SLOVENSKI STANDARD
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Nevezane in hidravliļ no vezane zmesi ï 7. del: Triosni preskus s cikliļ no obremenitvijo nevezanih zmesi

Unbound and hydraulically bound mixtures - Part 7: Cyclic load triaxial test for unbound mixtures

Ungebundene und hydraulisch gebundene Gemische - Teil 7: Dreiaxialprüfung mit zyklischer Belastung für ungebundene Gemische

Mélanges avec ou sans liant hydraulique - Méthodes d'essai - Partie 7: Essai triaxial sous charge cyclique pour mélanges sans liant hydraulique

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93.080.20	Materiali za gradnjo cest	Road construction materials

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Unbound and hydraulically bound mixtures - Part 7: Cyclic load triaxial test for unbound mixtures

Graves traitées aux liants hydrauliques et graves non traitées - Partie 7: Essai triaxial sous charge cyclique pour mélanges sans liant hydraulique

Ungebundene und hydraulisch gebundene Gemische - Teil 7: Dreiaxialprüfung mit zyklischer Belastung für ungebundene Gemische

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

This document (EN 13286-7:2004) has been prepared by Technical Committee CEN/TC 227 "Road materials", the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by July 2004, and conflicting national standards shall be withdrawn at the latest by July 2004.

Annexes A, B, C and D are informative.

This European Standard is one of a series of standards as listed below.

EN 13286-1, *Unbound and hydraulically bound mixtures — Part 1: Test methods for laboratory reference density and water content — Introduction, general requirements and sampling.*

prEN 13286-2, *Unbound and hydraulically bound mixtures — Part 2: Test method for the determination of the laboratory reference density and water content — Proctor compaction*.

EN 13286-3, *Unbound and hydraulically bound mixtures — Part 3: Test methods for laboratory reference density and water content — Vibrocompression with controlled parameters*.

EN 13286-4, *Unbound and hydraulically bound mixtures — Part 4: Test methods for laboratory reference density and water content — Vibrating hammer*.

EN 13286-5, *Unbound and hydraulically bound mixtures — Part 5: Test methods for laboratory reference density and water content — Vibrating table*.

EN 13286-7, *Unbound and hydraulically bound mixtures — Test methods - Part 7: Cyclic load triaxial test for unbound mixtures.*

EN 13286-40, *Unbound and hydraulically bound mixtures — Part 40: Test method for the determination of the direct tensile strength of hydraulically bound mixtures*.

EN 13286-41, *Unbound and hydraulically bound mixtures — Part 41: Test method for the determination of the compressive strength of hydraulically bound mixtures*.

EN 13286-42, *Unbound and hydraulically bound mixtures — Part 42: Test method for the determination of the indirect tensile strength of hydraulically bound mixtures.*

EN 13286-43, *Unbound and hydraulically bound mixtures — Part 43: Test method for the determination of the modulus of elasticity of hydraulically bound mixtures*.

EN 13286-44, *Unbound and hydraulically bound mixtures — Part 44: Test method for the determination of the alpha coefficient of vitrified blast furnace slag*.

prEN 13286-45, *Unbound and hydraulically bound mixtures — Part 45: Test method for the determination of the workability period of hydraulically bound mixtures.*

EN 13286-46, *Unbound and hydraulically bound mixtures — Part 46: Test method for the determination of the moisture condition value.*

EN 13286-47, *Unbound and hydraulically bound mixtures - Part 47: Test method for the determination of the California bearing ratio, immediate bearing index and linear swelling*.

prEN 13286-48, *Unbound and hydraulically bound mixtures — Part 48: Test method for the determination of the degree of pulverisation.*

prEN 13286-49, *Unbound and hydraulically bound mixtures — Part 49: Accelerated swelling test of soil treated by lime and/or hydraulic binder*.

prEN 13286-50, *Unbound and hydraulically bound mixtures — Part 50: Methods for making test specimens using proctor equipment or vibrating table compaction.*

prEN 13286-51, *Unbound and hydraulically bound mixtures — Part 51: Methods for making test specimens by vibrating hammer compaction.*

prEN 13286-52, *Unbound and hydraulically bound mixtures — Methods for making test specimens - Part 52: Making specimens by vibro-compression.*

prEN 13286-53, *Unbound and hydraulically bound mixtures — Methods for making test specimens - Part 53: Making cylindrical specimens by axial compression*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: 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.

1 Scope

This European Standard specifies test procedures for determining the resilient and permanent behaviour of unbound mixtures under conditions that simulate the physical conditions and stress states of these materials in pavement layers subjected to moving loads. These procedures allow to determine mechanical properties that can be used for performance ranking of materials and for calculating the structural responses of pavement structures.

The test is applicable to cylindrical specimens of unbound mixtures prepared by laboratory compaction, with an absolute maximum particle size smaller than one fifth of the specimen diameter.

For the loading of the specimen, two methods are provided :

— Method A: The Variable Confining Pressure method in which the cell pressure is cycled in phase with the axial load.

— Method B: The Constant Confining Pressure method in which only cyclic axial loading and constant confining pressure are performed.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 13285, *Unbound mixtures - Specification*.

3 Symbols and abbreviations

For the purposes of this European Standard, the symbols and definitions in Table 1 apply.

Table 1 — Symbols and definitions

Symbol	Definition	Unit
w	Water content	%
ρ_d	Dry density	Mg/m^3
N	Number of load cycles	
σ	Normal stress	kPa
σ_1	Total axial stress (major principal stress)	kPa
σ_{1min}, σ_{1max}	Minimum and maximum values of σ_1 during one load cycle	kPa
σ_1^r	Resilient axial stress, $\sigma_1^r = \sigma_{1max} - \sigma_{1min}$	kPa
σ_3	Total radial stress; i.e. the applied confining pressure in the triaxial chamber or the vacuum inside the specimen when no triaxial chamber is used (minor and intermediate principal stress)	kPa
σ_{3min}, σ_{3max}	Minimum and maximum values of σ_3 during one load cycle	kPa
σ_3^r	Resilient radial stress, $\sigma_3^r = \sigma_{3max} - \sigma_{3min}$	kPa
σ_d	Deviator stress, $\sigma_d = \sigma_1 - \sigma_3$	kPa
L_0	Gauge length for axial displacement, immediately following specimen preparation	mm
R_0	Gauge length for radial displacement, immediately following specimen preparation	mm
$L_p(N)$	Permanent axial displacement at cycle N, defined as the displacement accumulated during the application of a single stress combination, from the beginning of the first cycle to the end of cycle N	mm
$R_p(N)$	Permanent radial displacement at cycle N, defined as the displacement accumulated during the application of a single stress combination, from the beginning of the first cycle to the end of cycle N	mm
$L_r(N)$	Resilient axial displacement at cycle N, defined as the displacement during the unloading part of the cycle (between the point where the applied stresses are maximum and the end of the cycle)	mm
$R_r(N)$	Resilient radial displacement at cycle N, defined as the displacement during the unloading part of the cycle	mm
ε_1^r	Resilient or recovered axial strain. At cycle N, $\varepsilon_1^r(N) = L_r(N)/L_0$	10^{-3}
ε_1^p	Permanent axial strain. At cycle N, $\varepsilon_1^p(N) = L_p(N)/L_0$	10^{-3}
ε_3^r	Resilient or recovered radial strain. At cycle N, $\varepsilon_3^r(N) = R_r(N)/R_0$	10^{-3}
ε_3^p	Permanent radial strain. At cycle N, $\varepsilon_3^p(N) = R_p(N)/R_0$	10^{-3}
E_r	Resilient modulus, $E_r = \dfrac{\sigma_1^{r\,2} + \sigma_1^r\sigma_3^r - 2\sigma_3^{r\,2}}{\sigma_1^r\varepsilon_1^r + \sigma_3^r\varepsilon_1^r - 2\sigma_3^r\varepsilon_3^r}$ When $\sigma_3^r = 0$, (constant confining pressure) : $E_r = \dfrac{\sigma_1^r}{\varepsilon_1^r}$	MPa
NOTE Compressive stresses and strains are positive.		

4 Principle

The cyclic triaxial test consists of imposing, on a cylindrical specimen of unbound granular material, cyclic stresses that reproduce the stress range in an unbound pavement layer, and in measuring the axial and radial strains of the specimen induced by this loading. In method A (Variable Confining Pressure), a cyclic axial deviator stress and a variable (cyclic) confining cell pressure, varying in phase, are applied. A simplified stress regime with a cyclic axial deviator stress and a constant confining pressure may also be adopted, method B.

The standard proposes three different test procedures, described below.

4.1 Procedure for the study of the resilient behaviour

The resilient behaviour of the material represents the behaviour during one load application. The results of the test can be used to determine values of the elastic modulus of the material for different stress levels, or parameters of non linear elastic models which can be used in analytical and numerical pavement design procedures.

In this procedure, a cyclic conditioning is first applied to stabilise the permanent strains of the material and attain a resilient behaviour. This conditioning is performed by applying a large number of cycles of a stress path that corresponds to the maximum stress level applied during the test. The resilient behaviour is then observed for several stress paths applied each one with a small number of cycles on the same specimen.

4.2 Procedure for the study of permanent deformations

Each permanent deformation test consists in applying a large number of load cycles of a single stress combination, without prior conditioning. This procedure can be used to determine permanent deformations of the material for a particular stress level, or parameters of models of prediction of permanent deformations, which can be used for pavement analysis and design.

4.3 Multi-stage procedure

This procedure can be used for a rapid evaluation of permanent deformations produced by different stress levels. It consists of applying several load sequences, with increasing stress levels, to the same specimen, until the cumulated permanent axial deformation exceeds a specified limit.

5 Apparatus

5.1 General

The test apparatus shall be able to apply the required cyclic loading to a cylindrical specimen with a diameter larger than 5 times the maximum particle size of the material, and a height twice the diameter (±2 %).

In test method A, the apparatus shall be able to cycle the cell pressure in phase with the axial load. Hence, a triaxial cell shall be used.

In test method B, only the axial load is cyclic, and the confining pressure is held constant. Hence, the triaxial cell may not be necessary, and the constant confining pressure may be applied by partial vacuum inside the specimen.

NOTE Using a system without a triaxial cell will prevent applying some of the additional stress paths in this standard that are considered important for some types of structures.

5.2 Triaxial pressure chamber (‘cell’)

5.2.1 General

The pressure chamber, or ‘cell’, is similar to most conventional triaxial cells except that it is somewhat larger to facilitate the internally mounted load and deformation measuring equipment, and has additional outlets for the electrical leads from the measuring devices.

5.2.2 Chamber medium

Water, air, silicon oil or other suitable medium may be used as the chamber medium. Water is not suitable if the instrumentation does not have fully sealed electrical connections.

5.2.3 Top and bottom plate

Top and bottom plate alignment is critical to maintain uniform stresses and strains in the specimen. A ball joint may be suitable for alignment.

5.3 Loading device

5.3.1 Method A – Variable confining pressure

For test procedures with variable confining pressure (described in 7.2 and 8.2.2) the loading device shall satisfy the following requirements:

— The loading device shall be capable of applying variable repeated axial loads and confining pressures, in fixed cycles of load and release.

— During loading, the axial load and the confining pressure shall remain proportional and vary in phase.

— The axial loading device shall be able to apply a maximum deviatoric stress of 600 kPa on the specimen, and the cyclic pressure control system shall be able to apply a maximum confining pressure of 300 kPa.

— During each cycle, the minimum and maximum values of deviatoric stress and confining pressure shall be applied with an accuracy of ±2 kPa or 1 %, whichever is the greater.

— The frequency of loading shall be maintained between 0,2 Hz and 10 Hz.

— The phase difference between the pulses of the axial load and of the confining pressure shall not exceed 1 % of the cycle duration.

5.3.2 Method B - Constant confining pressure

For test procedures with constant confining pressure (described in 7.3, 8.2.3 and 8.3), the loading device shall satisfy the following requirements:

— The axial loading device shall be able to apply variable repeated axial loads, in fixed cycles of load and release, and to apply a maximum deviatoric stress of 600 kPa on the specimen.

— The pressure control system shall be able to apply a maximum confining pressure of at least 70 kPa.

— The confining pressure may also be applied by partial vacuum inside the specimen.

— During each cycle, the minimum and maximum values of deviatoric stress and the constant confining pressure shall be applied with an accuracy of ±2 kPa or 1 %, whichever is the greater.

— The frequency of axial loading shall be maintained between 0,2 Hz and 10 Hz.

5.4 Pressure transducers

The confining pressures in the cell or the partial vacuum in the specimen shall be monitored by pressure transducers with suitable sensitivity ranges, and with an accuracy of ±2 kPa.

5.5 Axial load transducer

The axial load applied to the specimen shall be monitored by a transducer with a suitable sensitivity range which will yield measurements of axial stress to an accuracy of ±2 kPa. The load transducer shall preferably be placed inside the triaxial cell, in direct contact with the specimen cap.

5.6 Response measuring equipment

The axial deformations of the specimen shall be measured using at least two displacement transducers attached directly to the central part of the specimen (such that the gauge length does not exceed half of the height of the specimen). An appropriate system for measuring axial deformations, using three linear variable displacement is presented in annex A.

The radial deformations of the specimen shall be measured at mid-height of the specimen, using transducers attached directly to the specimen. An appropriate system for measuring radial deformations, using three linear variable displacement is presented in annex A.

The axial and radial strains shall be measured with an accuracy of 5×10^{-3} mm + $10^{-3} \times L$ (where L is the measured displacement in millimetre).

Readings of all transducers should be recorded separately.

5.7 Other equipment

It is necessary to provide suitable signal excitation, conditioning, and recording equipment in addition to the measuring devices for simultaneous recording of axial load, confining pressure and axial and radial deformations.

The recording system shall operate at a frequency, or be of a type, which is able to capture both the minimum and the maximum values of stress applied and strain incurred at the frequency of testing which is to be employed.

5.8 Specimen cap and base

The specimen cap and base shall be designed to provide drainage from both ends of the specimen. They shall be constructed of a rigid, non-corrosive, impermeable material, and each shall, except for the drainage provision, have a circular plane surface in contact with the porous discs of circular cross section. The diameter of the cap and base shall be equal to or larger than the initial diameter of the specimen. The specimen base shall be connected to the triaxial compression chamber to prevent lateral motion or tilting, and the specimen cap shall be designed such that eccentricity of the loading piston-to-cap contact relative to the vertical axis of the specimen does not exceed 1 % of the specimen's diameter. The cylindrical surface of the specimen base and cap that contacts the membrane to form a seal shall be smooth and free of scratches.

5.9 Porous discs

The specimen shall be separated from the specimen cap and base by rigid porous discs fastened to the specimen cap and base of a diameter equal to or a little smaller than that of the specimen. The discs shall be regularly checked by passing air or water under pressure through them to determine whether they have