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

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

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

Bemessung von Befestigungen in Beton - Teil 4-4: Mechanische Dübel

Conception-calcul des éléments de fixation pour béton - Partie 4-4 : Chevilles de fixation - Systèmes mécaniques

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21.060.01	Vezni elementi na splošno	Fasteners in general
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Bemessung von Befestigungen in Beton - Teil 4-4: Dübel - mechanische Systeme

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Foreword

This Technical Specification (CEN/TS 1992-4-4:2009) 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 1992-4-4 — Post-installed fasteners — Mechanical systems, describes the principles and requirements for safety, serviceability and durability of post-installed fasteners with mechanical anchorage systems for use in concrete. Furthermore bonded expansion anchors and bonded undercut anchors are covered.

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

CEN/TS 1992-4-4 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 4 of this CEN/TS are additional to those in Part 1, all the clauses and sub-clauses of which also apply to Part 4 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 4 continue from the number of the last relevant clauses/subclauses of Part 1.

The above principles also apply to Figures and Tables in Part 4.

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. The characteristic values shown in Table 1 should be obtained from the relevant European Technical Specification as base for the design methods of this CEN/TS.

Table 1 — Characteristics used for the design of fasteners given in the European Technical Specification

Characteristic	Design method		
	A	B	C
$N_{Rk,p}$, $N_{Rk,s}$, $V_{Rk,s}$	x		
$M^0_{Rk,s}$	x	x	x
F_{Rd}, uncracked concrete		x	x
F_{Rd}, cracked concrete[a)]		x	x
$c_{cr,N}$, $s_{cr,N}$	x		
$c_{cr,sp}$, $s_{cr,sp}$	x		
c_{cr}, s_{cr}		x	x
c_{min}, s_{min}	x	x	
h_{min}	x	x	x
limitations on concrete strength classes of base material	x	x	x
k_{cr}, k_{ucr}, k_2, k_3, k_4	x		
d_{nom}, h_{ef}, l_f	x		
γ_{Mi}[b)]	x	x	x

a) only for products suitable to applications in cracked and non-cracked concrete

b) recommended partial factors for material see also 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

4.5.4 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 holes 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.

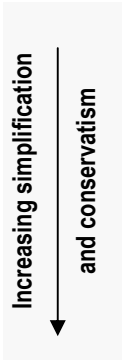
6 Verification of ultimate limit state by elastic analysis

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 For the design of post-installed fasteners in the ultimate limit state, there are three different design methods available.

The methods differ in the degree of simplification at the expense of conservatism:



Method A: Resistance is established for all load directions and all modes of failure, using actual values of edge distance c to the fasteners and spacing s between fasteners in a group.

Method B: A single value of resistance is used for all load directions and modes of failure. This resistance is related to the characteristic values c_{cr} and s_{cr}. It is permitted to use smaller values for c and s than these but the resistance should then be modified as indicated.

Method C: As method B but the values of c and s should not be less than c_{cr} and s_{cr}.

Each method has further options with regard to

a) use of fasteners in cracked and non-cracked or uncracked concrete; and

b) the concrete strength class for which the resistance is valid.

The above possibilities (assessment options) are summarized in Table 2 and described in detail in 6.2 to 6.4.

The design method to be applied is given in the relevant European Technical Specification.

With design method A technical data may be published also for design methods B or C and with method B also for design method C. But data for method C do not support method A or B and data for method B do not support design method A.

6.1.7 The spacing between outer fasteners of adjoining groups or the distance to single fasteners shall be $a > s_{cr,N}$ (design method A) or s_{cr} respectively (design methods B and C).

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

Table 2 — Assessment options for post-installed fasteners

Design method	Use for		F_{Rk}				c_{cr}	s_{cr}	c_{min}	s_{min}	Option No[2]
	cracked and non-cracked concrete	non-cracked concrete only	one F_{Rk} for C20/25 only	different F_{Rk} for C20/25 to C50/60	one F_{Rk} for all load directions	different F_{Rk} depending on load direction					
A	x[1]			x		x	x	x	x	x	1
	x		x			x	x	x	x	x	2
B	x			x	x		x	x	x	x	3
	x		x		x		x	x	x	x	4
C	x			x	x		x	x			5
	x		x		x		x	x			6
A		x		x		x	x	x	x	x	7
		x	x			x	x	x	x	x	8
B		x		x	x		x	x	x	x	9
		x	x		x		x	x	x	x	10
C		x		x	x		x	x			11
		x	x		x		x	x			12

[1] x applies to the design method [2] according to European Technical Specification

6.2 Design method A

6.2.1 Tension load

6.2.1.1 Required verifications

The required verifications are given in Table 3.

Table 3 — Verification for post-installed mechanical fasteners loaded in tension

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

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

6.2.1.2 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}.

6.2.1.3 Pull-out failure

The characteristic resistance in case of pull-out failure $N_{Rk,p}$ is given in the relevant European Technical Specification.

6.2.1.4 Concrete cone failure

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

$$N_{Rk,c} = N^{o}_{Rk,c} \cdot \frac{A_{c,N}}{A^{o}_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \quad [N] \tag{1}$$

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

a) Characteristic resistance of a single fastener

1) 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:

$$N^{o}_{Rk,c} = k_{cr} \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad [N] \tag{2}$$

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/mm^2], 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.

2) 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:

$$N^{o}_{Rk,c} = k_{ucr} \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \quad [N] \tag{3}$$

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.

b) Geometric effect of axial spacings and edge distances

The geometric effect of axial spacings and edge distances on the characteristic resistance is taken into account by the value:

$$A_{c,N} / A^{0}_{c,N}$$

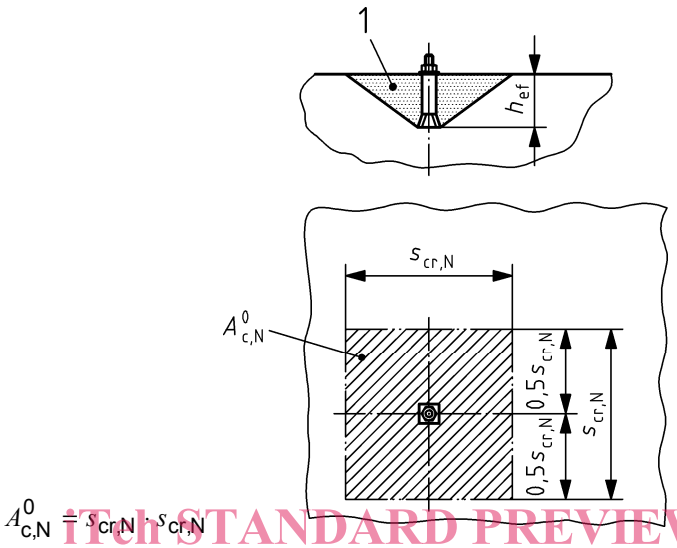
where $A^{0}_{c,N}$: = reference projected area, see Figure 1

$$= s_{cr,N} \cdot s_{cr,N} \quad (4)$$

$A_{c,N}$ actual area, limited by overlapping concrete cones of adjacent fasteners ($s \leq s_{cr,N}$) as well as by edges of the concrete member ($c \leq c_{cr,N}$). Examples for the calculation of $A_{c,N}$ are given in Figure 2.

$s_{cr,N}$, $c_{cr,N}$ given in the corresponding European Technical Specification

NOTE For post-installed fasteners according to current experience $s_{cr,N} = 2c_{cr,N} = 3h_{ef}$.



Key

1 Idealised concrete break-out body

Figure 1 — Idealised concrete cone and area $A^0_{c,N}$ of concrete cone of an individual fastener

c) Effect of the disturbance of the distribution of stresses in the concrete due to edges

The factor $\psi_{s,N}$ 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 (5).

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{c}{c_{cr,N}} \leq 1 \quad [-] \quad (5)$$

d) 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:

$$\psi_{re,N} = 0,5 + \frac{h_{ef}}{200} \leq 1 \quad [-] \quad (6)$$

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.