TECHNICAL REPORT

Design of anchor channels in addition to EN 1992-4

TR 047

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EUROPEAN ORGANISATION FOR TECHNICAL ASSESSMENT
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Contents

1 SCOPE OF THE TR

This Technical Report (TR) contains information for the design of anchor channels in addition to EN 1992-4:2018 [1].

This Technical Report is only applicable for anchor channels that hold European Technical Assessments (ETAs) based on EAD 330008-04-0601 [3].

2 SPECIFIC TERMS/SYMBOLS USED IN THIS TR

2.1 Notation

$N^{a}_{Ed,eq}$ = Design value of seismic tension load acting on an anchor of an anchor channel

$N^{cb}_{Ed,eq}$ = Design value of seismic tension load acting on a channel bolt

$M^{ch}_{Ed,eq}$ = Design value of bending moment acting on the anchor channel due to seismic tension loads $N^{cb}_{Ed,eq}$

$N^{a}_{Ed,re,eq}$ = Design value of seismic tension load acting on the supplementary reinforcement of one anchor of the anchor channel

$V^{a}_{Ed,y,eq}$ = Design value of seismic shear load acting on an anchor of an anchor channel perpendicular to the longitudinal channel axis

$V^{cb}_{Ed,y,eq}$ = Design value of seismic shear load acting on a channel bolt perpendicular to the longitudinal channel axis

$V^{a}_{Ed,x,eq}$ = Design value of seismic shear load acting on an anchor of an anchor channel in the direction of the longitudinal channel axis

$V^{cb}_{Ed,x,eq}$ = Design value of seismic shear load acting on a channel bolt in the direction of the longitudinal channel axis

$N_{Rd,s,a,eq}$ = Design resistance to steel failure of anchors under seismic tension load (seismic performance category C1)

$N_{Rd,s,c,eq}$ = Design resistance to steel failure of the connection between anchors and channel under seismic tension load (seismic performance category C1)

$N_{Rd,s,l,eq}$ = Design resistance to steel failure of channel lips and subsequently pull-out of channel bolt under seismic tension load (seismic performance category C1)

$N_{Rd,s,eq}$ = Design resistance to steel failure of channel bolt under seismic tension load (seismic performance category C1)

$M_{Rd,s,flex,eq}$ = Design flexural resistance of channel under seismic tension loads

$V_{Rd,s,eq}$ = Design value of resistance to steel failure of channel bolt under seismic shear load (seismic performance category C1)

$V_{Rd,s,a,y,eq}$ = Design value of resistance to steel failure of anchors under seismic shear load perpendicular to longitudinal channel axis (seismic performance category C1)

$V_{Rd,s,c,y,eq}$ = Design resistance to steel failure of the connection between anchors and channel under seismic shear load perpendicular to longitudinal channel axis (seismic performance category C1)

$V_{Rd,s,l,y,eq}$ = Design resistance to steel failure of channel lips and subsequently pull-out of channel bolt under seismic shear load perpendicular to longitudinal channel axis (seismic performance category C1)

$V_{Rd,s,a,x,eq}$	=	Design value of resistance to steel failure of anchors under seismic shear load in the direction of the longitudinal channel axis (seismic performance category C1)
$V_{Rd,s,c,x,eq}$	=	Design resistance to steel failure of the connection between anchors and channel under seismic shear load in the direction of longitudinal channel axis (seismic performance category C1)
$V_{Rd,s,l,x,eq}$	=	Design resistance to steel failure of the connection between channel bolt and channel lips under seismic shear load in the direction of longitudinal channel axis (seismic performance category C1)

3 DESIGN AND SAFETY CONCEPT

3.1 General

Anchor channels are designed according EN 1992-4 [1] and CEN/TR 17080 [2] with additional information for the design of anchor channels under static and quasi-static loads and under seismic actions according to this TR.

Sections of EN 1992-4 [1] which are amended by this TR are given below in front of those passages.

3.2 Design under static and quasi-static loads

CEN/TR 17080, Section 7.2.2.4.2 referenced to EN 1992-4, Section 7.2.2.5 (5) "Concrete edge failure"

For I-shaped anchors the value of d_{nom} may be taken as a function of the web thickness t_w and width (cutting length) w_A:

$$d_{nom} = \sqrt[4]{\frac{w_A \cdot t_w^3}{12} \cdot \frac{64}{\pi}}$$

Section 7.4.2.5 (7) referenced to 7.2.2.5 (13) "Concrete edge failure":

Value $\psi_{re,V}$ = 1,2 may be used for anchor channels in cracked concrete with edge reinforcement ($d_s \geq$ 12 mm).

In case of presence of edge reinforcement for applications in cracked concrete a factor $\psi_{re,V} > 1$ shall only be used, if the height of the channel is $h_{ch} \leq$ 40 mm.

3.3 Design under seismic actions

Section 1.4 "Fastener loading" (1):

Anchor channels subjected to seismic loading are covered by this TR, Section 3.3.

Section 1.6 "Concrete member loading":

The section concerning prequalification applies to anchor channels as well:

This design method applies to the design of anchor channels which fulfill the requirements of EAD 330008-04 [3]. Anchor channels shall be qualified according to EAD 330008-04 [3] for use in cracked concrete under seismic actions. The characteristic resistances of the anchor channel are given in the relevant ETA.

The design of anchor channels for seismic performance category C2 is not covered.

Section 9.1 "Verification for seismic loading/ General" (1):

This Clause provides requirements for the design of anchor channels used to transmit seismic actions by means of tension, shear (perpendicular and longitudinal), or a combination of tension and shear loads between connected structural elements or between non-structural attachments and structural elements.

Section 9.1 "Verification for seismic loading/ General" (5):

This section concerning stand-off installation or with grout layer ≥ 0.5 d applies to anchor channels as well.

Section 9.2 "Requirements" (3):

In the design of anchor channels option a2) of EN 1992-4 [1] may only be satisfied. Therefore, those Sections for option a1) and b) do not apply.

Section 9.3 (2) "Derivation of forces acting on fastener":

Distribution of forces of channel bolts to the anchor shall be analogue to Section 6.3.1 (2) considering the channel as a chain of simply supported single span beams between the anchors.

ANNEX C.1 "Design of fastenings under seismic actions/ General":

This section concerning transmission of seismic actions and type of connections applies to anchor channels as well.

ANNEX C.5 "Resistance" (2)

For the verification of concrete failure modes, the reduction factor α_{eq} shall be taken as 1,0 for anchor channels, except for anchorage failure of supplementary reinforcement (α_{eq} = 0,85).

ANNEX C.5 "Resistance" (3)

For the seismic design situation, the following verifications shall be performed for the anchor channel with:

$N_{Rk,s,a,eq}$, $N_{Rk,s,c,eq}$, $N^0_{Rk,s,l,eq}$, $N_{Rk,s,eq}$, $M_{Rk,s,flex,eq}$, $V_{Rk,s,eq}$, $V_{Rk,s,a,y,eq}$, $V_{Rk,s,c,y,eq}$, $V^0_{Rk,s,l,y,eq}$, $V_{Rk,s,a,x,eq}$, $V_{Rk,s,c,x,eq}$, $V_{Rk,s,l,x,eq}$ shall be taken from the relevant ETA and

$N_{Rd,p}$, $N_{Rd,c}$, $N_{Rd,sp}$, $N_{Rd,cb}$, $N_{Rd,re}$, $N_{Rd,a}$, $V_{Rd,cp}$, $V_{Rd,c}$, $V_{Rd,c,x}$, and $\psi_{l,N}$, $\psi_{l,V}$ according to EN 1992-4, Section 7 and CEN/TR 17080 [2] and

$\gamma_{M,eq} = \gamma_M$ for every failure mode according EN 1992-4, Section 4.4.2.2 (2).

Table 3.1: Required verifications for the most unfavorable anchor or channel bolt in tension

	failure mode		**most unfavorable anchor or channel bolt**
1	steel failure	anchor	$N^a_{Ed,eq} \leq N_{Rd,s,a,eq} = \frac{N_{Rk,s,a,eq}}{\gamma_{Ms}}$
2		connection anchor/ channel	$N^a_{Ed,eq} \leq N_{Rd,s,c,eq} = \frac{N_{Rk,s,c,eq}}{\gamma_{Ms,ca}}$
3		local flexure of channel lips	$N^{cb}_{Ed,eq} \leq N_{Rd,s,l,eq} = \frac{N^0{}_{Rk,s,l,eq} \cdot \psi_{l,N}}{\gamma_{Ms,l}}$
4		channel bolt	$N^{cb}_{Ed,eq} \leq N_{Rd,s,eq} = \frac{N_{Rk,s,eq}}{\gamma_{Ms}}$
5	concrete failure	pull-out	$N^a_{Ed,eq} \leq N_{Rd,p}$
6		concrete cone	$N^a_{Ed,eq} \leq N_{Rd,c}$
7		concrete splitting	$N^a_{Ed,eq} \leq N_{Rd,sp}$
8		concrete blow-out	$N^a_{Ed,eq} \leq N_{Rd,cb}$
9	supplementary reinforcement	steel failure	$N^a_{Ed,re,eq} \leq N_{Rd,re}$
10		anchorage failure	$N^a_{Ed,re,eq} \leq N_{Rd,a}$

Table 3.2: Required verifications for the channel profile in tension

	failure mode		Channel profile
1	steel failure	flexure of channel	$M_{Ed,eq}^{ch} \leq M_{Rd,s,flex,eq} = \frac{M_{Rk,s,flex,eq}}{\gamma_{Ms,flex}}$

Table 3.3: Required verifications for the most unfavorable anchor or channel bolt in shear perpendicular to the longitudinal channel axis

	failure mode		most unfavorable anchor or channel bolt
1	steel failure	channel bolt	$V_{Ed,eq}^{cb} \leq V_{Rd,s,eq} = \frac{V_{Rk,s,eq}}{\gamma_{Ms}}$
2		anchor	$V_{Ed,y,eq}^{a} \leq V_{Rd,s,a,y,eq} = \frac{V_{Rk,s,a,y,eq}}{\gamma_{Ms}}$
3		connection anchor/channel	$V_{Ed,y,eq}^{a} \leq V_{Rd,s,c,y,eq} = \frac{V_{Rk,s,c,y,eq}}{\gamma_{Ms,ca}}$
4		local flexure of channel lips	$V_{Ed,y,eq}^{cb} \leq V_{Rd,s,l,y,eq} = \frac{V^{0}{}_{Rk,s,l,y,eq} \cdot \psi_{l,V}}{\gamma_{Ms,l}}$
5	concrete failure	pry-out	$V_{Ed,y,eq}^{a} \leq V_{Rd,cp}$
6		concrete edge	$V_{Ed,y,eq}^{a} \leq V_{Rd,c}$
7	supplementary reinforcement	steel failure	$N_{Ed,re,eq}^{a} \leq N_{Rd,re}$
8		anchorage failure	$N_{Ed,re,eq}^{a} \leq N_{Rd,a}$

Table 3.4: Required verifications for the most unfavorable anchor or channel bolt in shear in the direction of the longitudinal channel axis

	failure mode		most unfavorable anchor or channel bolt
1	steel failure	anchor	$V_{Ed,x,eq}^{a} \leq V_{Rd,s,a,x,eq} = \frac{V_{Rk,s,a,x,eq}}{\gamma_{Ms}}$
2		connection anchor/ channel	$V_{Ed,x,eq}^{a} \leq V_{Rd,s,c,x,eq} = \frac{V_{Rk,s,c,x,eq}}{\gamma_{Ms,ca}}$
3		connection channel bolt/ channel lips	$V_{Ed,x,eq}^{cb} \leq V_{Rd,s,l,x,eq} = \frac{V_{Rk,s,l,x,eq}}{\gamma_{Ms,l}}$
4	concrete failure	pry-out	$V_{Ed,x,eq}^{a} \leq V_{Rd,cp}$
5		concrete edge	$V_{Ed,x,eq}^{a} \leq V_{Rd,c,x}$
6	supplementary reinforcement	steel failure	$N_{Ed,re,eq}^{a} \leq N_{Rd,re}$
7		anchorage failure	$N_{Ed,re,eq}^{a} \leq N_{Rd,a}$

For the verification of combined loading the following formula shall be used instead of (C.9):

$$\left(\frac{N_{Ed}}{N_{Rd,i,eq}}\right) + \left(\frac{V_{Ed,y}}{V_{Rd,y,i,eq}}\right) + \left(\frac{V_{Ed,x}}{V_{Rd,x,i,eq}}\right) \leq 1.0$$

for all failure modes and for most unfavourable anchor or channel bolt.

4 REFERENCE DOCUMENTS

[1]	EN 1992-4:2018	Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete
[2]	CEN/TR 17080:2018	Design of fastenings for use in concrete - Anchor channels - Supplementary rules
[3]	EAD 330008-04-0601	Anchor channels