SLOVENSKI STANDARD

SIST EN 12188:2000

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Proizvodi in sistemi za zaščito in popravilo betonskih konstrukcij - Preskusne metode - Določevanje zlepljenosti jekla na jeklo za ugotavljanje značilnosti konstrukcijskih lepil

Products and systems for the protection and repair of concrete structures - Test methods - Determination of adhesion steel-to-steel for characterisation of structural bonding agents

Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken - Prüfverfahren - Bestimmung der Klebewirkung an Stahl für die Charakterisierung der Eigenschaften von Klebstoffen für konstruktive Zwecke

Produits et systemes pour la protection et la réparation des structures en béton - Méthodes d'essais - Détermination de l'adhérence acier sur acier pour la caractérisation des produits de collage structural

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91.080.40 Betonske konstrukcije Concrete structures

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English version

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This European Standard was approved by CEN on 16 April 1999.

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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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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 104 "Concrete (performance, production, placing and compliance criteria)", 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of an identical text or by endorsement, at the latest by november 1999, and conflicting national standards shall be withdrawn at the latest by november 1999.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

NOTE This European Standard should be read in conjunction with EN 1504-1 and prEN 1504-4.

1 Scope

This European Standard describes a method for the characterisation of structural polymer based bonding agents for use in applications such as steel plate structural bonding for the strengthening of concrete structures. It involves the determination of the slant shear strength and the pull-off strength.

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.

EN 24624, *Paints and varnishes - Pull-off test.* (ISO 4624:1978)

EN 1542, *Products and systems for the protection and repair of concrete structures - Test methods - Pull-off test.*

3 Principle

The slant shear strength shall be determined using steel prism halves glued together with the bonding agent.

The bond planes shall be inclined at various angles to the longitudinal axis of the prisms.

The complete prisms shall be tested in axial compression.

NOTE Stresses which occur in a joint made with a structural bonding agent can be resolved into normal stress, σ. The object of the test methods described in this standard is to determine the relationship between σ, and τ which meets the criterion $f(\sigma, \tau) = 0$, i.e. to determine the shape of the failure envelope which represents failure of the adhesive agent in the bonded joint.

For the purposes of this standard, the failure envelope is defined by three straight lines on a plot of normal stress against shear stress at failure as shown in figure 1. Conventionally, σ values are plotted as abscissae and τ values as ordinates.

Failure of a bonding agent is governed by its strength parameters - coefficient of friction, cohesion and resistance to separation :

- the coefficient of friction μ, is the numerical value of the slope of the inclined lines in figure 1 ;
- the cohesion c is the shear capacity at $\sigma = 0$;
- the resistance to separation f_t, is the pull-off strength e.g. the tensile capacity at $\tau = 0^o$.

As these values are constant for a particular material, the shape of the failure envelope can be used to characterise a material.

The failure envelope can be explained as follows :

- sliding failure occurs when numerical values of shear stress $|\tau|$ meet the inequality $|\tau| \geq c - \mu\sigma$;

- separation failure occurs when the tensile stress exceeds the pull-off strength : $\sigma \geq f_t$

As noted above and as can be seen from figure 1, the failure envelope is formed by three straight lines. Stress fields within the area containing the origin do not cause failure.

As an option it is possible to extend the test to include for a slant shear test in tension to fully complete the failure envelope in figure 1.

4 Terms and definitions

For the purposes of this European Standard, the following definitions apply :

4.1
compressive stress (σ_o)
the ratio of the compressive force (F) to the surface area (A_c) of the cross section of the test specimen is :

$$\sigma_o = \frac{F}{A_c} \qquad \text{(MPa or N/mm}^2\text{)}$$

4.2
normal and shear stress
the normal stress, (σ), and shear stress, (τ), are the stresses at the inclined section of the test prism (see figure 2b) in which :

$$\sigma = \sigma_0 \cos^2\theta \qquad \text{(MPa or N/mm}^2\text{)}$$

$$|\tau| = \sigma_0 \cos\theta \sin\theta \qquad \text{(MPa or N/mm}^2\text{)}$$

where :

θ denotes the angle from the cross section of the test prism to the inclined section, (see figure 2a).

4.3
pull-off strength
the maximum tensile stress carried by the bonded joint in a pull-off test as shown in figure 3.

4.4
separation failure
a mode of failure where the failure occurs along a failure plane in such a way that the material on each side of the failure plane moves perpendicular to the failure plane.

4.5
sliding failure
a mode of failure where the failure occurs along a failure plane in such a way that the material on each side of the failure plane moves parallel to the failure plane.

4.6
slant shear strength
the compressive strength of a scarf-jointed test prism where failure occurs along the inclined bonded joint.

5 Test method

The failure envelope of the bonding agent (see figure 1), shall be determined, from the testing of the scarf-jointed prisms and from pull-off tests such that the failures occur entirely in the bonding agent.

5.1 Sliding failure

Test prisms having inclined bonded joints, where θ equal to 50°, 60° and 70°, shall be tested in compression until failure (see figure 2a). The slant shear strengths and the failures modes shall be observed and recorded. The corresponding values of σ and τ shall be plotted in a (σ ; τ)- co-ordinate system, and a straight line fitted by applying regression analysis technique. From the position of this line the coefficient of friction, μ and the cohesion, c, shall be determined.

5.2 Separation failure

The dollies shall be tested in tension by pull-off test until failure, (see figure 3). The pull-off strength represents the resistance against separation f_t.

6 Equipment

The compression testing machine for testing scarf-jointed prisms shall be of type capable of providing a constant stress rate between 0,1 MPa per second and 1,0 MPa per second. The testing apparatus for conducting the pull-off test shall be in accordance with EN 24624.

A vernier gauge for measuring joint thickness.

7 Slant shear test

7.1 Test specimens

The test specimens shall be bonded steel prisms meeting the following requirements :

7.1.1 Dimensions

Prismatic steel specimens having a square cross-section of 40 mm by 40 mm and a length of 160 mm shall be used. Each of the test prisms shall consist of two identical semi prisms produced from the 40 mm x 40 mm x 160 mm steel prism by a saw cut at an angle of θ to the transverse axis of the prism (see Figure 2a)). The sawn surfaces shall be degreased using a suitable degreasing agent, for example acetone and then shall be prepared by grit blasting. The intent is to achieve a roughness sufficient to ensure a failure within the bond plane of the adhesive (see 7.2.5). Immediately on completion of grit blasting any surface dust shall be removed and the adhesive applied immediately.

7.1.2 Number of specimens

For each set of prescribed testing conditions a minimum of three specimens shall be tested for each of three angles.

7.1.3 Preparation

Sets of two identical semi prisms shall be bonded with the adhesive agent and clamped together to achieve a 1 mm to 2 mm thick bond line with no entrapped air voids. Appropriate spacers shall be used to control the thickness of the bonding agent.

The steel-to-steel bonding shall be carried out in accordance with the specification given by the manufacturer. After hardening, excess bonding agent shall be cut away. For each test prism the thickness of the bonding joint shall be determined as the average of the joint thicknesses measured at the mid points of the four sides of the prism. The bonding agent shall be cured in accordance with the recommendations of the manufacturer.

7.1.4 Temperatures

The resin and hardener component of the bonding agent shall be conditioned to test temperature of (21 ± 2) °C, (60 ± 10) % relative humidity before mixing.

7.1.5 Tolerances of the geometry

Tolerances of the dimensions of the semi-prisms shall not be greater than ± 0,1 mm. Each of the long faces of the bonded test prisms shall lie between two parallel planes 0,20 mm apart.

7.2 Test procedure

7.2.1 Temperature

The test prisms shall be maintained at the temperature specified for not less than 16 h before testing commences. Testing shall be carried out at (21 ± 2) °C, (60 ± 10) % relative humidity unless any other temperature condition is agreed.

7.2.2 Extreme temperatures

For testing at extremes of environmental conditions, alternative conditioning and testing temperatures shall be used.

7.2.3 Loading procedure

The loading procedure shall be in accordance with the specification for the testing machine.

The scarf-jointed prisms shall be loaded according to the standard procedures for testing cylinders for compressive strength. The rate of axial stress shall be between 0,5 MPa/s ($N/mm^2/s$) and 1,0 MPa/s ($N/mm^2/s$) (see figure 2).

7.2.4 Failure modes

Various failure modes are possible for the scarf-jointed prisms. The failure modes achieved shall be described, and reported.

An acceptable failure mode will pass entirely through the adhesion agent. A test of a scarf-jointed prism shall be rejected if a sliding failure occurs at the interface between the steel surface and the adhesion agent. However, it is acceptable if not more than 10 per cent of the sliding area takes place at the interface.

7.2.5 Calculation of the slant shear strength

The slant shear strength (σ_o) shall be calculated for each specimen by dividing the load at failure by the cross-sectional area of the prism and expressing the results in units of MPa (N/mm^2). The determination of μ and c shall be carried out by linear regression analysis.

The mean slant shear strength of scarf-jointed prisms having equal values of angle θ of joint shall be calculated to the nearest 0,1 MPa for the purpose of the determination of coefficient of friction μ and the cohesion c, to be found by regression analysis.