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Geotechnical investigation and testing — Laboratory testing of soil —

Part 5:
Incremental loading oedometer test

Reconnaissance et essais géotechniques — Essais de laboratoire sur les sols —

Partie 5: Essai de chargement par palier à l'oedométre

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

ISO 17892-5 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 17892-5:2004, which has been technically revised. It also incorporates the Technical Corrigendum ISO/TS 17892-5:2004/Cor 1:2006.

A list of all 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 internationally. 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 practices (see Reference [1]).

Geotechnical investigation and testing — Laboratory testing of soil —

Part 5: Incremental loading oedometer test

1 Scope

This document specifies methods for the determination of the compressibility characteristics of soils by incremental loading in an oedometer.

This document is applicable to the laboratory determination of the compression and deformation characteristics of soil within the scope of geotechnical investigations.

The oedometer test is carried out on a cylindrical test specimen that is confined laterally by a rigid ring. The specimen is subjected to discrete increments of vertical axial loading or unloading and is allowed to drain axially from the top and bottom surfaces. Tests may be carried out on undisturbed, remoulded, recompacted or reconstituted specimens.

The stress paths and drainage conditions in foundations are generally three dimensional and differences can occur in the calculated values of both the magnitude and the rate of settlement.

The small size of the specimen generally does not adequately represent the fabric features present in natural soils.

Analysis of consolidation tests is generally based on the assumption that the soil is saturated. In case of unsaturated soils, some of the derived parameters may not be appropriate

NOTE This document fulfils the requirements of the determination of the compressibility characteristics of soils in the oedometer 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 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*

ISO 17892-3, *Geotechnical investigation and testing — Laboratory testing of soil — Part 3: Determination of particle 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
excess pore pressure
difference between the pore water pressure and the equilibrium pore pressure at the end of consolidation

3.2
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* (3.1) under constant total applied load

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

3.3
secondary compression
process in which compression occurs independent from *excess pore pressure* (3.1) dissipation

Note 1 to entry: Time dependant volume change during secondary compression is controlled by factors other than drainage conditions.

3.4
swelling
expansion due to reduction of stress or due to increase in water content

3.5
swelling pressure
pressure required to maintain constant volume (i.e. to prevent absorption of water) when a soil is flooded with water.

4 Symbols

A cross-sectional area of the specimen (mm^2)

D mean diameter of the oedometer ring (mm)

d_f deformation gauge reading at the end of a load increment

d_i deformation gauge reading at the start of a load increment

e_f void ratio of the specimen at the end of a load increment

e_0 initial void ratio of the specimen at the start of the test

H mean height of the oedometer ring (mm)

H_f height of the specimen at the end of a load increment (mm)

H_i height of the specimen at the start of a load increment (mm)

H_s equivalent height of solids (mm)

H_0 initial height of the specimen at the start of the test (mm)

m_d dry mass of the specimen (g)

w_0 initial water content of the specimen (%)

$\varepsilon_{v,f}$ vertical strain at the end of an increment, compression being defined as positive strain (%)

ρ initial bulk density of the specimen (Mg/m^3)

ρ_d initial dry density of the specimen (Mg/m^3)

ρ_s particle density (Mg/m^3)

σ'_v vertical effective stress (kPa)

5 Equipment

See Annex A for calibration requirements for the equipment in this clause.

5.1 Oedometer ring

The ring shall be made of corrosion-resistant material and shall have a sharp cutting edge. A ring mounted with a temporary sharp cutting edge may be used.

Internal dimensions should conform to the following:

— diameter (D): not less than 35 mm;

— height (H): not less than 12 mm;

— ratio (D/H): not less than 2,5.

The internal surface of the ring shall be smooth and may be lubricated with a thin film of silicone grease, petroleum jelly, or other suitable lubricant.

The ring shall either be laterally confined to restrict expansion under load, or have sufficient stiffness to prevent the internal diameter expanding by more than 0,05 % when subjected to the maximum horizontal stress resulting from the test.

5.2 Porous discs

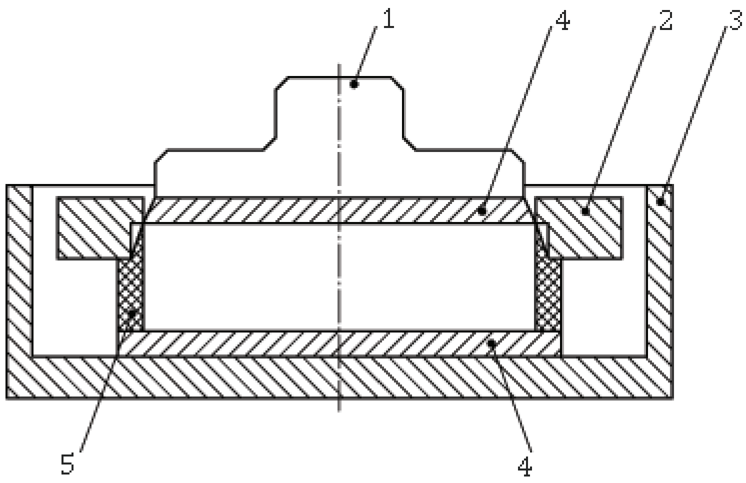
The top and bottom porous discs shall be of corrosion-resistant material and shall allow free drainage of water, while preventing intrusion of soil particles into their pores. The upper and lower surfaces shall be plain, clean and undamaged. The material shall be of negligible compressibility under the maximum stress likely to be applied during the test and shall be strong enough to prevent breakage under load.

If necessary, a filter paper may be used to prevent intrusion of the soil into the porous discs. However, the permeability of the discs and the filter paper shall be sufficiently high to prevent retardation of the drainage of the specimen.

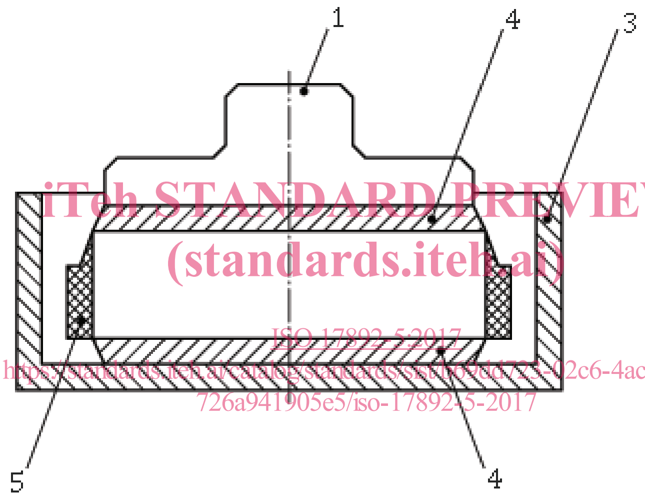
The diameter of the top porous disc shall be smaller than the ring by 0,2 mm to 0,5 mm in order to prevent binding to the ring and to prevent extrusion of the sample, and shall be larger than 85 % of the diameter of the loading cap. The top porous disc may be tapered towards the upper face to minimize the risk of binding due to tilt.

In a fixed-ring cell [see Figure 1 a)], the bottom porous disc shall be large enough to support the oedometer ring.

In a floating-ring cell [see Figure 1 b)], the diameter of the bottom porous disc shall meet the same requirements as the top disc, but tapered towards the lower face.



a) Fixed-ring cell oedometer



b) Floating-ring cell oedometer

Key

1 loading cap
2 lateral restraint for ring
3 cell body
4 porous discs
5 oedometer ring

Figure 1 — General arrangements of typical oedometer cells

Before use, new porous discs shall be saturated by boiling in distilled water for at least 20 min, and allowed to cool before use.

The surface of the porous discs which have previously been used shall be cleaned, for example using a natural bristle or nylon brush, followed by a check that the porous discs are readily permeable to water and that the pores are not clogged by soil particles.

Porous discs shall be kept immersed in water until required for use. For soils that readily absorb water (e.g. stiff clays), the porous discs should be air-dried immediately before use.

5.3 Cell body

The cell body shall be made of a suitable corrosion-resistant material.

A fixed-ring cell [see Figure 1 a)] shall accept the oedometer ring and shall be rigid enough to prevent significant lateral deformation of the ring when under load.

A floating-ring cell [see Figure 1 b)] shall provide adequate clearance around the outside of the ring.

The assembled cell shall be watertight and shall hold water to a level which submerges the upper porous disc.

5.4 Loading cap

The loading cap shall be rigid enough to ensure negligible deformation under load. It shall be fitted with a central load seating and shall be mounted centrally in the oedometer ring.

The loading cap shall have perforations or grooves to allow the free drainage of pore water.

5.5 Deformation measurement

The deformation measuring device shall have a resolution of at least 0,01 % and accuracy of at least 0,1 % of the initial specimen height.

The measurement of deformation of the soil to be tested shall use a device suitable for measuring and displaying/recording as mentioned above, e.g. a dial gauge or electrical displacement transducer.

5.6 Loading frame

The loading frame shall allow the application of vertical stresses acting centrally on the loading cap only. The frame may apply load either by addition of physical weights, or by other mechanical, hydraulic, pneumatic or electromechanical means.

The vertical stress applied to the specimen shall be accurate to at least 1 % of the intended stress or 1 kPa whichever is the greater. The stress shall remain constant within these limits throughout the duration of a loading increment. The mechanism should allow the application of a given load increment within a period of 2 s.

Adequate arrangements shall be made to ensure stability of the load frame, or a group of load frames, when fully loaded. This can be achieved by bolting the load frame or group of load frames to the floor. The load frame shall be free of vibration.

5.7 Ancillary apparatus

The ancillary apparatus consists of:

— balance, accurate up to 0,01 g or 0,1 % of the weighed mass, whichever value is greater;

— timer, readable to 1 s;

— thermometer, readable to 1°C maximum/minimum;

— metal disc with flat, smooth and parallel end faces. The diameter shall be about 1 mm less than the internal diameter of the oedometer ring and the height shall be the same as that of the ring;

— apparatus for determination of water content;

— apparatus for determination of particle density;

— vernier or digital callipers, reading to 0,05 mm.

5.8 Apparatus for specimen preparation

The apparatus for specimen preparation consists of:

- cutting and trimming tools, e.g. cheese-wire, wire-saw, sharp knife, scalpel;
- spatulas;
- straight-edge trimmer;
- straight edge;
- steel try-square;
- flat glass plate;
- extrusion equipment and clamping jig, for preparing and trimming specimens from a tube sample.

5.9 Water

Water of a similar chemistry to the pore water should be used if the soil is susceptible to the chemistry of the water. If the chemistry of the pore water is unknown, tap water should be used as its chemistry is more likely to be similar to ground water than distilled water would be.

6 Test procedure

6.1 General

The mean diameter of the largest particle within a specimen should be less than one-fifth of the height of the ring.

The initial water content (w_0) should be determined according to ISO 17892-1 on soil trimmings.

6.2 Specimen preparation

6.2.1 Selection of preparation method

6.2.1.1 Test specimens may be prepared by the following methods, depending on the type of sample available:

- trimming from an undisturbed sample extruded from its sampling tube, or from a block sample;
- extrusion directly into an oedometer ring from a sample tube of a larger diameter than that of the ring;
- recompaction, remoulding, reconstitution or reconsolidation of disturbed soil.

6.2.1.2 The cutting edge and condition of the oedometer ring shall be visually checked to be free from damage prior to each use.

6.2.2 Trimming from extruded or block sample

6.2.2.1 A horizontal flat surface shall be prepared on the sample of a size larger than the diameter of the oedometer ring.

6.2.2.2 The sample shall be placed on to the trimming apparatus, the ring shall be fitted into its holder and the cutting edge shall be lowered on to the prepared surface. The ring should be centred on the sample, unless visible discontinuities or disturbance suggests that a better quality specimen can be cut off-centre.

