BSI Standards Publication

Geotechnical investigation and testing – Laboratory testing of soil

Part 7: Unconfined compression test (ISO 17892-7:2017)

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National foreword

This British Standard is the UK implementation of EN ISO 17892-7:2018. It is identical to ISO 17892-7:2017. It partially supersedes BS 1377-1:1990, specifically clause 5.

The UK participation in its preparation was entrusted to Technical Committee B/526/3, Site investigation and ground testing.

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European foreword

This document (EN ISO 17892-7:2018) 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of an identical text or by endorsement, at the latest by August 2018, and conflicting national standards shall be withdrawn at the latest by August 2018.

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Foreword

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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 TC 182, *Geotechnics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 17892-7 cancels and replaces ISO/TS 17892-7:2004, which has been technically revised. It also incorporates the Technical Corrigendum ISO/TS 17892-7:2004/Cor 1:2006.

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

Introduction

This document covers areas in the international field of geotechnical engineering never previously standardized. It is intended that this document presents broad good practice throughout the world and significant differences with national documents are not anticipated. It is based on international practice (see Reference [4]).

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INTERNATIONAL STANDARD ISO 17892-7:2017

Geotechnical investigation and testing – Laboratory testing of soil —

Part 7:
Unconfined compression test (ISO 17892-7:2017)

1 Scope

This document specifies a method for the unconfined compression test.

This document is applicable to the determination of the unconfined compressive strength for a homogeneous specimen of undisturbed, re-compacted, remoulded or reconstituted soil under compression loading within the scope of geotechnical investigations.

This test method is useful to estimate the undrained shear strength of soil. It is noted that drainage is not prevented during this test. The estimated value for undrained shear strength is, therefore, only valid for soils of low permeability, which behave sufficiently undrained during the test.

NOTE This document fulfils the requirements of unconfined compression tests 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 14688-1, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description*

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*

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:

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

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

3.1
unconfined compressive strength
vertical stress at *failure* (3.3) in the test

3.2
undrained shear strength
shear strength in the unconfined compression test equal to one-half of the *unconfined compressive strength* (3.1)

3.3
failure
stress or strain condition at which one of the following criteria are met:

— peak stress during the test;

— a specified deformation criterion if a peak stress has not been achieved, e.g. 15 % vertical strain.

4 Symbols

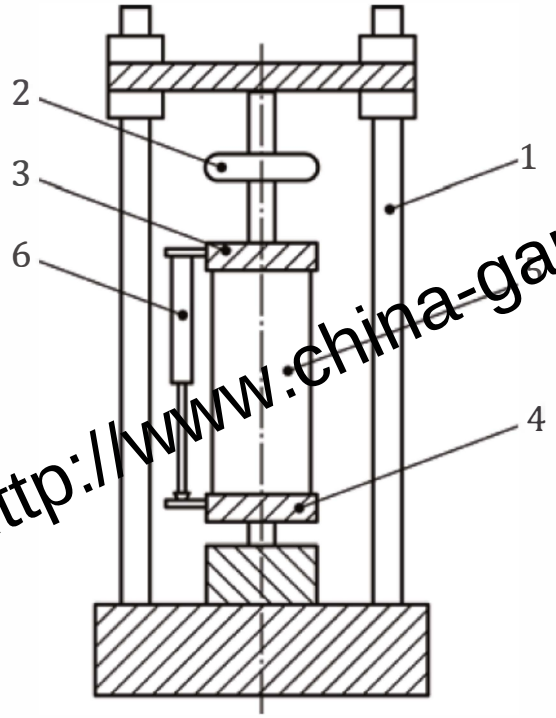
σ_v	vertical stress on the specimen
ε_v	vertical strain
q_u	unconfined compressive strength
c_u	undrained shear strength
H_i	initial height of the specimen
ΔH	change in height of the specimen during compression
A_i	initial cross-sectional area of specimen
P	vertical load on the specimen including the weight of the top platen if it is resting on the specimen

5 Apparatus

5.1 General

The apparatus shall undergo regular maintenance, checking and calibration as specified in Annex A.

A schematic diagram of a typical apparatus for unconfined compression testing is shown in Figure 1.



Key

1 load frame
2 load measuring device
3 top platen
4 bottom platen
5 soil specimen
6 displacement measuring device

Figure 1 — Schematic diagram of a typical unconfined compression apparatus

5.2 Load frame

5.2.1 The load frame shall be able to provide a range of rates of strain required for the test (see 6.4.1) and shall have sufficient capacity to load the soil specimen to failure. The actual rate shall not fluctuate more than 20 % of the intended rate. The movement of the platen shall be smooth without vibration, such that fluctuations do not occur in the test results.

5.2.2 The stroke of the load frame shall be more than that required for the test. A value of 30 % of the specimen height is normally suitable.

5.2.3 The top and the bottom platen shall be designed such that their deformations are negligible compared to the deformations of the soil specimen. Their diameter shall be such that no part of the soil specimen projects beyond them in any part of the test.

5.2.4 The equipment shall be designed so that it maintains alignment during the test.

5.3 Measuring devices

5.3.1 Load measuring device.

The accuracy of the load measuring device, within the range 20 % to 100 % of the capacity of the device, shall be 2 % of the actual value or better. The device should be insensitive to changes in horizontal forces or bending moment and to changes in temperature during a test. The capacity of the load measuring device should be chosen so that the failure load is at least 20 % of its capacity.

NOTE Class 1 load measuring devices calibrated to ISO 7500-1 meet this accuracy requirement.

5.3.2 Displacement measuring device.

The device for measuring the change in height of the specimen shall be accurate to 0,1 mm or to 0,1 % of the initial specimen height, whichever is greater.

5.4 Ancillary apparatus

The ancillary apparatus consists of

— balance, accuracy 0,01 g or 0,1 % of the weighed mass, whichever value is greater, and

— apparatus for determination of water content.

The apparatus for the specimen preparation consists of

— cutting and trimming tools (e.g. a sharp knife, wire saw, spatula, cutting ring, soil lathe),

— steel straight edge, with a maximum deviation from straight of 0,1 % of its length,

— try-square or a jig (e.g. a mitre box) or split mould to ensure that flatness shall be accurate to within 0,5 % of each dimension and that right-angles are within 0,5° of true, and

— callipers, either analogue or digital, readable to 0,1 mm or 0,1 % of the measured length, whichever value is greater.

6 Test procedure

6.1 General requirements and equipment preparation

6.1.1 The cross-sectional area of the specimen may either be circular or square and shall be at least 34 mm in diameter or 1 000 mm^2 in area.

6.1.2 For cylindrical specimens, the ratio between height and diameter shall be between 1,8 and 2,5. For square specimens, the ratio between the height and length of the side shall be between 2,0 and 2,8.

6.1.3 The largest particle in the specimen should not exceed 1/6 of the specimen diameter for cylindrical specimens and should not exceed 1/6 of the side length for square specimens.

6.1.4 Prior to each test, check that there is no visible sign of damage to any of the equipment.

6.2 Preparation of specimens

6.2.1 The following procedures shall apply to undisturbed, re-compacted, remoulded or reconstituted samples.

6.2.2 Examine undisturbed samples prior to testing. If significant disturbance is apparent in the specimen, this should be recorded in the test report. Highly disturbed samples will not provide meaningful results and should not be tested.

6.2.3 Take care to maintain the water content of the specimen during the preparation process. If the process is interrupted, the specimen shall be protected so that the water content does not change. Air circulation around the specimen shall be avoided.

6.2.4 Cut and trim the specimen to the required dimensions. Take care to avoid deforming the specimen during the cutting and trimming process.

6.2.5 The soil specimen end surfaces shall be plane and perpendicular to the longitudinal axis in accordance with ISO 17892-2. Remove grooves and holes in the ends and sides of the specimen by further trimming or by selecting a new specimen, if available. Otherwise, fill grooves or holes not exceeding 1/6 of the specimen diameter with remoulded sample material. Grooves and holes in the ends may be filled with a material that hardens with time and which does not release or absorb water.

6.2.6 Specimens may be prepared in the laboratory by reconstituting the material in a mould. Water mixed into the material shall be given time of at least 16 h before compaction to equalize throughout the soil mass.

6.2.7 Measure the specimen height, diameter and mass immediately prior to the test in accordance with ISO 17892-2 by linear measurement.

6.2.8 Mount the specimen into the apparatus so that it is centred with respect to the top and bottom platens. Take extreme care to avoid deforming the specimen during the mounting process. Very soft specimens may have to be mounted without touching the specimen by hand at any stage during the preparation.

6.3 Initial readings

6.3.1 Move the piston towards the specimen and record the initial load measuring device reading while the piston is moving, prior to contact with the specimen. Continue to move the piston until it is just in contact with the specimen. This seating load should be kept as small as possible.

6.3.2 Take an initial reading of the displacement transducer at the moment of contact of the piston with the specimen.

6.4 Compression

6.4.1 Compress the specimen at a strain rate of between 1 % and 2 % of the specimen height per minute.

6.4.2 Select an appropriate recording frequency so that at least 15 readings should be taken prior to failure and, thereafter, at least every 0,5 % strain. For brittle materials, readings may need to be taken at smaller intervals of strain to define failure.

6.4.3 If the axial strain at which the test is to be stopped has not been specified, the test may be stopped when the strain reaches 15 % or exceeds the strain at peak stress by 5 %, or when the stress decreases by 20 % from the peak value, whichever occurs earlier.

6.4.4 During compression, record the following:

— load;

— displacement;

— elapsed time.

If the displacement of only one platen is measured, the displacement of the other platen, if significant, shall be taken into account when calculating the change in height of the specimen.

6.5 Dismounting

6.5.1 Unload the specimen and remove it from the apparatus.

6.5.2 Sketch or photograph the specimen illustrating the mode of failure.

6.5.3 Cut open the specimen to allow any internal structures or inhomogeneity to be identified and recorded. If there are particles greater than 1/10 of the specimen diameter, their size and approximate proportion shall be noted. A photograph of the cut specimen may be taken.

NOTE The presence of particles greater than 1/10 of the specimen diameter can affect the results. The magnitude of the effects will depend on the nature of the specimen and the quantity, location and composition of these particles.

6.5.4 Determine the dry mass of the entire specimen or determine the water content of a representative part of the specimen, without further delay, in accordance with ISO 17892-1. If a failure surface is present, an additional water content may be taken from near the failure surface.

7 Test results

7.1 Bulk density, dry density and water content

7.1.1 Determine the water content from the final dry weight and the initial wet weight if the whole specimen has been dried. Otherwise, the water content of the representative part of the specimen (see 6.5.4) shall be used.

7.1.2 Calculate the initial bulk and dry densities from the initial measurements of specimen dimensions and mass following the linear measurement procedures in ISO 17892-2.

7.2 Stress and strain during compression

7.2.1 The vertical strain shall be determined from Formula (1):

$$\varepsilon_v = \frac{\Delta H}{H_i} \tag{1}$$

7.2.2 The vertical stress shall be determined from Formula (2):

$$\sigma_v = \frac{P}{A_i / (1-\varepsilon_v)} \tag{2}$$

7.3 Unconfined compressive strength

Determine the unconfined compressive strength, q_u, as the value of σ_v at failure.

7.4 Undrained shear strength

If required, the estimated undrained shear strength, c_u, shall be determined from Formula (3):

$$c_u = 0{,}5 \times q_u \quad (3)$$

8 Test report

8.1 Mandatory reporting

The test report shall affirm that the test was carried out in accordance with this document and shall include the following:

a) identification of the specimen tested, e.g. by borehole number, sample number and sample depth and any other relevant details required, e.g. depth of specimen within a sample, method of sample selection, if relevant;

b) visual description of the specimen tested including any observed features noted after testing, following the principles in ISO 14688-1, including a description of particles that exceed 1/10 of the specimen diameter, if present, and a note that the results may have been affected if any particles exceed 1/6 of the specimen diameter;

c) specimen type, i.e. undisturbed or artificially prepared, and the procedure used for the preparation of specimens;

d) initial specimen dimensions (mm);

e) water content (%);

f) initial bulk density (Mg/m^3);

g) dry density (Mg/m^3);

h) mean rate of compression in either mm/min or % strain per minute, in either case, to two significant figures;

i) unconfined compressive strength to the nearest kPa;

j) strain at failure to the nearest 0,1 %;

k) description, sketch and/or photograph of the specimen showing the type of failure;

l) any deviation from this procedure.

8.2 Optional reporting

The following additional information may be required:

a) the estimated undrained shear strength to the nearest kPa;

b) plot of vertical stress as ordinate versus strain as abscissa.

Annex A
(normative)

Calibration, maintenance and checks

A.1 General requirements

All measurement equipment used in this document shall be calibrated periodically. Its performance shall be checked where required at intervals and it shall be operated in a controlled environment, if so specified. This annex defines these requirements for this method.

If calibration of measurement equipment is carried out by a third party, it shall be carried out by an accredited calibration laboratory. The certification shall show traceability to recognized national or international standards of measurement.

Where calibration of test measuring equipment is carried out in-house, the laboratory shall hold appropriate reference standards or instruments that are used solely for calibration purposes. These should be calibrated by an accredited calibration laboratory with certification requirements as above. When not in use, the reference measurement equipment should be retained securely in a suitable environment separate from working standards or instruments. Reference standards and instruments shall be of an accuracy at least that of the working device so that the desired accuracy of test measurement is achieved.

In-house calibration procedures shall be documented and shall only be performed by approved persons, and records of such calibrations and of performance checks shall be retained on file.

Notwithstanding the required calibration or check intervals in this annex, whenever any item of reference equipment or test measurement equipment has been mishandled, repaired, dismantled, adjusted or overhauled, it shall be recalibrated before further use.

All calibrated equipment shall be used only within the range for which it has been calibrated.

A.2 Environmental conditions

There are no specific environmental conditions applicable to the execution of this test method.

A.3 Equipment

A.3.1 Deformation of apparatus

Correction for displacement due to apparatus compliance shall be investigated and recorded. Unless it can be shown to be insignificant, checks shall be carried out to determine the compliance of the apparatus at least once a year and when essential parts are changed or replaced.

The following procedure may be used: the apparatus shall be assembled by using a steel cylinder in place of the specimen. The height change recorded by the displacement system under axial load shall be measured and recorded and, if required, used as a correction to the observed height change during tests.

A.3.2 Load frame

Unless the actual average speed of travel is calculated from specimen test data, representative speed settings of the unloaded load frame should be checked at least once a year. In either case, if the observed

speeds are more than 10 % different to the selected speeds or are outside the allowable range for the test, corrective action shall be taken.

A.3.3 Measuring devices

The following requirements apply equally to

— load measuring device, and

— displacement measuring device

The performance of each device shall be verified at least once a year.

The response of the device shall be recorded at a minimum of six values of increasing measurement at approximately zero, 20 %, 40 %, 60 %, 80 % and 100 % of its working range. Additional test points will be required if the device is to be used to generate results below 20 % of its working range.

Repeat the measurements over the calibration range, two more times to give a set of three measurements. Plot the mean recorded values and add the curve of best fit, which may be linear or non linear. The use of the device is acceptable if all the individual points lie within 2 % of the measured value.

Bibliography

[1] ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

[2] EN 1997-1, *Eurocode 7 — Geotechnical design — Part 1: General rules*

[3] EN 1997-2, *Eurocode 7 — Geotechnical Design — Part 2: Ground investigation and testing*

[4] DIN. ISSMGE (Eds.) (1998): Recommendations of the ISSMGE for geotechnical laboratory testing; (in English, German and French); Berlin, Wien, Zürich (Beuth Verlag)

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