EOTA®

TECHNICAL REPORT

Design of mounting channels

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1 INTRODUCTION

This Technical Report contains a design method for mounting channels which have been subject to an European Technical Assessment (ETA) in accordance with EAD 330667-01-0602 [1].

2 SCOPE

2.1 General

This Technical Report provides a design method for mounting channels (connection between structural elements and attachment of non-structural elements to structural components).

This Technical Report is intended for safety related applications in which the failure of mounting channels may result in collapse or partial collapse of the structure, cause risk to human life or lead to significant economic loss. In this context it also covers non-structural elements.

The design rules in this Technical Report are only valid for mounting channels with an European Technical Assessment (ETA) in accordance with EAD 330667-01-0602 [1].

This Technical Report provides rules for the design of mounting channels for the following cases:

- the design of mounting channels subject to static, quasi static tension forces
- the design of mounting channels subject to static or quasi static shear forces acting perpendicular to the longitudinal direction of the channel
- the design of mounting channels subject to static or quasi static shear force acting in the longitudinal direction of the channel;
- the design for the combined static or quasi static action of longitudinal shear, perpendicular shear and tension load acting on the mounting channel.

> *NOTE The proposed design method for combined action of longitudinal shear, perpendicular shear and tension load acting on the mounting channel can be realized only if the relevant parameters as specified in this Technical Report, e.g. characteristic resistances and product dependent partial factors are given in an European Technical Assessment (ETA).*

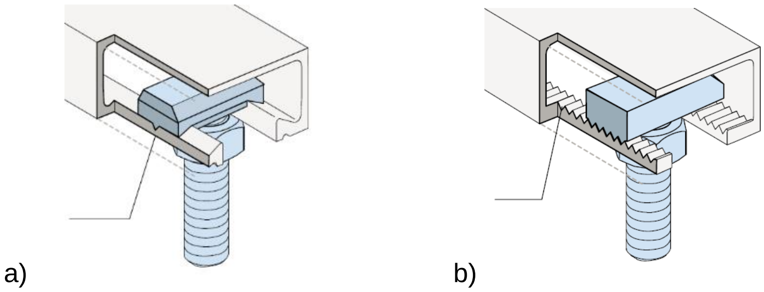
In the case of post-installed mounting channel installed on concrete substructure, the transfer of the loads applied to the mounting channel to the concrete support shall be shown for both, ultimate limit state and serviceability limit state according to EN 1992-4 [2]. For the dimensioning of the anchors in the concrete, the load distribution in the anchor channel is to be assumed as a beam on 2 supports; a continuous effect of the channel must not be assumed.

In the case of welded mounting channel installed on steel substructure, the transfer of the loads applied to the mounting channel to the steel support shall be shown for both, ultimate limit state and serviceability limit state according to EN 1993-1-1 [6].

Mounting channels are produced from steel with at least two fixing points fillet welded to the back of the channel. A fixture is connected to the mounting channel by channel bolts with nut and washer.

Special design provisions apply for mounting channels for shear loads acting in direction of the longitudinal axis of the channel. These special design provisions apply for mounting channels where the shear load in the longitudinal axis of the channel. is transferred to the channel by corresponding locking channel bolts creating mechanical interlock by means of a notch in the channel lips or serrated channel bolts which interlock with serrated lips of the channel (Figure 1.1).

Examples of mounting channels and channel bolts ensuring mechanical interlock are given in Figure 1.1.



a) notching channel bolt creating a notch in the channel

b) channel with serrated lips and matching serrated channel bolt

Figure 1.1: Mounting channels with mechanical interlock – Examples

This Technical Report does not cover the design of the fixture. The design of the fixture shall be carried out to comply with the appropriate standards and fulfill the requirements on the fixture as given in this Technical Report.

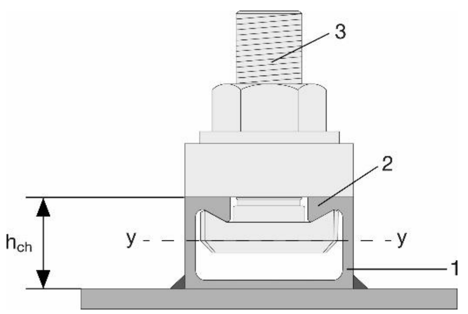
This document relies on characteristic resistances and distances which are stated in an ETA according to EAD 330667-01-0602 [1].and referred to in this Technical Report.

The length, spacing and thickness of the welding seams shall be calculated according to EN 1993-1-8 [6]. The minimum weld length and width has to be provided by the manufacturer and needs to be taken from the ETA.

2.2 Type, dimensions and materials of mounting channels

This Technical Report applies to mounting channels with rigid connections (e.g. welded, separately anchored) between the substructure and the channel.

This Technical Report covers mounting channels made of either carbon steel or stainless steel. The surface of the steel may be coated or uncoated. This Technical Report is valid for mounting channels with a nominal steel tensile strength f_{uk} ≤ 1000 N/mm². An example of mounting channels is given in Figure 2.1.



Key

1 channel
2 channel lip
3 channel bolt

Figure 2.1 Definitions for mounting channels

2.3 Mounting channel loading

Loading on the mounting channel covered by this document may be static and quasi-static. The loading on the mounting channel resulting from the actions on the fixture will generally be axial tension and/or shear (acting in the longitudinal direction and/or perpendicular to the longitudinal direction), see Figure 2.2. A shear force applied with a lever arm will result in a bending moment on the channel bolt and the channel. Any axial compression on the fixture should be transmitted to the substructure via contact between the fixture and the mounting channel.

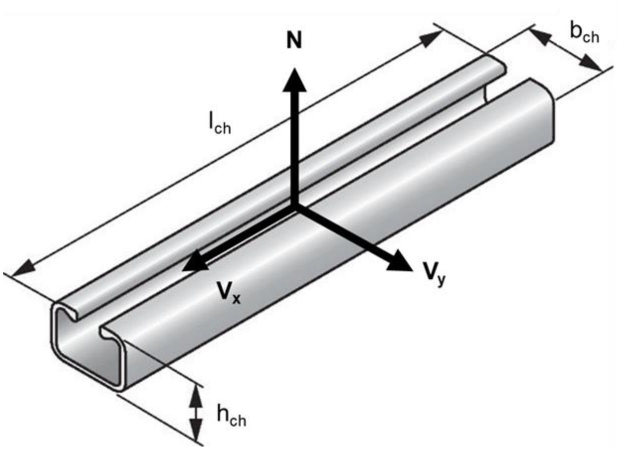


Figure 2.2 Load directions

Loading scenarios such as fatigue, impact and seismic loads as well as design under fire exposure are not covered.

3 NOTATIONS AND DEFINITIONS

3.1 Indices

E	action effects
L	load
M	material
N	normal force
R	resistance, restraint
V	shear force
adm	admissible
cbo	channel bolt
ch	channel
ef	effective
fix	fixture
flex	bending
ind	indirect
k	characteristic value
l	local
max	maximum
min	minimum
nom	nominal
s	steel
u	ultimate
y	yield

3.2 Superscripts

0	basic value
cb	channel bolt
ch	mounting channel

3.3 Actions and resistances

γ	partial factor
z	height of the non-structural element above the level of application of the seismic action
Cd	nominal value, e.g. limiting displacement
E	effect of action
R	resistance
F	force in general
N	axial force (positive = tension force, negative = compression force)
N_{Ed}	resultant design tension force
V	shear force
M	moment
$F_{Rk}(N_{Rk}\ ;\ V_{Rk})$	characteristic value of resistance (axial force, shear force)
$F_{Rd}(N_{Rd}\ ;\ V_{Rd})$	design value of resistance (axial force, shear force)
$F_{Ek}\ (N_{Ek};\ V_{Ek};\ M_{Ek})$	characteristic value of actions acting on the fixture (axial load, shear load, bending moment, torsion moment)
$F_{Ed}\ (N_{Ed};\ V_{Ed};\ M_{Ed})$	design value of actions acting on the channel bolt (axial load, shear load, bending moment)

N_{Ed}^{cb}	design tension force acting on the channel bolt
N_{Ed}^{ch}	design tension force acting on the channel
$N_{Rd,i}$	design tension resistance for a certain failure mode
$N_{Rd,s}$	design tension resistance for steel failure modes, in general
$N_{Rd,s,cb}$	design tension steel resistance of the channel bolt
$N_{Rd,s,l}$	design tension steel resistance of the channel lip and mechanical interlock
$V_{Ed,x}^{cb}$	design shear force acting on the channel bolt in direction of the channel axis
$V_{Ed,y}^{cb}$	design shear force acting on the channel bolt perpendicular to the channel axis
$V_{Rd,s}$	design shear resistance for steel failure modes, in general
$V_{Rk,s,l,x}$	characteristic steel resistance of the local flexure of the channel in x-direction
$V_{Rk,s,l,y}$	characteristic steel resistance of the local flexure of the channel in y-direction
$V_{Rd,s,l,x}$	design steel resistance of the local flexure of the channel in x-direction
$V_{Rd,s,l,y}$	design steel resistance of the local flexure of the channel in y-direction
$V_{Rk,s,M}$	characteristic steel shear resistance for shear force with lever arm
$V_{Rd,s,M}$	design steel shear resistance for shear force with lever arm
$s_{l,N}$	characteristic spacing for channel lip failure under tension
$s_{l,V}$	characteristic spacing for channel lip failure under shear
s_{cbo}	spacing of channel bolts
$A_{s,cb}$	stressed cross section area of the channel bolt
$f_{uk,cb}$	nominal ultimate steel strength of the channel bolt
$\gamma_{Ms,l,x}$	partial factor for steel failure of the channel lips in x-direction

3.4 Steel

f_{yk}	nominal characteristic steel yield strength
f_{uk}	nominal characteristic steel ultimate tensile strength
I_y	moment of inertia of the channel relative to the y-axis of the channel (Figure 2.1)

3.5 Definitions

attached element

structural or non-structural component that is connected to the attachment

attachment, fixture

assembly that transmits loads to the mounting channel

bending

bending effect induced by a shear load applied with a lever arm with respect to the surface of the substructure

channel bolt

bolt which connects the element to be fixed to the mounting channel (Figure 2.1)

characteristic resistance

5 % fractile of the resistance (value with a 95 % probability of being exceeded, with a confidence level of 90 %)

combined tension and shear loads

tension and shear load applied simultaneously

direction x

direction in the longitudinal axis of the channel

direction y

direction perpendicular to the longitudinal axis of the channel

direction z

direction of the axis of the bolt, perpendicular to the surface of the substructure

displacement

movement of a channel bolt or the mounting channel relative to the substructure in the direction of the axis of the bolt in case of tension and perpendicular to this axis or in longitudinal direction in case of shear.

European Technical Assessment (ETA)

document containing performance characteristics for mounting channels based on an European Assessment Document (EAD)

flexure

bending effect in the channel of a mounting channel induced by a tension load

locking channel bolt

channel bolt interlocking with serrated channels by means of matching serrations (Figure 1b).

mounting channel

steel profile (see Figure 2.1)

notching channel bolt

channel bolt creating a notch in the channel lip to transfer a shear load by mechanical interlock in the longitudinal axis of the channel (Figure 1a).

serrated channel

mounting channel with special serrations formed into the lips of the channel. The channel bolts used to fix to this channel have matching serrations (Figure 1b).

shear load

load acting parallel to the substructure and perpendicular with respect to the longitudinal axis of the channel

spacing

distance between center lines of channel bolts

steel failure

failure mode characterized by fracture of the steel elements of mounting channels: channel bolt or flexure of the channel lip or channel itself

substructure

base material to which the mounting channel is installed to

tension load

load applied perpendicular to the surface of the substructure

3.6 Units

In this Technical Report SI-units are used. Unless stated otherwise in the equations, the following units are used: Dimensions are given in mm, cross sections in mm^2, section modulus in mm^3, moment of inertia in mm^4, forces and loads in N and stresses, strengths and module of elasticity in N/mm^2.

4 DESIGN AND SAFETY CONCEPT

4.1 General

The design procedure is applicable to mounting channels assessed as per EAD 33-0667-01-06.02 [1], and having a valid ETA.

Mounting channels shall resist all actions and influences likely to occur during execution and use with the level of required reliability (ultimate limit state). Deformation to an inadmissible degree (serviceability limit state) shall be avoided and the mounting channels shall remain fit for the use for which they are required (durability). They shall not be damaged by accidental events to an extent disproportional to the original cause.

The design of mounting channels shall be in accordance with the same principles and requirements valid for structures given in EN 1990 [3] (including load combinations).

The design working life of the mounting channels shall meet that of the fixture. The partial factors for resistance and durability in this Technical Report are based on a design working life of 50 years for the mounting channel. Actions shall be determined based on the relevant parts of EN 1991 [4].

A safe transfer of loads to the supports of the member shall be ensured. For the design and execution of mounting channels the same quality requirements are valid as for the design and execution of structures and the attachment:

- The design of the mounting channels shall be performed by qualified personnel;
- The installation shall comply with the requirements stated in Section 4.5.

In the ultimate limit state (ULS), verifications are required for all appropriate load directions and all relevant failure modes. In the serviceability limit state (SLS), the displacements caused by the applied actions shall not be larger than the admissible displacement.

The material of the mounting channels, including channel bolts, and the corrosion protection shall be selected and demonstrated taking into account the environmental conditions at the place of installation, and whether the mounting channels are inspectable and maintainable.

The channel shall have an adequate fire resistance where required. In this document it is assumed that the fire resistance of the fixture is adequate.

4.2 Design format

At Ultimate Limite State (ULS) the value of the design action E_d shall not exceed the value of the design resistance R_d.

$$E_d \leq R_d \qquad (4.1)$$

where

E_d = value of design action;

R_d = value of design resistance.

The design resistance shall be calculated as follows:

$$R_d = R_k / \gamma_M \qquad (4.2)$$

where

R_k = characteristic resistance of a mounting channel;

γ_M = partial safety factor for material

The forces in the mounting channel shall be derived using appropriate combinations of actions on the fixture in accordance with EN 1990 [3].

In general actions on the fixture may be calculated ignoring the displacement of the mounting channels. However, the effect of displacement of the mounting channels should be considered when a statically indeterminate stiff element is attached.

At Service Limite State (SLS) the following criteria shall be met:

$$E_d \leq C_d \tag{4.3}$$

where the displacement of the mounting channel, E_d, shall be determined based on the information provided in the relevant ETA.

4.3 Verification by the partial factor method

4.3.1 Partial factors for actions

4.3.1.1 General

Partial factors shall be in accordance with EN 1990 [3]. The partial factor γ_{ind} shall be applied for the verification of indirect actions.

> Note: The value of γ_{ind} for use in a country may be found in its National *Annex to EN 1990 [3]. The recommended values for ULS is γ_{ind} = 1,0 for all failure modes.*

4.3.1.2 Special factor for transfer of shear loads acting in the direction of the longitudinal axis

The transfer of shear loads acting in the direction of the longitudinal axis of the channel by mechanical interlock from the channel bolt to the channel is more sensitive to installation than in the cases of tension and perpendicular shear loading. For this reason, an additional factor is incorporated in the partial factor for material as follows

$$\gamma_{Ms,l,x} = \gamma_{inst} \cdot \gamma_{Ms,l} \tag{4.4}$$

where

γ_{inst} product dependent factor to account for sensitivity to installation, given in the relevant ETA.

Mounting channels should provide safe and effective resistance to load. This is ensured by considering the effect of installation conditions on the design resistance via the factor γ_{inst}. For mounting channels that have been qualified to resist shear loads in the longitudinal direction, the value of the factor γ_{inst} which takes into account the sensitivity of the mounting channel to installation to be applied to the verification of the channel lip and mechanical interlock between channel lip and notching channel bolt (Figure 1a) or serrated channel lip and matching locking channel bolt (Figure 1b) depends mainly on the conversion of torque to tension force on the channel bolt. The relationship between torque and tension force can vary considerably for different products.

The factor γ_{inst} is determined as part of the prequalification of the mounting channel. It is product dependent. The value of γ_{inst} should not be altered. For the ideal case of mounting channels completely insensitive to installation γ_{inst} is 1,0. For mounting channels that show sensitivity to the quality of the installation, the value of γ_{inst} is higher.

4.3.2 Partial factors for resistances – Ultimate limit states

Partial factors under static and quasi-static loading shall be applied to characteristic resistances.

Note: In absence of national regulations the recommended values of partial factors are given in Table 4.1.

Table 4.1 Recommended values of partial factors

Failure modes		**Partial factor**	
		Permanent and transient design situations	**Accidental design situations**
Steel failure – mounting channels			
Tension in channel bolts	γ_{Ms}	$= 1{,}2 \cdot f_{uk}/f_{yk} \geq 1{,}4$	$= 1{,}05 \cdot f_{uk}/f_{yk} \geq 1{,}25$
Shear with and without lever arm in channel bolts	γ_{Ms}	$= 1{,}0 \cdot f_{uk}/f_{yk} \geq 1{,}25$ for $f_{uk} \leq 800$ N/mm² <u>and</u> $f_{yk}/f_{uk} \leq 0{,}8$ $= 1{,}5$ for $f_{uk} > 800$ N/mm² <u>or</u> $f_{yk}/f_{uk} > 0{,}8$	$= 1{,}0 \cdot f_{uk}/f_{yk} \geq 1{,}25$ for $f_{uk} \leq 800$ N/mm² <u>and</u> $f_{yk}/f_{uk} \leq 0{,}8$ $= 1{,}3$ for $f_{uk} > 800$ N/mm² <u>or</u> $f_{yk}/f_{uk} > 0{,}8$
Local failure of mounting channel by bending of lips in tension and shear	$\gamma_{Ms,l}$	= 1,8	= 1,6
Bending of channel	$\gamma_{Ms,flex}$	= 1,15	= 1,00

4.3.3 Partial factors for resistances – Serviceability limit state

The partial factor for resistance γ_M shall be applied to characteristic resistances.

Note: The value of the partial factor for serviceability limit state for use in a country may be found in its National Annex to EN 1990 [3]. The recommended value for the partial factor is $\gamma_M = 1{,}0$.

4.4 Project specification

The project specification shall typically include the following:

a) Environmental exposure used for the design (EN 1990 [3])

b) A note indicating that the number, manufacturer, type and geometry of mounting channel or channel bolts shall not be changed unless verified and approved by the responsible designer.

c) Construction drawings or supplementary design documents should include:
- location of the mounting channels in the structure, including tolerances;
- length, spacing and thickness of the welding seams calculated according to EN 1993 [6].
- number and type of mounting channels and channel bolts;
- spacing of the mounting channels including tolerances (typically specified with positive tolerances only);
- thickness of fixture and diameter of the clearance holes (if applicable);
- (special) installation instructions (if applicable). These shall not be in contradiction with the manufacturer's installation instructions.

d) Reference to the manufacturer's installation instructions.

4.5 Installation of mounting channels

The mounting channels are either fillet welded (fully or partially) directly to a steel substructure or fillet welded to steel plates and are then post-installed into the concrete.

For the welding of the mounting channels to the substructure the installer shall possess the corresponding recognition for the intended welding process.

For the attachment of the mounting channels by means of post-installed fasteners into the concrete, the anchorages shall be designed under the responsibility of an engineer experienced in anchorages and concrete work. The anchor installation shall be carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.

5 DURABILITY

Mounting channels and fixtures shall be chosen to have adequate durability taking into account the environmental conditions for the structure (such as exposure classes) as given in EN 1992-4 and EN 1993-1-4.

Note: Product specific information might be stated in the relevant ETA. Additional general information may be available on a national level.

6 FORCES ACTING ON MOUNTING CHANNELS - ANALYSIS

6.1 General

The actions acting on a fixture shall be transferred to the mounting channels as statically equivalent tension and shear forces.

Friction forces are neglected in the design of mounting channels.

6.2 Shear loads $V_{Ed,y}$ acting perpendicular to the longitudinal axis of the channel

Shear loads acting on mounting channels may be assumed to act without a lever arm if the following two conditions are satisfied:

a) The fixture is made out of steel and is in contact with the channel bolt over a length of at least 0,5 t_{fix}.

b) The fixture is fixed directly to the channel without an intermediate layer.

If the above conditions are not satisfied, shear force shall be considered acting with lever arm. For shear loads $V_{Ed,y}$ with a lever arm, a bending moment acting on the channel bolt has to be taken into account. The corresponding design moment is calculated as follows:

$$M_{Ed} = V_{Ed,y} \cdot \frac{l_a}{\alpha_M} \quad (6.1)$$

where

$$l_a = e_1 \quad (6.2)$$

with

e_1 = distance between shear load and channel surface (Figure 6.2a)

α_M = factor accounting for the degree of restraint of the mounting channel at the side of the fixture of the application in question. It should be determined according to good engineering practice.
= 1,0, if no restraint is assumed, meaning the fixture can rotate freely (Figure 6.2b)
= 2,0, if full restraint is assumed, valid only if the fixture cannot rotate (Figure 6.2c)

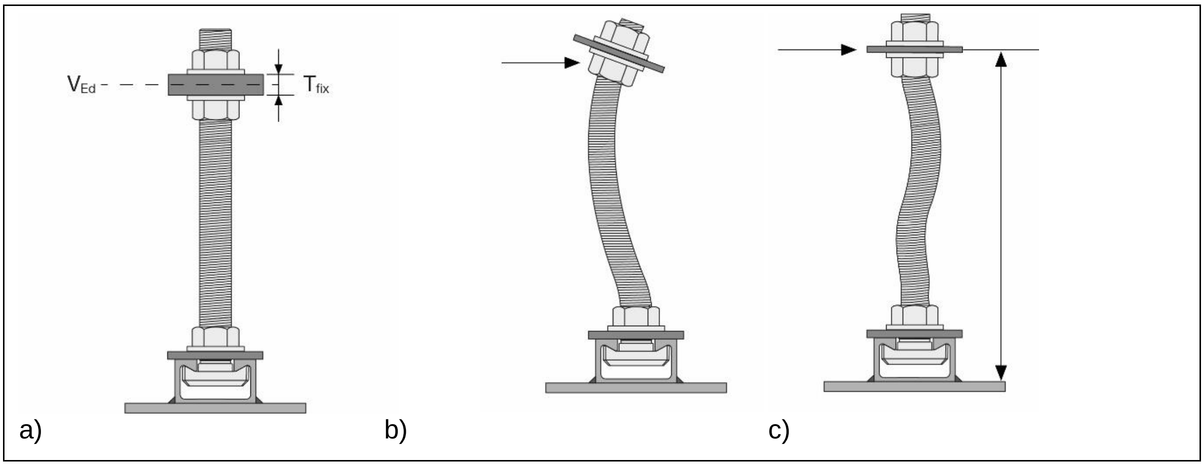


Figure 6.2 Shear load with lever arm: a) Definition of lever arm; b) free rotation of the fixture; c) no rotation of fixture:

7 VERIFICATION OF ULTIMATE LIMIT STATE

7.1 General

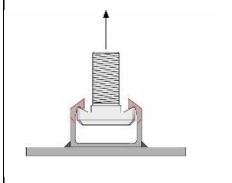
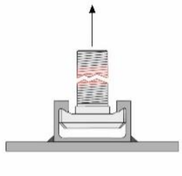
Equation (4.1) shall be fulfilled for all load directions (tension, shear, combined tension and shear) as well as for all failure modes for each load combination.

7.2 Tension load

7.2.1 Required verifications

The verifications of Table 7.1 apply.

Table 7.1 Required verifications for mounting channels in tension

	failure mode		Channel	most unfavourable channel bolt	
1	**Steel failure**	local flexure of channel lip	$N_{Ed}^{cb} \leq N_{Rd,s,l} = \frac{N_{Rk,s,l}}{\gamma_{Ms,l}}$	-	
2		channel bolt	-	$N_{Ed}^{cb} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$	
3		flexure of channel [a,b]	$M_{Ed}^{cb} \leq M_{Rd,pl} = \frac{M_{pl} \cdot \alpha_R}{\gamma_{Ms,flex}}$	-	

[a] verification of flexure of channel not needed for continuous welding

[b] α_R – factor: to take the degree of restrain of the mounting channel at the welding point into account. Determination of α_R - factor based on engineering judgement considering the base material stiffness

α_R = 1,0 no restrain is assumed, the channel can rotate at the welding point;

α_R = 2,0 full restrain is assumed, the channel cannot rotate at the welded point

7.2.2 Steel failure

The characteristic resistances $N^{0}_{Rk,s,l}$ (basic value for local failure by flexure of channel lips) and $N_{Rk,s}$ (failure of the channel bolt) are given in the relevant ETA.

The characteristic resistance $N_{Rk,s,l}$ for lip failure is given as

$$N_{Rk,s,l} = N^{0}_{Rk,s,l} \cdot \psi_{l,N} \quad (7.1)$$

with

$$\psi_{l,N} = 0{,}5 \cdot \left(1 + \frac{s_{cbo}}{s_{l,N}}\right) \le 1 \quad (7.2)$$

Where

$\psi_{l,N}$ = influence factor for closely spaced channel bolts

s_{cbo} = spacing of channel bolts (centre to centre)

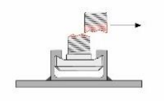
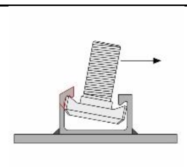
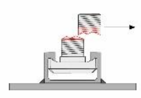
$s_{l,N}$ = characteristic spacing of channel bolts for channel lip failure under tension, taken from the ETA

7.3 Shear load $V_{Ed,y}$ acting perpendicular to the longitudinal axis of the channel

7.3.1 Required verifications

The verifications of Table 7.2 apply.

Table 7.2 Verifications for mounting channels under shear load $V_{Ed,y}$ acting perpendicular to the longitudinal channel axis

	failure mode			Channel	most unfavourable channel bolt	
1	**Steel failure**	**shear force without lever arm**	channel bolt [a]	-	$V^{cb}_{Ed,y} \le V_{Rd,s,y} = V_{Rk,s}/\gamma_{Ms}$	
2			local flexure of channel lip [a]	$V^{cb}_{Ed,y} \le V_{Rd,s,l} = \frac{V_{Rk,s,l,y}}{\gamma_{Ms,l,y}}$ [a]	-	
3		**shear force with lever arm**	channel bolt	-	$V^{cb}_{Ed,y} \le V_{Rd,s,M} = \frac{V_{Rk,s,M}}{\gamma_{Ms}}$	

[a] Verification for most loaded channel bolt.

NOTE: The values of the partial factors are given in Section 4.3

7.3.2 Steel failure

7.3.2.1 Shear force without lever arm

The characteristic resistances $V_{Rk,s}$ (failure of channel bolt) and $V^0_{Rk,s,l}$ (basic value for failure due to local flexure of channel lips) are given in the relevant ETA. The characteristic resistance $V_{Rk,s,l}$ for lip failure is

$$V_{Rk,s,l} = V^0_{Rk,s,l} \cdot \psi_{l,V} \tag{7.3}$$

with

$$\psi_{l,V} = 0,5 \cdot \left(1 + \frac{s_{cbo}}{s_{l,V}}\right) \le 1 \tag{7.4}$$

where

$\psi_{l,V}$ = influence factor for closely spaced channel bolts

s_{cbo} = spacing of channel bolts (centre to centre)

$s_{l,V}$ = characteristic spacing of channel bolts for channel lip failure under shear, taken from the ETA.

7.3.2.2 Shear force with lever arm

The characteristic resistance of a channel bolt in case of steel failure, $V_{Rk,s,M}$, shall be calculated according to Equation (7.5).

$$V_{Rk,s,M} = \frac{\alpha_M \cdot M_{Rk,s}}{l_a} \tag{7.5}$$

with

α_M as defined in Section 6.2

$$M_{Rk,s} = M^0_{Rk,s} \cdot \left(1 - N^{cb}_{Ed} / N_{Rd,s}\right) \tag{7.6}$$

$$N_{Rd,s} = N_{Rk,s} / \gamma_{Ms} \tag{7.7}$$

$M^0_{Rk,s}$ = characteristic bending resistance of the channel bolt, given in the relevant ETA

l_a = see Figure 6.2

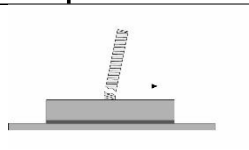
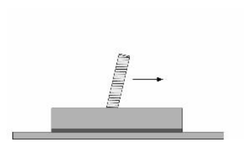
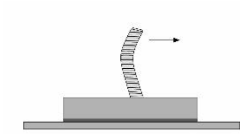
Note: The influence of the shear load with lever arm on lip failure is covered by the prequalification of the mounting channel

7.4 Shear load $V_{Ed,x}$ acting in direction of the longitudinal axis of the channel

7.4.1 Required verifications

The verifications of Table 7.3 apply.

Table 7.3: Verifications for mounting channels under shear load $V_{Ed,x}$ acting in longitudinal axis of the channel

	failure mode			**Channel**	**most unfavourable channel bolt**	**Failure modes illustrated for mounting channels with n_a = 2 welding points**
1	**steel failure**	**shear force without lever arm**	channel bolt	-	$V_{Ed,x}^{cb} \leq V_{Rd,s,x} = V_{Rk,s}/\gamma_{Ms}$	
2			connection between channel bolt and channel lip	$V_{Ed,x}^{cb} \leq V_{Rd,s,l,x} = V_{Rk,s,l,x}/\gamma_{Ms,l,x}$	-	
3		**shear force with lever arm**	channel bolt	-	$V_{Ed,x}^{cb} \leq V_{Rd,s,M} = \frac{V_{Rk,s,M}}{\gamma_{Ms}}$	
NOTE: The values of the partial factors are given in Section 4.3						

7.4.1.1 Steel failure

7.4.1.1.1 Channel bolt without lever arm

Section 7.3.2.1 applies

7.4.1.1.2 Channel bolt with lever arm

The characteristic resistance of the channel bolt in case of steel failure $V_{Rk,s,M}$ for the verification according to Table 7.3, line 3 shall be calculated according to Section 7.3.2.2.

NOTE The influence of the shear load with lever arm on lip failure is covered by the European Technical Assessment (ETA) of mounting channels.

7.4.1.1.3 Connection between channel bolt and channel

The characteristic resistance $V_{Rk,s,l,x}$ of the channel lips and the mechanical interlock for the verification according to Table 7.3, line 2 shall be taken from the relevant ETA.

7.5 Combined tension and shear loads

The required verifications in the following section shall be carried out separately for each steel failure mode. All verifications shall be fulfilled.

Steel failure of channel bolts

The following verification shall be fulfilled:

$$\left(\frac{N_{Ed}^{cb}}{N_{Rd,s}}\right)^2 + \left(\frac{V_{Ed}^{cb}}{V_{Rd,s}}\right)^2 \leq 1 \qquad (7.8)$$

$$V^{cb}{}_{Ed} = \sqrt{V_{Ed,x}^2 + V_{Ed,y}^2} \qquad (7.9)$$

The characteristic steel resistances $N_{Rd,s}$, and $V_{Rd,s}$ of the channel bolt shall be taken from the relevant ETA.

Equation (7.9) is valid for channel bolts with the same characteristic shear resistances in x-direction and in y-direction.

Steel failure of channel lips and flexural failure of channel

The following verification shall be fulfilled.

$$Max\left[\frac{N_{Ed}^{cb}}{N_{Rd,s,l}};\frac{M_{Ed}^{ch}}{M_{Rd,s,flex}}\right]^{k2}+\frac{V_{Ed,y}^{cb}}{V_{Rd,s,l,y}}^{k2}\leq\left[1-\frac{V_{Ed,x}^{cb}}{V_{Rd,s,l,x}}\right]^{k2} \quad (7.10)$$

with

k_2 = 2,0 if $V_{Rd,s,l,y} \leq N_{Rd,s,l}$

= to be taken from the ETA if $V_{Rd,s,l,y} > N_{Rd,s,l}$, conservatively k_2 = 1,0 may be taken.

NOTE *The basic interaction concept according to Equation (7.10) for mounting channels loaded in either 2 or all 3 directions is shown in Fig.7.*

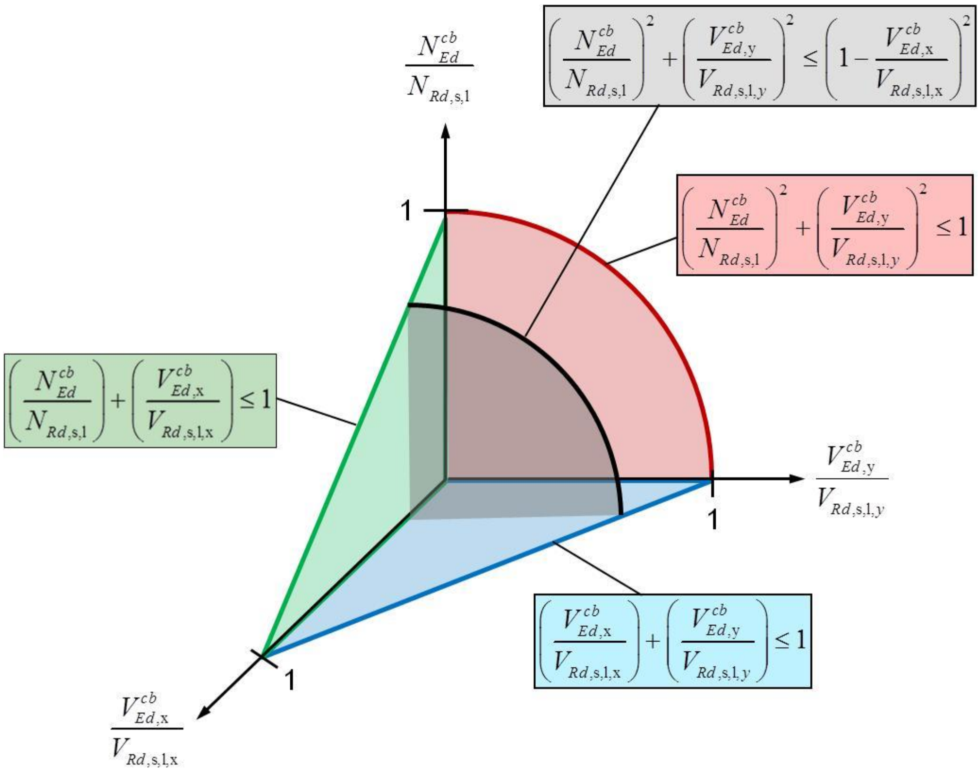


Figure 7: Interaction concept for mounting channels

The design resistances $N_{Rd,s,l}$, $M_{Rd,s,flex}$ and $V_{Rd,s,l}$ shall be determined from the corresponding characteristic values given in the relevant ETA.

8 VERIFICATION OF SERVICEABILITY LIMIT STATE

The required verifications are stated in Section 4.2. The admissible displacement C_d shall be evaluated by the designer taking into account the type of application at hand (e.g., the structural element to be attached). The displacements C_d may be assumed to be a linear function of the applied load. In the case of combined tension and shear load, the displacements for the shear and tension components of the resultant load shall be added vectorially.

The characteristic displacement of the mounting channel under given tension and shear loads shall be taken from the relevant ETA.

9 REFERENCES

[1] EAD 15-33-0667-00-06.02: Mounting channels.

[2] EN 1992-4, Eurocode 2: Design of concrete structures - Part 4: design of fastenings for use in concrete, European Committee for Standardization (CEN), Belgium.

[3] EN 1990: Eurocode – Basis of structural design, European Committee for Standardization (CEN), Brussels, Belgium.

[4] EN 1991, Eurocode 1: Actions on structures, European Committee for Standardization (CEN), Brussels, Belgium.

[5] EN 1993-1-1: Eurocode 3: Design of steel structures. Part 1-4: General rules and rules for buildings

[6] EN 1993-1-4 +A1: Eurocode 3: Design of steel structures. Part 1-4: General rules - Supplementary rules for stainless steel