.2
shearbox test
direct shear test (3.1) whereby a specimen is placed in a rigid square or circular container (shear box) and shearing is applied by linear displacement of one half of the shear box relative to the other

Note 1 to entry: See Figure 1.

3.3
ring shear test
direct shear test (3.1) whereby an annular specimen is subjected to shear induced by rotation of one half of the specimen relative to the other while subjected to vertical stress applied normal to the *failure* (3.4) plane

Note 1 to entry: See Figures 2 and 3.

3.4
failure
stress or strain condition at which either peak horizontal shear stress is achieved or a specified deformation criterion is achieved, if a peak horizontal shear stress is not observed

3.5
pore pressure
pressure of water in the voids within the soil specimen

3.6
primary consolidation
process whereby the void ratio of a specimen decreases as a result of an increase in the effective stress due to a decrease in the excess *pore pressure* (3.5) under a constant total applied load

Note 1 to entry: Time-dependent volume change during primary consolidation is primarily controlled by drainage conditions.

4 Symbols

D_a	outer diameter of specimen container rings
D_i	inner diameter of specimen container rings
D_m	mean diameter of specimen container rings
R_i	inner radius of the container rings
R_a	outer radius of the container rings
H	height of annulus in the specimen container rings or shear box
t_c	time value from vertical displacement versus root time plot
t_f	calculated minimum time to failure during shear stage
v_{max}	maximum allowable rate of shear displacement
s_{rs}	horizontal shear deformation during ring shear
s_f	estimated horizontal shear deformation at failure
r	mean radius of the specimen in the ring shear test
θ	angular displacement during the ring shear test
θ_{max}	maximum rate of angular displacement in the ring shear test
ρ	initial bulk density of specimen

ρ_d	initial dry density of specimen
ρ_s	particle density
H_0	initial height of the specimen
w_0	initial water content
m_0	initial mass of specimen
m_d	final dry mass of specimen
e	void ratio
e_0	initial void ratio
S_r	initial degree of saturation
ρ_w	water density
ΔH	change in specimen height from the initial zero reading
τ	shear stress on the surface of shear
τ_R	residual shear strength
σ_v	vertical stress on the surface of shear
P	horizontal shear force
N	vertical force
φ'	angle of effective shearing resistance
φ'_R	residual angle of effective shearing resistance
c'	effective cohesion intercept
A	initial plan area of specimen
M_t	moment (torque) applied to the specimen in the ring shear

5 Apparatus

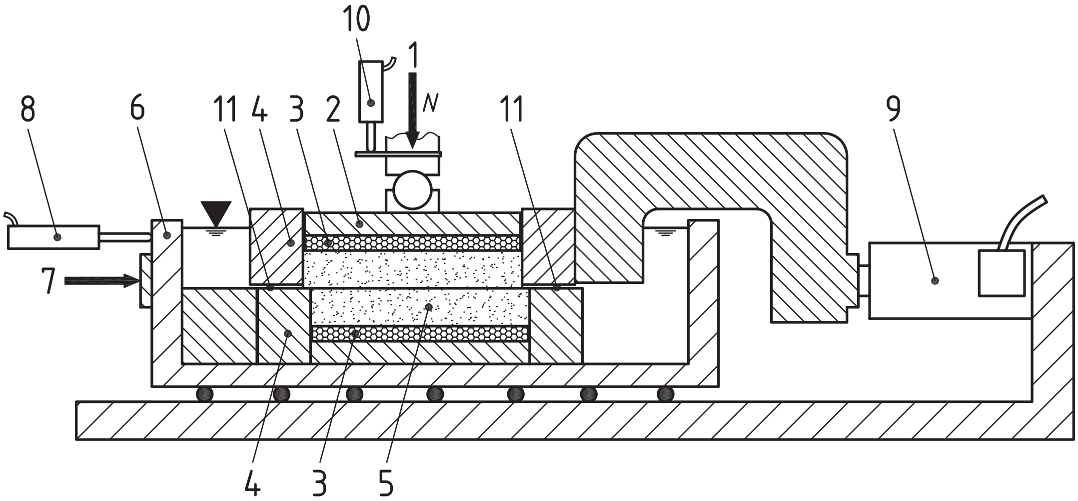
5.1 General

The equipment shall undergo regular calibration, maintenance and checks as specified in Annex A.

5.2 Shear devices

5.2.1 Shearbox test apparatus

5.2.1.1 A typical shearbox apparatus is shown schematically in Figure 1.



Key

1 (device to apply) vertical force, *N*
2 loading cap to apply vertical force
3 porous discs or shear friction plates
4 upper and lower part of the shear box
5 soil specimen
6 outer container (carriage)
7 device to apply (a constant rate of) horizontal displacement
8 device for measurement of horizontal displacement
9 device for measurement of horizontal force
10 device for measurement of vertical displacement
11 gap between upper and lower parts of shear box to prevent friction

Figure 1 — Schematic drawing of a typical shearbox

5.2.1.2 The frame, the outer container (carriage), the shearbox and internal components shall be made of corrosion resistant materials of sufficient rigidity to resist distortion and deformation during the test.

5.2.1.3 The outer container (carriage) should allow testing to be carried out with the specimen and porous discs or shear friction plates submerged under water.

5.2.1.4 The outer container (carriage) shall be supported on the frame by a low-friction bearing which allows movement in the horizontal direction only.

5.2.1.5 The shear box shall be square or circular in plan and divided horizontally into two rigid halves. The design of the shear box shall fulfil the following requirements:

— The design shall allow the two halves of the shear box to be locked securely together. Once locked together they shall form a square or circular prism with a smooth internal surface.

— The design shall allow the upper half to be lifted relative to the lower half prior to shear by a small, controlled vertical displacement without tilt.

— The arrangement shall be such that when lifted, one half of the shear box shall be able to move smoothly and parallel to the other half.

— The square shear box should be designed for a square specimen with a minimum width of 50 mm. The circular shear box should be designed for a specimen with a minimum diameter of 50 mm.

— In both cases the shear box should be designed for a specimen with a minimum initial height of 20 mm or not less than 6 times the maximum particle size diameter, whichever is larger.

— The ratio of the specimen width or diameter to height should not be less than 2,5.

5.2.1.6 Porous discs or shear friction plates shall cover the upper and lower surfaces of the specimen:

— They shall allow free drainage of water, while preventing intrusion of soil particles into their pores. The upper and lower surfaces shall be plane, clean and undamaged. They shall be made of corrosion-resistant materials of negligible compressibility under the maximum stress likely to be applied during the test and shall be strong enough to prevent breakage under load.

— They should be sufficiently rough to provide an interlock with the sample but without causing localised stress concentrations.

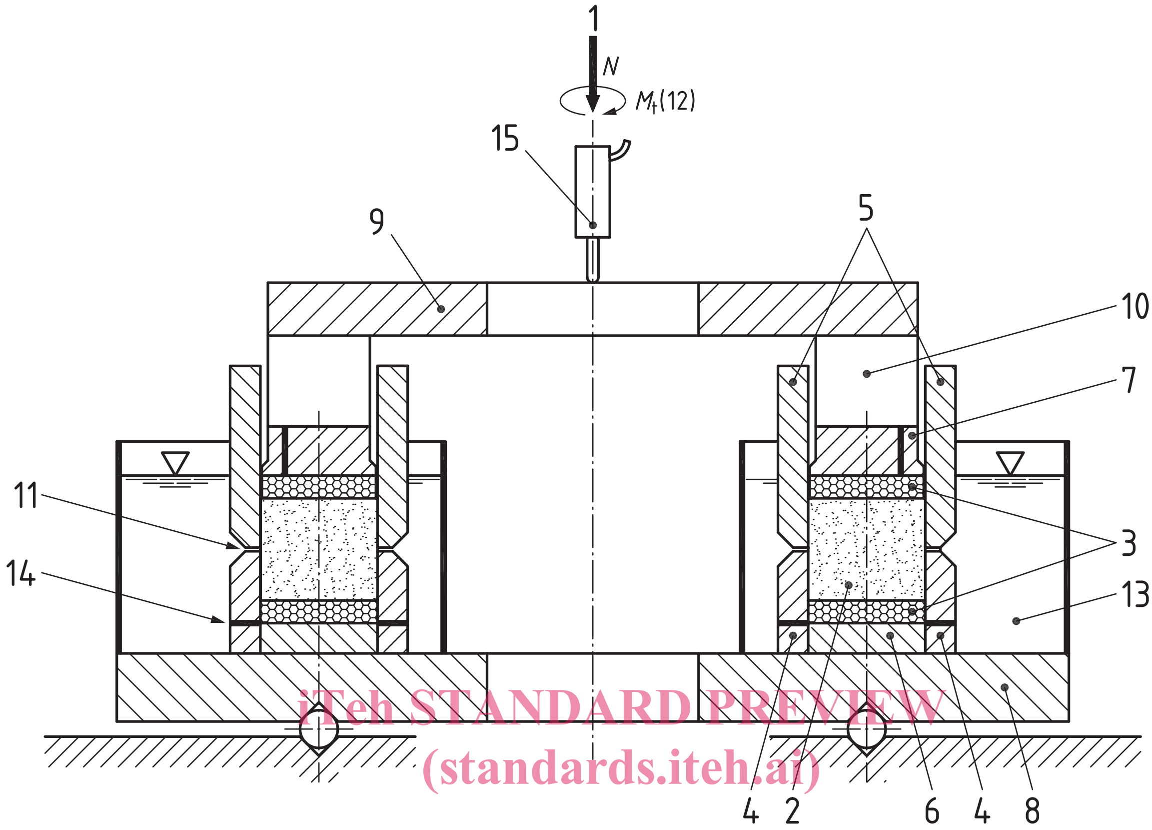
— They shall be smaller in plan than the internal dimensions of the shear box in order to prevent binding to the walls but large enough to prevent extrusion of the specimen.

5.2.1.7 The loading cap shall be smaller in plan than the internal dimensions of the shear box such that the loading cap can tilt without jamming and be rigid and sufficiently large so as to transmit the vertical load uniformly to the specimen.

5.2.1.8 The loading cap and base shall have grooves or perforations to allow free drainage of water from the porous discs.

5.2.2 Ring shear apparatus

5.2.2.1 The apparatus shall be constructed such that shearing forces are purely rotational. Typical arrangements for ring shear apparatus are shown in Figures 2 and 3. Figure 2 shows a typical arrangement for a ring shear test with a split specimen container such that failure occurs at the depth defined by the split container (Type A). Figure 3 shows a typical arrangement for a ring shear test with a solid specimen container where the location of the failure surface is not defined by the apparatus (Type B).



Key

1 (device to apply) vertical force, transmitted through (10) and (7) to the specimen
2 specimen
3 porous discs or shear friction plates
4 lower circular frame (lower soil container ring)
5 upper circular frame (upper soil container ring)
6 base ring
7 loading ring (with drainage opening)
8 base plate, which is rotated by a driving gear, together with the lower circular frame (4) and the base ring (6)
9 top plate to apply the vertical load *N* to the loading ring by radially distributed ridged blocks (10)
10 rigid blocks to transmit the load to the loading ring
11 gap between upper and lower circular frame to allow for rotation of the one relative to the other
12 device to measure torque, M_t
13 outer container (water bath)
14 drainage openings
15 device for measurement of vertical displacement

Figure 2 — Example of a Type A ring shear apparatus

