BRITISH STANDARD

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Products and systems for the protection and repair of concrete structures — Test methods — Determination of modulus of elasticity in compression

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ICS 91.080.40

National foreword

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Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken - Prüfverfahren - Bestimmung des Elastizitätsmoduls im Druckversuch

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Foreword

This document (EN 13412:2006) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, 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of an identical text or by endorsement, at the latest by February 2007, and conflicting national standards shall be withdrawn at the latest by February 2007.

This document supersedes EN 13412:2002

It has been drafted by CEN/TC 104/SC 8 "Products and systems for the protection and repair of concrete structures", the secretariat of which is held by AFNOR.

This European Standard is one of a series dealing with products and systems for the protection and repair of concrete structures.

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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard specifies two methods for determining the modulus of elasticity in compression for repair products and systems.

Method 1 is for products and systems with high creep characteristics typically those containing polymer binders (PC).

Method 2 is for products and systems with low creep characteristics typically those containing polymer modified (PCC) and cementitious (CC) binders.

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.

EN 196-1, *Methods of testing cement — Part 1: Determination of strength*

EN 1504-1:2005, *Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity — Part 1: Definitions*

EN 1504-3:2005, *Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity — Part 3: Structural and non-structural repair*

EN 12190, *Products and systems for the protection and repair of concrete structures — Test methods — Determination of compressive strength of repair mortar*

EN 12390-3, *Testing hardened concrete — Part 3: Compressive strength of test specimens*

EN 12390-4, *Testing hardened concrete — Part 4: Compressive strength — Specification for testing machines*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1504-1:2005 and EN 1504-3:2005 and the following apply.

3.1
compressive stress
compressive force carried at any time by the test specimen per unit of the original cross-section

3.2
compressive strain
ratio of the change in the distance between two reference points along the axis of the test specimen per unit length of the original distance

3.3
secant modulus
ratio of stress to a corresponding strain, measured relative to a level of pre-stress applied to firmly bed the specimen, platens and ball seating

NOTE The secant modulus is also known as the static modulus of elasticity in compression as defined in ISO 6784.

3.4
creep
additional time-dependent strain that occurs in a test specimen under a constant applied stress

4 Principle

The principle of the test is to measure the secant modulus of the specimen by applying a controlled axial compressive load to a prism with a 4:1 aspect ratio and relating a longitudinal compressive strain to the compressive stress, thus inducing it. Two methods are used:

— Method 1 is for products and systems with high creep characteristics, typically those containing polymer binders (PC), where a high rate of loading is necessary to counteract the effects of creep, which can significantly reduce the calculated value of the secant modulus.

— Method 2 is for products and systems with low creep characteristics, typically those containing polymer modified (PCC) and cementitious (CC) binders.

5 Equipment

5.1 Mortar mixer, in accordance with EN 196-1, or a forced action pan mixer.

5.2 Moulds, prisms with a dimension of 40 mm × 40 mm × 160 mm in accordance with EN 196-1.

5.3 Strain measuring instruments, strain gauges with a gauge length of at least 50 mm, a maximum sensitivity of 50 µm/m that provide a continuous indication of change in gauge length.

NOTE Alternative methods of strain measurement of equivalent sensitivity may be used.

5.4 Compression testing machine, suitable for testing specimens with the dimension given in (5.2) and conforming to the requirements of EN 12390-4.

5.5 Standard laboratory climate, of (21 ± 2) ºC and (60 ± 10) % RH in accordance with Annex A.

6 Preparation of test specimens

The components of the product undergoing testing shall be maintained at the standard test conditions (5.5) for at least 24 h before mixing. A mortar mixer (5.1) shall be used to prepare a batch of product in accordance with the manufacturer's recommendations.

NOTE A supplier's complete pack of pre-weighed components should preferably be used but where this is not practicable, the proportioning of components should be in accordance with the manufacturer's specification.

The mixed material shall then be compacted into prism moulds (5.2) and fully cured, following the manufacturer's recommended procedure. At least three prisms are required as test specimens.

The specimens shall be cured and stored as described in Annex A. The moulds shall be removed 24 h after preparation of the test specimens.

7 Procedure

7.1 Conditions and conditioning: Immediately prior to testing, the test specimens shall be conditioned for at least 24 h under the standard conditions laid down in (5.5).

7.2 Measurement: Measure the width and thickness of each specimen from the middle to the nearest 0,1 mm, to calculate the cross-sectional area.

7.3 Fitting strain measuring instruments: When attaching a strain gauge (5.3) to a specimen, ensure that the strain measurement is parallel to the longitudinal axis of the prism and any distortion about the axis is eliminated. There shall be no slippage between the grips of mechanical strain gauges and the specimen.

7.4 Method 1: The secant modulus is based on the compressive stress required to reduce the gauge length of the test specimen by 0,2 % from a pre-stress of approximately 10% of the expected stress at 0,002 compressive strain.

7.4.1 Pre-loading: Place the specimen centrally in the compression test machine in accordance with the procedure of EN 12390-3, with the strain measuring instruments (5.3) attached axially.

The load shall be applied smoothly at a constant rate to produce a stress of between 2 N/mm^2/s and 10 N/mm^2/s until a compressive strain of approximately 0,002 m/m is indicated. Record the applied load as N_1. Using the same rate of loading, smoothly remove to a load of N_2, which is 10 % of N_1, and then re-apply the same load at least twice, using the same rate of loading, to ensure that the specimen and the platens are well seated and that the strain gauges are indicating consistently.

If the individual strains are not within a range of ± 10 % of their mean value at N_1, the pre-loading in (7.4.1) should be repeated at a higher loading rate, to a maximum of 10 N/mm^2/s.

NOTE If the above procedure does not produce a consistent result for the strain at N_1, this can be due to the effects of excessive creep strain and can be reduced by using a faster rate of load application.

If, following repeat testing at a higher rate of loading it is not possible to reduce the differences to within a range of ± 10 % of their mean value at N_1, do not proceed with the test loading (7.4.2).

7.4.2 Test Loading: While the load is held at N_2, zero the strain gauges. Measure the change in the compressive strain ($\Delta\varepsilon$) as the load is increased from N_2 to N_1 at the same rate of loading used for pre-loading (7.4.1). Calculate ΔN as the difference between the two levels of applied load (i.e. N_1 - N_2). Reduce the load to N_2, using the same rate of loading and then repeat the loading and unloading cycle a further three times. Four measurements of (ΔN) and ($\Delta\varepsilon$) shall be recorded. The load (ΔN) should then be converted to a stress ($\Delta\sigma$) by dividing by the cross-sectional area (7.2) of the specimen.

7.5 Method 2: The secant modulus is established by measuring the change in the strain in the specimen when loaded to produce a stress of between 0,5 N/mm^2 (σ_2) and one-third of the compressive strength (σ_c) of the specimen, measured in accordance with EN 12190.

7.5.1 Pre-loading: Place the test specimen, with the strain measuring instruments (5.3) attached axially and centrally in the machine. Apply the basic stress of 0,5 N/mm^2 (σ_2) and record the strain. Steadily increase the stress at a constant rate within the range (0,6 ± 0,4) N/mm^2/s until a stress equal to one-third of the compressive strength (σ_c) of the specimen ($\sigma_1 = \sigma_c/3$) is reached.

NOTE The preferred rate of stress application is 0,6 N/(mm^2 x s).

Maintain the stress for 60 s and record the strain readings taken during the following 30 s.

If the individual strain readings on the specimen are not within a range of ± 10 % of their mean value at (σ_1), re-centre the test specimen and repeat the pre-loading in (7.5.1).

If it is not possible to reduce the differences to within a range of ± 10 % of their mean value at σ_1, do not proceed with the test loading (7.5.2).

Carry out at least two additional preloading cycles, using the same loading and unloading rate, and maintaining the stress (σ_1 and σ_2) at a constant for a period of 60 s.

7.5.2 Test Loading: After completing the last preloading cycle and a waiting for a period of 60 s under the stress (σ_2), measure the change in the compressive strain ($\Delta\varepsilon$) as the stress is increased from (σ_2 to σ_1), calculating ($\Delta\sigma$) as the difference between the two levels of applied stress (i.e. σ_1 - σ_2). Measurements of (σ_1) and ($\Delta\varepsilon$) should be completed within 30 s.

When all measurements have been completed, remove the strain measuring instruments (5.3) where applicable and then increase the load on the test specimen, at the specified rate, until failure of the specimen occurs and calculate the failure stress (σ_f). If the compressive strength of the specimen at failure (σ_f) differs from (σ_c) by more than 20 %, this shall be noted in the test report.

8 Calculation

Calculate the secant modulus for each specimen by dividing ($\Delta\sigma$) by ($\Delta\varepsilon$). Calculate the mean secant modulus for the three specimens, expressing the mean value to the nearest 100 N/mm^2.

9 Report

The following information shall be included in the test report:

a) reference to the test method standard;

b) name and address of the test laboratory;

c) identification number and date of the test;

d) name and address of the manufacturer or supplier of the product;

e) name and identification marks or batch number of the product;

f) date of supply of the product;

g) date of preparation of the test specimens and any deviation from the prescribed method of preparation;

h) cross-sectional area of each specimen;

i) conditions of storage of prepared specimens prior to test;

j) date of test and details of the test equipment used, including the make, type and capacity and the calibration details or the identification number of the apparatus;

k) rate of loading used and applicable standard;

l) test results, including the upper (σ_1) and lower (σ_2) stress levels used in the testing cycle, the mean compressive strain for each test specimen, the secant modulus of each test specimen and the mean secant modulus and the compressive strength at failure;

m) precision data;

n) date of test report and signature;

o) any other information required by the standard.

Annex A
(normative)

Summary of temperatures and humidities for the curing, conditioning and testing of repair products and systems

A.1 Curing

A.1.1 CC (grouts, mortars and concretes)

— Prepare as indicated in EN 196-1, cover in film for 24 h.

— De-mould after 24 h.

— Cure under water at (21 ± 2) °C for 27 days.

A.1.2 PCC (grouts, mortars and concretes)

— Prepare as indicated in EN 196-1, cover in film for 24 h.

— De-mould after 24 h and wrap in film for 48 h.

— Unwrap and cure for 25 days in a standard laboratory climate of (21 ± 2) °C and (60 ± 10) % RH.

A.1.3 PC (grouts, mortars and concretes)

— Cure for 7 days at (21 ± 2) °C and (60 ± 10) % RH.

A.2 Conditioning and Testing

For specific applications, the following definitions apply.

A.2.1 Standard laboratory climate (dry conditioning):
Take from the curing/storage environment and condition for 7 days in a standard laboratory climate of (21 ± 2) °C and (60 ± 10) % RH

A.2.2 Wet conditioning:
Immerse for 7 days at (21 ± 2) °C, or for CC, take directly for test after 28 days of immersion.
Remove all the surface water by standing the specimens upright for 30 min before using them for tests

Bibliography

[1] ISO 6784, *Concrete — Determination of static modulus of elasticity in compression.*

[2] EN 12390-1, *Testing hardened concrete — Part 1: Shape, dimensions and other requirements for specimens and moulds*.

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