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Geotechnical investigation and testing — Laboratory testing of soil —

Part 7: Unconfined compression test on fine-grained soil

Reconnaissance et essais géotechniques — Essais de sol au laboratoire —

Partie 7: Essai de compression simple sur sol cohérent

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Foreword

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ISO/TS 17892-7 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 182, *Geotechnics*, Subcommittee SC 1, *Geotechnical investigation and testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European pre-Standard..." to mean "...this Technical Specification...".

ISO 17892 consists of the following parts, under the general title *Geotechnical investigation and testing — Laboratory testing of soil*:

— *Part 1: Determination of water content*

— *Part 2: Determination of density of fine-grained soil*

— *Part 3: Determination of particle density — Pycnometer method*

— *Part 4: Determination of particle size distribution*

— *Part 5: Incremental loading oedometer test*

— *Part 6: Fall cone test*

— *Part 7: Unconfined compression test on fine-grained soil*

— *Part 8: Unconsolidated undrained triaxial test*

— *Part 9: Consolidated triaxial compression tests on water-saturated soil*

— *Part 10: Direct shear tests*

— *Part 11: Determination of permeability by constant and falling head*

— *Part 12: Determination of the Atterberg limits*

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Foreword

This document (CEN ISO/TS 17892-7:2004) has been prepared by Technical Committee CEN/TC 341 “Geotechnical investigation and testing”, the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 182 “Geotechnics”.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Introduction

This document covers areas in the international field of geotechnical engineering never previously standardised. It is intended that this document presents broad good practice throughout the world and significant differences with national documents is not anticipated. It is based on international practice (see [1]).

1 Scope

This document covers the determination of an approximate value of the unconfined compressive strength for a square or cylindrical water-saturated homogeneous specimen of undisturbed or remoulded cohesive soil of sufficiently low permeability to keep itself undrained during the time it takes to perform the test within the scope of geotechnical investigations according to prEN 1997-1 and -2.

The unconfined compressive strength of cohesive soils is a measure of the apparent cohesion. A cohesive soil behaves as if it is truly cohesive, e.g. clay and clayey soils, but most soils in this group behave cohesively due to negative pore pressure and friction and not due to actual cohesion.

This test method is useful to derive the undrained shear strength of soil. It should however be noted that no provisions are taken to prevent drainage. The derived value for undrained shear strength is therefore only valid for soils of low permeability, which behave sufficiently undrained during testing.

The method is not appropriate for fissured or varved clays or silts or peats.

2 Normative references

The following referenced documents are indispensable for the application 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.

prEN 1997-1, *Eurocode 7: Geotechnical design - Part 1: General rules*

prEN 1997-2, *Eurocode 7: Geotechnical design - Part 2: Design assisted by laboratory testing*

CEN ISO/TS 17892-1, *Geotechnical investigation and testing — Laboratory testing of soil — Part 1: Determination of water content (ISO/TS 17892-1:2004).*

CEN ISO/TS 17892-2, *Geotechnical investigation and testing — Laboratory testing of soil — Part 2: Determination of bulk density (ISO/TS 17892-2:2004).*

3 Terms and definitions

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

3.1
unconfined compressive strength
q_u
maximum vertical stress an unconfined specimen can sustain or the vertical stress at 15 % vertical strain, whichever occurs first during the performance of the test

3.2
undrained shear strength
c_u
undrained shear strength is equal to one half of the unconfined compressive strength

3.3
undisturbed sample
normally sample of quality class 1 according to prEN 1997-2

4 Equipment

4.1 Loading machine

4.1.1 General

A loading machine for performance of unconfined compression tests (see Figure 1) normally consists of the following main parts:

a) Top and bottom platen between which the soil specimen is placed;

b) load frame with a drive unit to compress the soil specimen (loading press);

c) load measuring device to measure the force applied to the soil specimen;

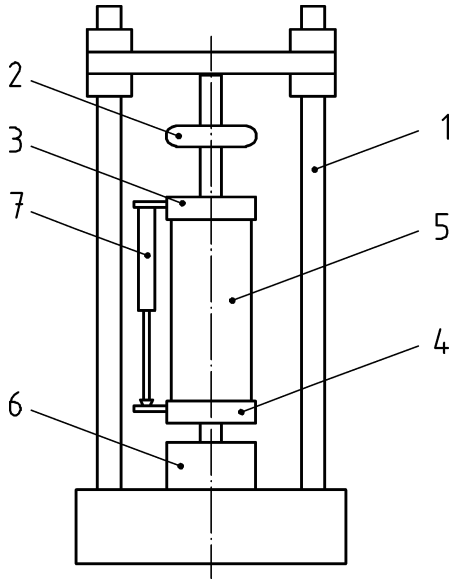
d) compression measuring device to measure the axial compression of the specimen.

4.1.2 Loading press

4.1.2.1 The loading press shall have sufficient capacity to load the soil specimen to failure (see 4.1.4.3).

4.1.2.2 The top and the bottom platen shall be designed such that their deformations are negligible compared to the deformations of the soil specimen, and their diameter shall be so large that no part of the soil specimen projects beyond them.

4.1.2.3 Both platens may be prevented from tilting as shown in Figure 1, or one platen, usually the top platen, may be allowed to tilt, but neither of the platens shall be allowed to move horizontally.



Key

1 load frame
2 load measuring device
3 top platen
4 bottom platen
5 soil specimen
6 drive unit
7 axial compression measuring device

Figure 1 — Schematic drawing of a loading machine for performing unconfined compression tests

4.1.2.4 The drive unit shall move one of the platens with a constant speed, called the platen rate, which shall be within the ranges specified in 5.4. When the drive unit is set to advance the platen at a certain rate, the actual platen rate shall not deviate more than ± 20 % from the set value. The movement of the platen shall be smooth without fluctuations or vibrations.

4.1.3 Load measuring device

4.1.3.1 The force applied on the specimen shall be measured with an accuracy of ± 5 % or within ± 1N, whichever is the greater.

4.1.3.2 The compression of the load measuring device when the specimen fails, shall not exceed 10 mm.

4.1.3.3 If the load measuring device can be subjected to bending moments and/or horizontal forces (as it may be in the set up shown in Figure 1), the device shall be sufficiently insensitive to such factors that they can be neglected or accounted for.

4.1.4 Compression measuring device

4.1.4.1 The readability of the compression measuring device shall be better than 0,20 % of the initial specimen height.

4.1.4.2 The device, with its reading equipment, shall be readable to ± 0,030 % of the initial specimen height, and have a travel range of at least 20 % of the initial specimen height.

4.1.4.3 If only the travel of one platen (not the change in distance between the two platens as in Figure 1) is measured, the displacement of the other platen, if significant, shall be accounted for when calculating the compression of the specimen.

NOTE For specimen diameters up to about 70 mm a loading machine with a maximum load capacity of 7 kN and platen speeds of 0,5; 1; 2 and 3 mm/min should be sufficient in most cases provided the maximum compression of the load measuring device does not exceed about 2 mm.

Machines with softer load measuring devices than this, shall have higher platen speeds in order to keep the time to failure about the same as for machines with maximum 2 mm compression of the load measuring device.

4.2 Ancillary apparatus

— Tools for trimming and cutting the specimens;

— suitable equipment for measuring the specimen dimensions within 0,1 mm;

— mould of circular cross-section with dimensions meeting the requirements in 6.1 for making remoulded specimens (only required if remoulded specimens are to be prepared);

— balance allowing the mass of the specimen to be determined within ± 0,1 %. Only required if bulk density of the specimen shall be determined. Determination of bulk density is recommended, but not required,

— equipment for water content determination is recommended, but not mandatory.

5 Test procedure

5.1 General

5.1.1 The cross-sectional area of the specimen may either be circular or square, and shall be at least 1000 mm².

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

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

5.2 Preparation of undisturbed specimens

5.2.1 Disturbed material near the ends of a sample should not be used for unconfined compression tests.

5.2.2 Cut and trim the specimen to the required dimensions. Great care shall be taken to avoid, as much as possible, deforming the specimen during the cutting and trimming process.

5.2.3 Care shall be taken to maintain the water content of the specimen during the preparation process. If the process for some reason is interrupted, the specimen shall be carefully wrapped in plastic foil. Air circulation around the specimen shall be avoided.

5.2.4 The end surfaces shall be as plane and perpendicular to the longitudinal axis as possible.

5.2.5 Grooves and holes in the ends and sides of the specimen shall be filled with remoulded material if they cannot be removed by further trimming and if new specimens cannot be trimmed. Grooves and holes in the ends greater than 1/10 of the specimen diameter should be filled in with a material that hardens with time and which does not release water to the specimen.

5.2.6 Take at least four diameter measurements and two height measurements to the nearest 0,1 mm. For soft specimens care shall be taken to avoid penetration of the measuring equipment into the specimen.

5.2.7 If bulk density is required, the mass of the specimen shall be measured to the nearest ± 0,1 %.

5.2.8 When the specimen will be used after testing to prepare a remoulded specimen, loss of water during the testing of the undisturbed specimens should be minimized by sealing the specimen in a rubber membrane.

5.3 Preparation of remoulded specimens

5.3.1 Unless otherwise specified, remoulded specimens shall be prepared by remoulding undisturbed material at its natural water content without significantly changing the water content.

5.3.2 After remoulding, the soil shall be kneaded, still without changing the water content, into the mould for making remoulded specimens (see 4.2). Care shall be taken to avoid entrapped air in the material during the kneading process.

5.3.3 Loss of water during the remoulding process may be minimized by wrapping the material in a thin rubber membrane or in a plastic bag and kneading thoroughly with the fingers to ensure complete remoulding.

5.3.4 After trimming of the ends of the remoulded specimen and removing it from the mould it shall be treated as described in 5.2 for undisturbed specimens.

5.3.5 Evaporation during the succeeding remoulding process may be minimized by wrapping the material in a thin rubber membrane or in a plastic bag and work the material thoroughly with the fingers to assure complete remoulding.

5.4 Compression

5.4.1 The specimen shall be placed in the loading machine so that it is centred with respect to the bottom platen. If the top platen can tilt, the specimen shall be centred with respect to the top platen.

5.4.2 The load measuring device shall be zeroed when there is no contact between the top of the specimen and the top platen. The loading press shall be adjusted so that the top platen just makes contact with the specimen. The displacement measuring device shall then be zeroed and the corresponding reading on the load measuring device recorded.

5.4.3 A platen rate shall be selected which will result in the specimen in 2 minutes to 15 minutes (see 5.4.4).

5.4.4 The compression of the specimen at the selected rate shall be started and load and displacement at sufficient intervals to define the stress-strain curve. At least 10 readings should be taken prior to failure, thereafter a reading should be taken at every 1 % vertical strain. The compression may be stopped when the vertical strain reaches 15 %, or starts to decrease, whichever is earlier.

NOTE For loading machines with maximum compression of the load measuring device less than 2 mm the lowest required platen rate usually should be a rate corresponding to 0,5 % strain of the test specimen per minute (i.e. for a specimen with initial height 100 mm the minimum required rate should be 0,5 mm per minute). The maximum required platen rate (when the maximum compression of the load measuring device is less than 2 mm) should usually be a rate corresponding to about 2 % strain per minute. The lowest rates should be selected for specimens with the lowest failure strains. Conversely higher rates should be used for specimens with higher failure strains.

5.5 Dismounting

5.5.1 The axial load shall be removed.

5.5.2 A rough sketch shall be made or photograph shall be taken of the specimen indicating the failure planes.

5.5.3 The water content, if required, shall be determined as quickly as possible after the compression test, from a representative part of the soil specimen.

5.5.4 The specimen shall be broken into pieces and the soil shall be described. It shall be noted, if there are particles greater than permitted (see 5.1).

6 Test results

6.1 Stress and strain

For each set of readings the vertical strain ε and the vertical stress σ_1 shall be calculated from the equations (1) and (2):

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

$$\sigma_1 = \frac{P(1-\varepsilon)}{A_1} \tag{2}$$

where

ΔH is vertical compression of the specimen, (mm)

H_i is initial height of specimen, (mm),

P is vertical load acting on the specimen, (N),

A_i is initial cross-sectional area of specimen, (mm²).

6.2 Unconfined compressive strength

The unconfined compressive strength q_u shall be determined as:

— maximum value of σ_1 i.e. where failure takes place or

— value of σ_1 at ε = 15 %,

whichever occurs first.

6.3 Undrained shear strength

The undrained shear strength c_u shall be determined as:

$$c_u = 0{,}5 \times q_u \tag{3}$$

6.4 Sensitivity

If the unconfined compressive strength is determined for the same material both in undisturbed and remoulded condition, the sensitivity S_t is computed as follows:

$$S_t = \frac{q_u(\text{undisturbed})}{q_u(\text{remoulded})}$$

6.5 Bulk density and water content

The bulk density shall be calculated according to CEN ISO/TS 17892-2 and the water content according to CEN ISO/TS 17892-1.