

**Products and systems for the protection and repair of concrete structures — Test methods - Shear adhesion coated steel to concrete (pull-out test)**

*Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken — Prüfverfahren - Haftzugfestigkeit zwischen beschichtetem Stahl und Beton (Ausziehversuch)*

ICS:

Descriptors:

Document type: European Standard  
Document subtype:  
Document stage: CEN Enquiry  
Document language: E

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## Foreword

This document (prEN 15184:2005) has been prepared by Technical Committee CEN/TC 104 "Concrete and related products", the secretariat of which is held by DIN.

This document is submitted to Formal Vote.

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

## 1 Scope

This European Standard specifies a method for determining the shear adhesion of steel rebar coated with a corrosion protection product or system to a standard reference concrete.

The test applies to products based on hydraulic binders or polymers or mixtures of both.

## 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 - Determination of strength*

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

prEN 1504-7, *Products and systems for the protection and repair of concrete structures – Definitions requirements, quality control and evaluation of conformity – Part 7: Reinforcement Corrosion Protection*

ENV 1504-9, *Products and systems for the protection and repair of concrete structures – Definitions requirements, quality control and evaluation of conformity – Part 9: General principles for the use of products and systems*

EN 1766, *Products and systems for the protection and repair of concrete structures – Test methods – Reference concretes for testing*

ENV 10080, *Steel for the reinforcement of concrete – Weldable reinforcing steel – Part 1: General requirements*

EN 12390-2, *Testing hardened concrete - Part 2: Making and curing specimens for strength tests*

EN ISO 12944-4, *Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 4: Types of surface and surface preparation*

## 3 Definitions

For the purpose of this European Standard the definitions given in EN 1504-1, prEN 1504-7 and ENV 1504-9 apply.

## 4 Test principle

The test compares the shear adhesion of bars coated with a corrosion protection product or system to that of uncoated bars embedded in a standard reference concrete.

The test is carried out using concrete specimens in which coated and uncoated rebars are embedded. A tensile load is applied to one end of the rebar and increased at a controlled rate until failure occurs. The applied force and resulting displacement of the coated and uncoated rebar are measured and the results compared.

## 5 Apparatus

- 5.1 Concrete mixer** in accordance with EN 196-1, or a forced action pan mixer
- 5.2 Compaction tools** and equipment in accordance with EN 196-1
- 5.3 Stirrer and brush** to mix and apply the coating product
- 5.4 Moulds** for the preparation of concrete blocks of dimensions 200 mm x 200 mm x 200 mm (see Figure 1).
- 5.5 Thermometer** accurate to within 1 °C.
- 5.6 Tensile testing apparatus** of adequate capacity, capable of measuring load to an accuracy of  $\pm 2\%$ , and fitted with a load pacer to control the rate of load increase.
- 5.7 A measuring device**, interlocked with the rebar and one or more displacement sensors, capable of measuring relative movement between the anchored bar and a fixed reference point on the test block to an accuracy of  $\pm 0,01$  mm.

## 6 Preparation of the test specimens

### 6.1 Description of the test specimens

For each coating three coated bars and three uncoated bars, taken from the same batch of reinforcement, shall be tested. The test specimen is a concrete cube with the bar incorporated in its central axis (Figure 1).

The effective bond length of the bar is 5 times the diameter of the bar ( $5d_s$ ). The remainder of the bar is enclosed within a plastic sleeve so that the end of the bar is unrestrained. The bar extends from two opposite faces of the specimen. The tensile load is applied to the longer end, and the device for measuring the displacement between steel and concrete is set on the shorter end. The plastic sleeve shall fit around the bar with a 1 mm tolerance and the thickness shall not exceed 2 mm. The annulus between the sleeve and the steel bar shall be sealed at the end with a suitable non-setting sealant. (Care must be taken not to contaminate the surface of the bar which is to be bonded in the concrete.)

Test specimens shall be produced in a room or chamber maintained at the standard laboratory climate,  $21 \pm 2$  °C and  $60 \pm 10$  % RH. Moulds (see Figure 2) shall be non-deformable and of dimensions 200 mm x 200 mm x 200 mm.

### 6.2 Surface preparation of bars to be tested

For each coating product to be tested, six 16 mm diameter ribbed bars in accordance with ENV 10080, (type S235) shall be tested, three uncoated and three coated. The bars shall be free from grease, and shall be blast cleaned to Sa 2½ according to EN ISO 12944-4, (or according to the manufacturer's instructions). The length of the bars is typically 550 mm, but may be varied if the apparatus requires.

**Figure 1 — Description and dimension of specimens (section and view from below)**

### 6.3 Coating of bars

All materials shall be conditioned at the standard laboratory climate for a period of not less than 24 hours prior to mixing.

The test bars shall be cleaned as specified in 6.2 immediately prior to coating. The coating product shall be mixed and applied at the standard laboratory climate in accordance with the manufacturer's instructions. The coating shall be applied at the maximum thickness recommended by the manufacturer. After application the specimens shall be cured for 7 days under the standard laboratory climate.

The test bars shall be located in the mould as shown in Figure 2, with the plastic sleeve applied to the bar. The bars shall typically extend from the mould by 50 mm on one side and by 300 mm on the other side, sufficient to permit measurement and the application of tensile load (see Figure 1). The bar shall be located and supported along the centre line of the hole. The assembled mould containing the bar shall be placed in a room or chamber maintained at the standard laboratory climate prior to casting of the concrete specimens.

## **6.4 Casting of specimens**

### **6.4.1 Composition of the concrete**

The specimens shall be cast using type C 0,70 concrete in accordance with EN 1766.

### **6.4.2 Placing and compacting**

The assembled moulds, equipment and tools required for mixing and placing shall be stored for at least 24 hours in a room or chamber maintained at laboratory standard climate.

The bar is kept horizontal along the axis of the mould during placing and compaction of fresh concrete (Figure 2). Compaction is carried out as specified in EN 12390-2 to the same degree as for the cubes or cylinders used to determine the strength of concrete.

The concrete shall be placed in two layers of equal thickness and vibrated using a 25 mm diameter concrete vibrator. Each specimen shall be vibrated at four points, each position being equidistant from the two adjacent faces.

### **6.4.3 Storage of cast test specimens**

The specimens shall be removed from the moulds 3 days after casting, during which time they shall be covered with wet cloths. After removal of the moulds, the specimens shall be stored at laboratory standard climate for 25 days.

**Figure 2 — Sketch of the mould (longitudinal section)**

## **7 Execution of the bond test**

### **7.1 Testing apparatus**

The arrangement of the apparatus for the shear adhesion test is shown in Figure 3.

### **7.2 Test procedure**

The shear adhesion test is carried out by applying a tensile force to the free end of the bar. The specimen is seated onto a 200mm x 200mm resilient bearing pad sufficient to accommodate variations in the surface of the specimen, supported by a 10mm thick steel plate, both of which have a 32mm diameter hole to allow free movement of the bar during the test; this assembly is placed vertically on the baseplate of the tensile testing device. The measurement of the displacement is made on the upper portion of the bar, and the tensile force (F) is applied to the lower end.

Before load is applied the two supports for the displacement measuring device are firmly attached to the surface of the test specimen, at least 150mm apart. The sensor is rigidly attached to the supports, and brought into contact with the end of the rebar. It may be necessary to prepare the end of the rebar to ensure proper contact with the measuring device.

The specimen is loaded progressively up to bond failure or the splitting of the concrete cube. The applied force and the displacement shall be measured continuously. The test report shall indicate the applied force and displacement throughout the test, as well as the type of failure, bond or splitting.

### **7.3 Testing machine**

The load range of the testing machine must exceed the expected failure load of the test specimen. Failure load is usually 100 kN.

## 7.4 Loading rate

The specimen should be loaded at a rate of 128 N/s.

Figure 3 — Testing setup

## 7.5 Calculation of test results

The value of the force applied at a displacement of 0,1 mm shall be determined from the force displacement curve for each of the coated specimens and the uncoated specimens. The mean value shall then be calculated for both coated and uncoated specimens.

## 8 Test report

The test report shall include the following coating product information and test data:

- a) A reference to the test method standard
- b) Name and address of the test laboratory
- c) Name and address of the manufacturer or supplier
- d) Identification of the coating product (pack size)
- e) Name and identification marks or batch number
- f) Surface preparation of the bars
- g) Quantity of mixture prepared
- h) Mass of applied coating and the mean thickness of the dried coating layer on the top of the ribs
- i) Method used for mixing the constituents and the time taken
- j) Time between mixing the constituents and painting the bar
- k) Method used to paint the bar (painting, spraying etc.)
- l) Date of preparation of the test specimen
- m) Conditions of storage of prepared specimens prior to test
- n) Time taken to coat and install the bar in the specimen, and any difficulties encountered
- o) Time period between coating the bar and testing
- p) Date of test
- q) The progressive load displacement
- r) The mean load at 0,1 mm displacement for coated and uncoated bars



s) Description of the type of failure, or combination of failure types for each test-specimen, as follows

Type 1: extraction of the bar from the coating

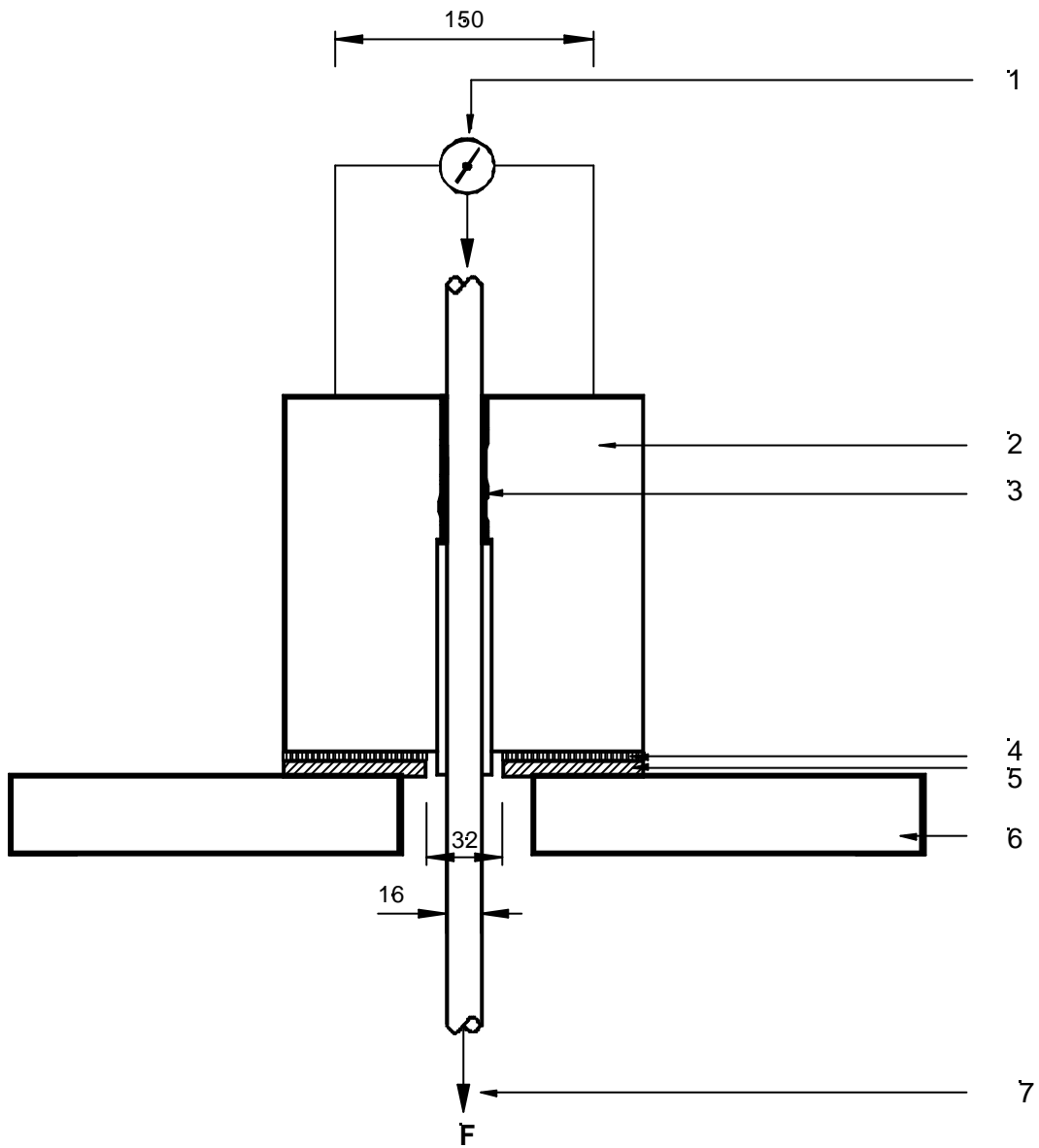
Type 2: extraction of the bar and coating from the concrete

Type 3: failure within the coating itself

t) Any incident liable to have affected the results

u) Any deviation from the conditions specified in this standard

v) Date of test report and signature



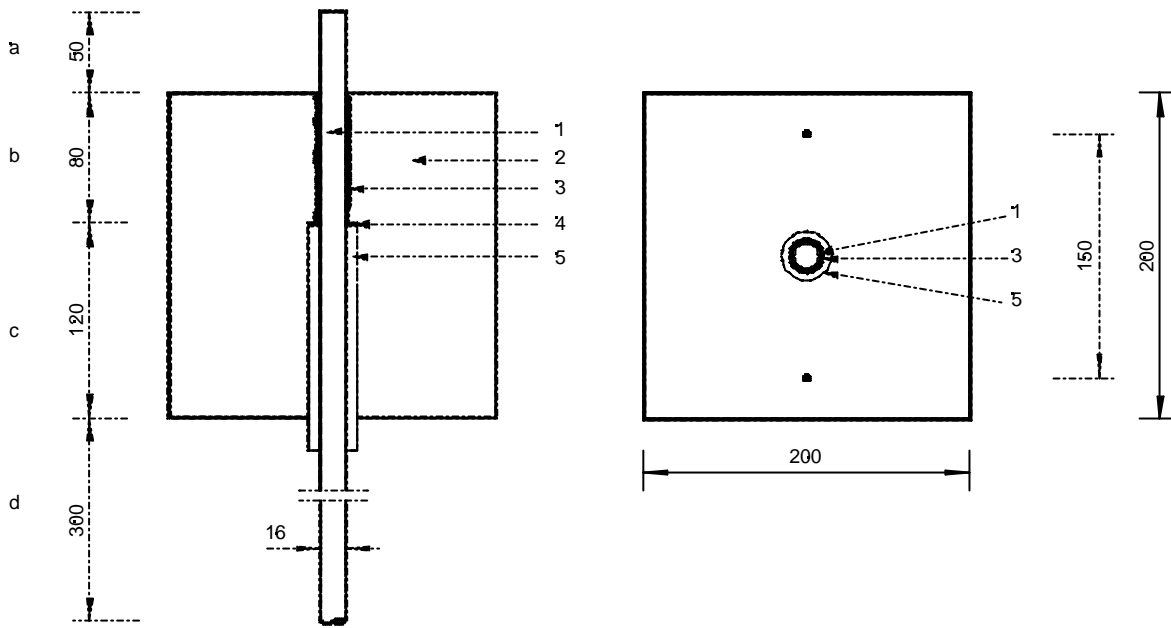
9 Figure 3 Testing setup

1 – displacement measuring device (attached to two sensors on the surface of the specimen)

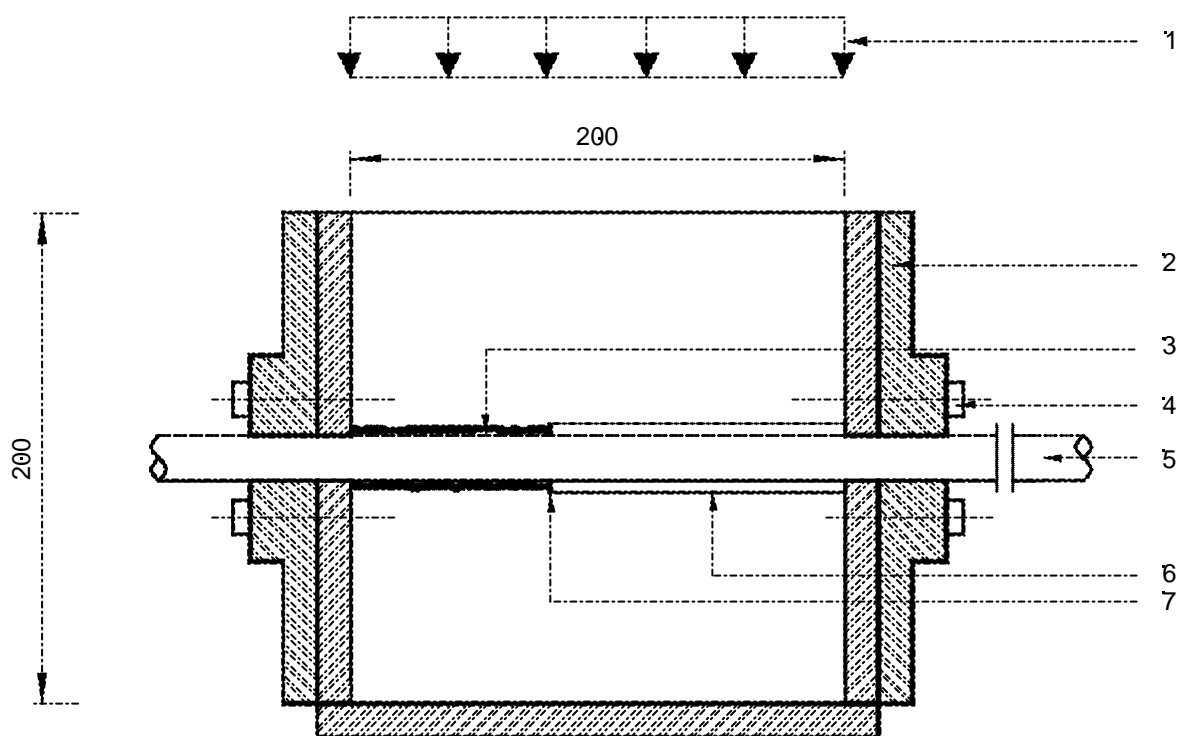
- 2 – specimen
- 3 – coating
- 4 – resilient bearing pad
- 5 – steel plate,  $\approx 10$  mm thick
- 6 – baseplate
- 7 – tensile force

**Figure 1** Description and dimension of specimens (section and view from below)

- 1 – reinforcing bar (rebar)
  - 2 – concrete
  - 3 – coating
  - 4 – sealing
  - 5 – plastic sleeve
  - 6 – displacement sensors (a figure 6 needs placing by each solid black dot in the right hand plan view)
- 
- a – part of the bar up to the point of application of the displacement measuring device
  - b – bond length
  - c – free pre-length



d – part of the bar up to the point of application of the tension force (typically 300mm) (a “~” needs placing before the 300 for this dimension)



**Figure 2** Sketch of the mould (longitudinal section)

1 – direction of concreting

2 – mould

3 – coating

4 – fixing element

5 – rebar

6 – plastic sleeve

7 – sealing

