SLOVENSKI STANDARD
SIST-TS CEN/TS 1992-4-5:2009

01-oktober-2009

Projektiranje pritrjevanja za uporabo v betonu - 4-5. del: Naknadno vgrajena pritrjevala - kemijski sistemi

Design of fastenings for use in concrete - Part 4-5: Post-installed fasteners - chemical systems

Bemessung von Befestigungen in Beton - Teil 4-5: Chemische Dübel

Conception-calcul pour les éléments de fixation pour béton - Partie 4-5 : Chevilles des fixation - Systémes chimiques

Ta slovenski standard je istoveten z: CEN/TS 1992-4-5:2009

ICS:

21.060.01	Vezni elementi na splošno	Fasteners in general
91.080.40	Betonske konstrukcije	Concrete structures

SIST-TS CEN/TS 1992-4-5:2009 en

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN/TS 1992-4-5

May 2009

ICS 21.060.99; 91.080.40

English Version

Design of fastenings for use in concrete - Part 4-5: Post-installed fasteners - Chemical systems

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Bemessung von Befestigungen in Beton - Teil 4-5: Dübel - chemische Systeme

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Ref. No. CEN/TS 1992-4-5:2009: E

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Foreword

This Technical Specification (CEN/TS 1992-4-5:2009) has been prepared by Technical Committee CEN/TC 250 "Structural Eurocodes", the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This Technical Specification CEN/TS 1992-4-5 – Post-installed fasteners – Chemical systems, describes the principles and requirements for safety, serviceability and durability of post-installed fasteners with chemical anchorage systems for use in concrete.

This Technical Specification does not provide information about the use of National Determined Parameters (NDP).

CEN/TS 1992-4-5 is based on the limit state concept used in conjunction with a partial factor method.

CEN/TS 1992-4 'Design of fastenings for use in concrete' is subdivided into the following parts:

— *Part 1: General*

— *Part 2: Headed fasteners*

— *Part 3: Anchor channels*

— *Part 4: Post-installed fasteners –Mechanical systems*

— *Part 5: Post-installed fasteners – Chemical systems*

Connection to Part 1 of this Technical Specification TS

The principles and requirements of Part 5 of this CEN/TS are additional to those in Part 1, all the clauses and subclauses of which also apply to Part 5 unless varied in this Part. Additional information is presented under the relevant clauses/sub-clauses of Part 1 of the CEN/TS. The numbers for the clauses/sub-clauses of Part 5 continue from the number of the last relevant clauses/sub-clauses of Part 1.

The above principles also apply to Figures and Tables in Part 5.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, 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 the United Kingdom.

1 Scope

1.1 General

1.1.6 This document relies on characteristic resistances and distances which are stated in a European Technical Specification. In general the design concept is valid in the product dimensions $6 \leq h_{ef}/d_{nom} \leq 20$. The actual range for a particular fastener may be taken from the relevant European Technical Specification. In minimum the following characteristics should be given in the relevant European Technical Specification as base for the design method of this CEN/TS.

— $N_{Rk,s}$, $V_{Rk,s}$

— $M^0_{Rk,s}$

— τ_{Rk}

— $c_{cr,N}$, $s_{cr,N}$

— $c_{cr,sp}$, $s_{cr,sp}$

— c_{min}, s_{min}

— h_{min}

— limitations on concrete strength classes of base material

— k_{cr}, k_{ucr}, k_{τ}, k_2, k_3, k_4, k_8

— d_{nom}, h_{ef}, l_f , limitations on h_{ef}/d_{nom}

— γ_{Mi}, recommended partial factors see CEN/TS 1992-4-1:2009, clause 4

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.

NOTE The following references to Eurocodes are references to European Standards and European Prestandards. These are the only European documents available at the time of publication of this TS. National documents take precedence until Eurocodes are published as European Standards.

EN 1992-1-1, *Eurocode 2 — Design of concrete structures — Part 1-1: General rules and rules for buildings*

CEN/TS 1992-4-1:2009, *Design of fastenings for use in concrete — Part 4-1: General*

3 Definitions and symbols

Definitions and symbols are given in CEN/TS 1992-4-1.

4 Basis of design

4.1 General

4.5.4 The following assumptions in respect to installation have been made in this CEN/TS. The installation instructions should reflect them:

1) Concrete has been compacted adequately in the area of the fastening. This should be checked prior and during installation via visual check.

2) Requirements for drilling operation and bore hole:

  — Holes are drilled perpendicular to the surface of the concrete unless specifically required otherwise by the manufacturer's instructions.

  — Drilling is carried out by method specified by the manufacturer.

  — When hard metal hammer-drill bits are used, they should comply with ISO or National Standards.

  — When diamond core drilling is permitted, the diameter of the segments should comply with the prescribed diameter.

  — Reinforcement in close proximity to the hole position is not damaged during drilling. In prestressed concrete structures it is ensured that the distance between the drilling hole and the prestressed reinforcement is at least 50mm; for determination of the position of the prestressed reinforcement in the structure a suitable device e.g. a reinforcement detector is used.

  — Holes are cleaned according to the instructions given in the European Technical Specification.

  — Aborted drill holes are filled with high strength non-shrinkage mortar.

3) Inspection and approval of the correct installation of the fasteners is carried out by appropriately qualified personnel.

NOTE Many drill bits exhibit a mark indicating that they are in accordance with ISO or National Standards. If the drill bits do not bear a conformity mark, evidence of suitability should be provided.

5 Determination of action effects

The determination and analysis of the condition of the concrete – cracked or non-cracked - serving as base material for the fastener and of the loads acting on the fastener is given in CEN/TS 1992-4-1:2009, clause 5.

6 Verification of ultimate limit state by elastic analysis

6.1 General

6.1.5 This section applies when forces on the fasteners have been calculated using elastic analysis. CEN/TS 1992-4-1:2009, Annex B should be used for plastic analysis.

6.1.6 The spacing between outer post-installed fasteners of adjoining groups or the distance to single fasteners shall be $a > s_{cr,N}$.

6.1.7 Aborted drill holes filled with high strength non-shrinkage mortar do not have to be considered in the design of the fastenings.

6.2 Tension load

6.2.1 Required verifications

The required verifications are given in Table 1.

Table 1 — Verification for post-installed fasteners loaded in tension

		Single fastener	Fastener group[1)] most loaded fastener	Fastener group[1)] fastener group
1	**Steel failure**	$N_{Ed} \leq N_{Rd,s} = N_{Rk,s} / \gamma_{Ms}$	$N^{h}_{Ed} \leq N_{Rd,s} = N_{Rk,s} / \gamma_{Ms,s}$	
2	**Combined pull-out and concrete failure**	$N_{Ed} \leq N_{Rd,p} = N_{Rk,p} / \gamma_{Mp}$		$N^{g}_{Ed} \leq N_{Rd,p} = N_{Rk,p} / \gamma_{Mp}$
3	**Concrete cone failure**	$N_{Ed} \leq N_{Rd,c} = N_{Rk,c} / \gamma_{Mc}$		$N^{g}_{Ed} \leq N_{Rd,c} = N_{Rk,c} / \gamma_{Mc}$
4	**Splitting failure**	$N_{Ed} \leq N_{Rd,sp} = N_{Rk,sp} / \gamma_{Msp}$		$N^{g}_{Ed} \leq N_{Rd,sp} = N_{Rk,sp} / \gamma_{Msp}$

1) Verification is performed only for the fasteners of a group loaded in tension.

6.2.2 Steel failure

The characteristic resistance of a fastener in case of steel failure $N_{Rk,s}$ is given in the relevant European Technical Specification. The strength calculations are based on f_{uk}.

Combined pull-out and concrete failure

The characteristic resistance of a fastener, a group of fasteners and the tensioned fasteners of a group of fasteners in case of combined pull-out and concrete failure may be obtained by Equation (1).

$$N_{Rk,p} = N^{0}_{Rk,p} \cdot \frac{A_{p,N}}{A^{0}_{p,N}} \cdot \psi_{s,Np} \cdot \psi_{g,Np} \cdot \psi_{re,N} \cdot \psi_{ec,Np} \quad [N] \qquad (1)$$

The different factors of Equation (1) are given below.

NOTE This verification is necessary only in the case that $\tau_{Rk} < \tau_{Rk,max}$. τ_{Rk} , see Equation (2), and $\tau_{Rk,max}$, see Equation (8)

6.2.2.1 Basic resistance of a single fastener

The characteristic resistance of a single bonded fastener $N^{0}_{Rk,p}$ not influenced by adjacent bonded fasteners or edges of the concrete member is:

$$N^{0}_{Rk,p} = \tau_{Rk} \cdot \pi \cdot d \cdot h_{ef} \qquad (2)$$

with

τ_{Rk} [N/mm²] characteristic bond resistance, depending on the concrete strength class, values given for non-cracked ($\tau_{Rk,ucr}$) or cracked concrete ($\tau_{Rk,cr}$) in the corresponding European Technical Specification

d [mm] diameter of the anchor rod or outer diameter of internally threaded sleeves

h_{ef} [mm] embedment depth

6.2.2.2 Effect of axial spacing and edge distances

The geometric effect of axial spacing and edge distance on the characteristic resistance is taken into account by the value $A_{p,N} / A^0_{p,N}$, where

$$A^0_{p,N} := s_{cr,Np} \cdot s_{cr,Np}, \text{ reference bond influence area of an individual fastener} \quad (3)$$

$A_{p,N}$ actual bond influence area, limited by overlapping areas of adjacent fasteners ($s \leq s_{cr,Np}$) as well as by edges of the concrete member ($c \leq c_{cr,Np}$).

$$s_{cr,Np} = 7{,}3 \cdot d \cdot \sqrt{\tau_{Rk}} \leq 3h_{ef} \quad (4)$$

d [mm], τ_{Rk} [N/mm²], value for non-cracked concrete C20/25

$$c_{cr,Np} = s_{cr,Np}/2 \quad (5)$$

NOTE $A^0_{p,N}$ and $A_{p,N}$ are calculated similar to the reference projected area $A^0_{c,N}$ and the actual projected area $A_{c,N}$ in case of concrete cone failure (see Figures 1 and 2). However, then the values $s_{cr,N}$ and $c_{cr,N}$ are replaced by the values $s_{cr,Np}$ and $c_{cr,Np}$. The value $s_{cr,Np}$ calculated according Equ. (4) is valid for cracked and uncracked concrete.

6.2.2.3 Effect of closely spaced fasteners

The factor $\psi_{g,Np}$ takes account of a group effect, if the fasteners are closely spaced.

$$\psi_{g,Np} = \psi^0_{g,Np} - \left(\frac{s}{s_{cr,Np}}\right)^{0,5} \cdot \left(\psi^0_{g,Np} - 1\right) \geq 1 \quad [-] \quad (6)$$

with

$$\psi^0_{g,Np} = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,max}}\right)^{1,5} \geq 1 \quad (7)$$

n number of bonded anchors of a group [-]

τ_{Rk} [N/mm²] characteristic bond resistance, depending on the concrete strength class, values given for non-cracked ($\tau_{Rk,ucr}$) or cracked concrete ($\tau_{Rk,cr}$) in the corresponding European Technical Specification

$$\tau_{Rk,max} = \frac{k_8}{\pi \cdot d} \sqrt{h_{ef} \cdot f_{ck,cube}} \quad (8)$$

k_8 given in the relevant European Technical Specification for cracked and non-cracked concrete [-]

$f_{ck,cube}$ [N/mm²] characteristic cube strength of the concrete strength class but noting the limitations given in the relevant European Technical Specification.

s spacing [mm], in case of multiple spacings the mean value of the spacings should be used

$s_{cr,Np}$ characteristic spacing, see Equation (4)

NOTE According to current experience the value for k_8 is 7,2 for applications in cracked concrete and k_8 = 10,1 for applications in non-cracked concrete.

6.2.2.4 Effect of the disturbance of stresses in the concrete

The factor $\psi_{s,Np}$ takes account of the disturbance of the distribution of stresses in the concrete due to edges of the concrete member. For fastenings with several edge distances (e.g. fastening in a corner of the concrete member or in a narrow member), the smallest edge distance c shall be inserted in Equation (9).

$$\psi_{s,Np} = 0{,}7 + 0{,}3 \cdot \frac{c}{c_{cr,Np}} \leq 1 \quad [-] \tag{9}$$

6.2.2.5 Effect of shell spalling

The shell spalling factor $\psi_{re,N}$ takes account of the effect of a dense reinforcement for embedment depths h_{ef} < 100 mm:

$$\psi_{re,N} = 0{,}5 + \frac{h_{ef}}{200} \leq 1 \quad [-] \tag{10}$$

with: h_{ef} [mm]

Irrespective of the embedment depth of the fastener, $\psi_{re,N}$ may be taken as 1,0 in the following cases:

1) Reinforcement (any diameter) is provided at a spacing ≥ 150mm, or

2) Reinforcement with a diameter of 10 mm or less is provided at a spacing ≥ 100 mm.

6.2.2.6 Effect of the eccentricity of the load

The factor $\psi_{ec,Np}$ takes account of a group effect when different tension loads are acting on the individual fasteners of a group.

$$\psi_{ec,Np} = \frac{1}{1 + 2 \cdot e_N / s_{cr,Np}} \leq 1 \quad [-] \tag{11}$$

with: e_N: eccentricity of the resulting tensile load acting on the tensioned fasteners (see CEN/TC 1992-4-1:2009, 5.2).

Where there is an eccentricity in two directions, $\psi_{ec,Np}$ shall be determined separately for each direction and the product of both factors shall be inserted in Equation (1).

6.2.3 Concrete cone failure

The characteristic resistance of a single tensioned fastener and a group of tensioned fasteners in case of concrete cone failure may be obtained by Equation (12).

$$N_{Rk,c} = N^{o}_{Rk,c} \cdot \frac{A_{c,N}}{A^{o}_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \quad [N] \qquad (12)$$

The different factors of Equation (12) are given below.

6.2.3.1 Characteristic resistance of a single fastener

— **Cracked concrete:**

The characteristic resistance of a single fastener placed in cracked concrete and not influenced by adjacent fasteners or edges of the concrete member is obtained by:

$$N^{o}_{Rk,c} = k_{cr} \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad [N] \qquad (13)$$

where k_{cr} factor to take into account the influence of load transfer mechanisms for applications in cracked concrete, the actual value is given in the corresponding European Technical Specification.

$f_{ck,cube}$ [N/mm²] characteristic cube strength of the concrete strength class but noting the limitations given in the relevant European Technical Specification.

h_{ef} [mm] see CEN/TS 1992-4-1:2009, Figure 5, the actual value is given in the corresponding European Technical Specification.

NOTE For fasteners according to current experience the value is 7,2 or 8,5. The actual value for a particular fastener may be taken from the relevant European Technical Specification.

— **Non-cracked concrete:**

The characteristic resistance of a single fastener placed in non-cracked concrete and not influenced by adjacent fasteners or edges of the concrete member is obtained by:

$$N^{0}_{Rk,c} = k_{ucr} \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad [N] \qquad (14)$$

with k_{ucr} factor to take into account the influence of load transfer mechanisms for applications in non-cracked concrete, the actual value is given in the corresponding European Technical Specification.