

Design of fastenings for use in concrete

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

ICS 21.060.99; 91.080.40

National foreword

This Draft for Development is the UK implementation of CEN/TS 1992-4-4:2009.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than 3 years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of Update Standards.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee B/525/2, Structural use of concrete.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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English Version

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

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

Bemessung von Befestigungen in Beton - Teil 4-4: Dübel -
mechanische Systeme

This Technical Specification (CEN/TS) was approved by CEN on 20 October 2008 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

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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		
$M_{Rk,s}^0$	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:

Increasing simplification ↓ and 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 method²⁾ 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	$N_{Ed} \leq N_{Rd,s} = N_{Rk,s} / \gamma_{Ms}$	$N_{Ed}^h \leq N_{Rd,s} = N_{Rk,s} / \gamma_{Ms,s}$	
2	Pull-out	$N_{Ed} \leq N_{Rd,p} = N_{Rk,p} / \gamma_{Mp}$	$N_{Ed}^h \leq N_{Rd,p} = N_{Rk,p} / \gamma_{Mp}$	
3	Concrete cone failure	$N_{Ed} \leq N_{Rd,c} = N_{Rk,c} / \gamma_{Mc}$		$N_{Ed}^g \leq N_{Rd,c} = N_{Rk,c} / \gamma_{Mc}$
4	Splitting failure	$N_{Ed} \leq N_{Rd,sp} = N_{Rk,sp} / \gamma_{Msp}$		$N_{Ed}^g \leq N_{Rd,sp} = N_{Rk,sp} / \gamma_{Msp}$

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

6.2.1.2 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} .