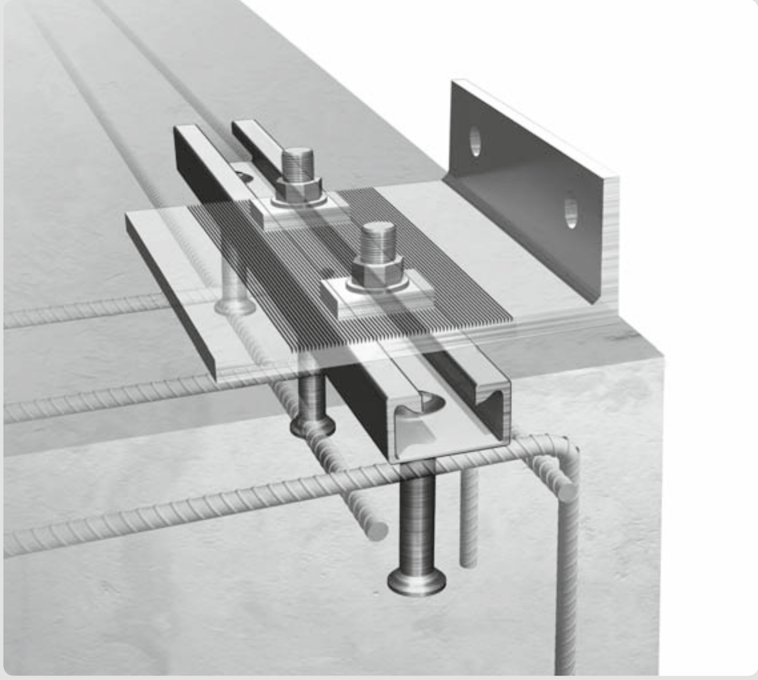


Design of JORDAHL® Anchor Channels

Technical Information

JORDAHL®
anchored in quality

Contents

Cover photo by Kati Forkert.

1 General

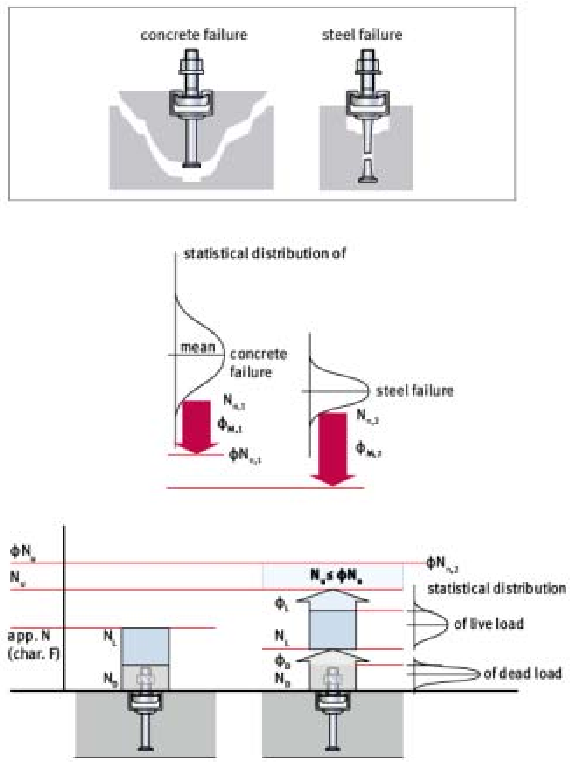
Previously, the design of anchor channels has usually been carried out through the use of load tables. These charts have been established historically from the results of tests in uncracked concrete using a global safety factor. Often these permissible loads have also been assumed to apply to cracked concrete conditions. With today's knowledge this is an inaccurate modelling of the effects of the formation of cracks, as it is well known that the concrete breaking load is reduced by cracks in the concrete (see [1]). Also, the use of these simplified load charts often results in designs which are either too conservative, or where the necessary safety against failure might not be achieved. In today's world where economical anchoring solutions are mandatory, precise design methods with optimized material usage are required. With the presence of engineering design approaches for anchors in concrete (e.g. ACI 318-Appendix D [2] and AC 232 [3]) there is a basis for such a design available today. This booklet summarizes the existing North American design provisions for anchor channels. In addition, in section 7, the relevant specifications and strength values for JORDAHL® JTA Anchor channels are listed. All data given here is subject to continuous quality tests by accredited test labs.

In recent years, our understanding of the behaviour of anchor channels has been greatly enhanced through extensive research and testing. Today's knowledge of the load distribution from the attachment to concrete and the different failure modes of anchor channels has elevated the design approach for anchor channels to a new level. Knowledge of the material behaviour combined with empirically derived data from long term testing are combined in the design method presented in this booklet. Together with this detailed and accurate new design method the requirement of more complex calculations has become necessary since all possible failure modes are checked individually. This design approach demands a user friendly, flexible and up-to date design software package. The new JORDAHL® EXPERT software is a tool to help design anchor channels efficiently for various applications. The calculations provided by the software are based on the detailed description of the design in this booklet to the best of our knowledge.

2 Safety concept for North America

Today the safety factors for anchor channel design are based on the LRFD approach from ACI 318 Appendix D. According to this concept, individual strength reduction factors for different failure modes have to be applied. The loads and load combinations for this design method shall be considered as described in ACI 318-11, section 9.2. Figure 2.1 describes the main principle of the LRFD concept for anchor channels cast in concrete. The load amplification and strength reduction factors are summarized in table 2.1 (strength reduction for tension failure modes) and table 2.2 (strength reduction factors for shear).

All nominal strengths determined in accordance with this design guideline shall be factored with the Φ strength reduction factors given in table 2.1 and 2.2 respectively.



$N_{n,i}$ = nominal strength for material
$\phi_{M,i}$ = individual strength reduction factors for material i
ϕN_n = min $(\phi N_{n,1}, \phi N_{n,2})$
N_u = factored load
$N_u = \phi_D \times D + \phi_L \times L$
N_L = unfactored live load
ϕ_L = load factor for live load
N_D = unfactored dead load
ϕ_D = load factor for dead load

Figure 2.1: Safety concept

2.1 Load factors and combinations

For load factors and combinations we recommend the use of ACI 318-11 chapter 9.2. Static design should consider the worst case of the subsequent load combinations:

U = 1.4 D

U = 1.2 D + 1.6 L + 0.5 (Lr or S or R)

U = 1.2 D + 1.6 (Lr or S or R) + (1.0 L or 0.5 W)

U = 1.2 D + 1.0 W + 1.0 L + 0.5 (Lr or S or R)

U = 0.9 D + 1.0 W

where:

D = dead loads

F = loads due to fluids

H= loads due to soil

L = live loads

Lr = roof live loads

R = rain loads

S = snow loads

T = temperature and time-dependent loads

W = wind load

2.2 Φ-Strength reduction factors

	Type of failure		Φ-Factor
1	Steel failure	Anchors	0.75
2		Connection between anchor and channel	0.75
3		Local failure of the channel lip	0.75
4		Channel T-bolts	0.65
5		Bending of the channel	0.85
6	Pull-out		0.70
7	Concrete cone failure		0.70
8	Steel failure of supplementary reinforcement		0.90
9	Anchorage failure of the supplementary reinforcement		0.75

Table 2.1 Φ-Strength reduction factors for anchor channels under tensile loads

	Type of failure			Φ-Factor
1	Steel failure	Without lever arm	Channel T-bolts	0.60
2			Local bending of the channel lip	0.75
3		With lever arm	Channel T-bolts	0.65
4	Pry-out failure			0.70
5	Concrete edge failure			0.70
6	Steel failure in supplementary reinforcement			0.90
7	Anchorage failure of the supplementary reinforcement in the failure cone			0.75

Table 2.2 Φ-Strength reduction factors for anchor channels under shear load

3 Description

3.1 General

The anchor channels consist of a U-shaped channel of either hot-rolled or cold-formed steel and at least two anchors attached to the channel back. The channel profile contains returns or lips that hold matching hammerhead or hooked T-bolts[1] within the profile. The anchor channel is mounted to the formwork and embedded surface-flush into the concrete. JTA anchor channels are provided with a removable foam filler, that prevents concrete from intruding into the profile. After curing of the concrete and removal of the formwork, the filler is removed from the channel. The appropriate channel T-bolts and washers are placed in the anchor channel, allowing left-right adjustment of the connection for compensation of building tolerances. The anchor channels are shown in Figure 3.1, the channel T-bolts are shown in Figure 3.2.

Typical applications for anchor channels are connections of precast elements, attachments of façade claddings and for mechanical installations.

[1] In some literature T-bolts are called “special screws”.

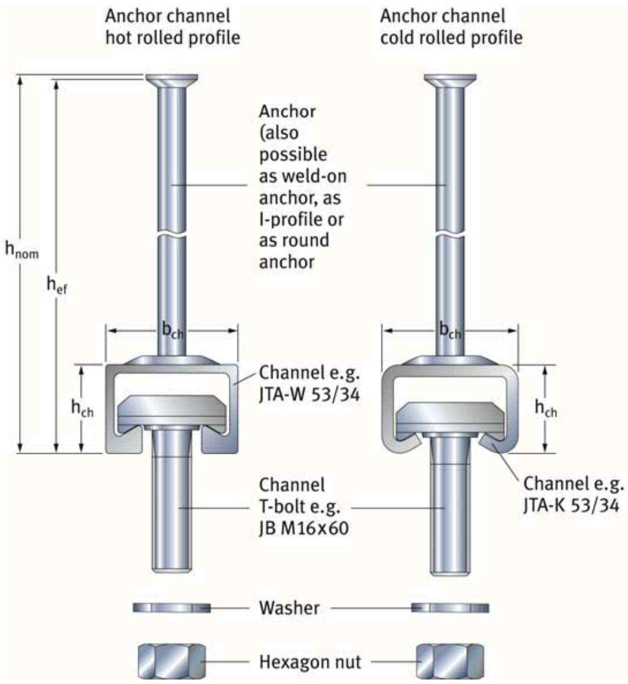


Figure 3.1: Anchor channels

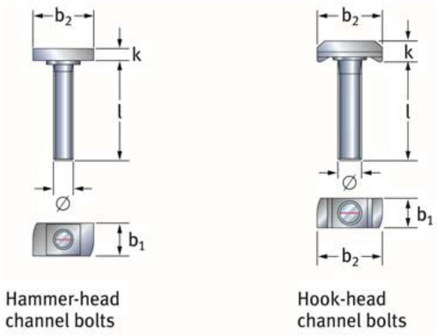


Figure 3.2: Hammer-head channel T-bolts and hook head channel T-bolts

3.2 Concrete

Normal-weight concrete must comply with Sections 1903 and 1905 of the IBC. The specified compressive strength of the concrete must be within a range from 2,500 psi to 10,000 psi (17.2 MPa to 68.9 MPa).

3.3 Lightweight Concrete

Anchor channels may be used in sand-lightweight concrete according to ACI 318-11 (lightweight concrete containing only normal weight fine aggregate that conforms to ASTM C33 and only lightweight aggregate that conforms to ASTM C330). To account for the use of lightweight concrete, unless specifically noted otherwise, a modification factor λ appears as a multiplier of $\sqrt{f'c}$ in all applicable equations, with λ = 0.85 for sand-lightweight concrete.

4 Determination of forces acting on the anchors

4.1 Tensile loads

Analysis of the loads acting on the anchors is necessary for several verifications in the design of an anchor channel. The distribution of the loads acting on the T-bolts through the channel and into the anchors can be done using the triangular load distribution method. The method considers partially restrained channel ends, the moment of inertia of the channel profile, the anchor spacing and the position of the load acting on the T-bolt.

The tension loads $N^{a}_{ua,i}$ on an anchor due to a tension load N_{ua} acting on the T-bolt shall be computed in accordance with Eq. (3.1). An example for the calculation of the tension loads acting on the anchors is given in Figure 4.1

$$N^{a}_{ua,i} = k \cdot A'_i \cdot N_{ua} \qquad (3.1)$$

where:

A'_i= ordinate at the position of the anchor i assuming a triangle with the unit height at the position of load N_{ua} and the base length 2 l_{in} with l_{in} determined in accordance with Equation (3.3). Examples are provided in Fig. 4.1

$$k = \frac{1}{\sum A'_i} \qquad (3.2)$$

$$l_{in} = 4.93\,(I_y)^{0.05} \cdot \sqrt{s} \geq s, \text{ (inch)} \qquad (3.3)$$

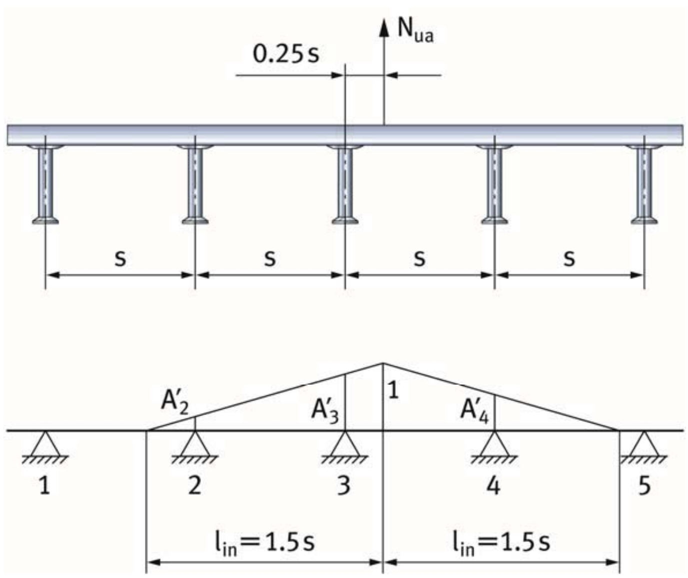
$$l_{in} = 13\,(I_y)^{0.05} \cdot \sqrt{s} \geq s,\ (mm) \qquad (3.4)$$

s = anchor spacing, (inch, mm)

N_{ua} = factored tension load on T-bolt, (lbf, N)

The moment of inertia of the channel shall be taken from Table 1 of this booklet.

If several tension loads are simultaneously acting on the channel, a linear superimposition of the anchor forces for all loads shall be assumed.
If the exact position of the load on the channel is not known, the most unfavourable loading position shall be assumed for each failure mode (e.g. load acting over an anchor for the case of failure of an anchor by steel rupture or pull-out and load acting between anchors in the case of bending failure of the channel).



$A'_2 = 1 - \frac{1.25s}{l_{in}} = \frac{1}{6}$

$A'_3 = 1 - \frac{0.25s}{l_{in}} = \frac{5}{6}$

$A'_4 = 1 - \frac{0.75s}{l_{in}} = \frac{1}{2}$

$k = \frac{1}{A'_2 + A'_3 + A'_4} = \frac{2}{3}$

$N^a_{ua,1} = N^a_{ua,5} = 0$

$N^a_{ua,2} = \frac{1}{6} \cdot \frac{2}{3} \cdot N = \frac{1}{9} N_{ua}$

$N^a_{ua,3} = \frac{5}{6} \cdot \frac{2}{3} \cdot N = \frac{5}{9} N_{ua}$

$N^a_{ua,4} = \frac{1}{2} \cdot \frac{2}{3} \cdot N = \frac{1}{3} N_{ua}$

Figure 4.1— Load directions – Example for the calculation of anchor forces in accordance with the triangular load distribution method for an anchor channel with five anchors – the influence length is assumed as l_{in} = 1.5s

4.2 Shear loads

The equations and method outlined in Section 4.1 apply, however tensile loads are replaced with shear loads throughout (N is replaced by V).

It can be assumed that a shear load without a lever arm is applied to the anchor channel if the attachment is connected directly to the anchor channel or the concrete, the thickness of any mortar layer present ≤ 0.5 d, and the diameter d_f of the through hole in the attachment does not exceed the values according to Table 4.1.

bolt diameter d [mm]	6	8	10	12	14	16	18	20	22	24	27	30
Diameter d_f of clearance hole in the fixture [mm]	7	9	12	14	16	18	20	22	24	26	30	33

Table 4.1: Hole clearance

If the above conditions are not met, it must be assumed that the shear load is applied at a distance from the anchor channel. For these stand-off installations the bending moment in the T-bolt depends on whether the attachment can rotate (see figure 5.8).

4.3 Bending moments

The bending moment M_{ua} on the channel due to tension loads acting on the channel shall be computed assuming a simply supported single span beam with a span length equal to the anchor spacing.

4.4 Supplementary reinforcement

4.4.1 Tensile loads in the supplementary reinforcement

The value of the tensile force $N_{ua,re}$ of the supplementary reinforcement of anchor i corresponds to the value $N^{a}_{ua,i}$ of the affected anchor.

4.4.2 Shear loads in the supplementary reinforcement

If the upper layer of the reinforcement is considered to tie back shear loads into the structure, the additional offset between the shear load applied to the T-bolt and the reinforcement has to be considered (Figure 4.2). The tensile force in supplementary reinforcement $N_{ua,re}$ caused by shear loads of anchor i can be calculated according equation (3.4). If the supplementary reinforcement is not in the direction of the applied shear load, this must be taken into account when determining the tensile force in the reinforcement.

$$N_{ua,re} = V_{ua} \left(\frac{e_s}{z} + 1\right) \text{ (lbf, N)} \qquad (3.4)$$

where (as illustrated in Figure 4.2):

e_s = distance between reinforcement and shear force acting on the fixture, in. (mm)

z = internal lever arm of the concrete member, (in, mm)

$$= 0.85 \cdot (h' - h_{ch} - 0.5d_b) \leq \min \begin{pmatrix} 2h_{ef} \\ 2c_{a1} \end{pmatrix}$$

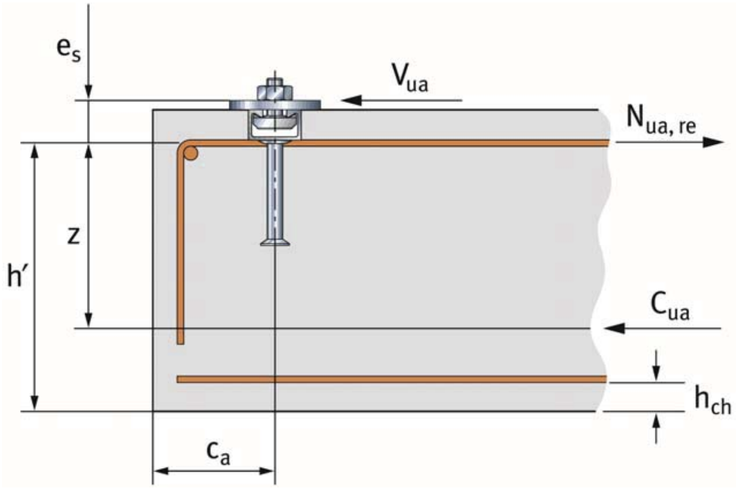


Figure 4.2: Anchor reinforcement to resist shear loads

5 Strength Design

5.1 Tensile load

5.1.1 General

The possible failure types under tensile load are shown in Figure 5.1. The necessary verification for all failure types is listed in Table 5.1. For applications without supplementary reinforcement, the verification is to be provided according to Table 5.1, lines 1 to 8. For applications with supplementary reinforcement, the load-bearing capacity must be provided according to Table 5.1, lines 1 to 6 and lines 8 to 10. The proof against concrete cone failure is thus replaced by the proof for failure of the supplementary reinforcement.

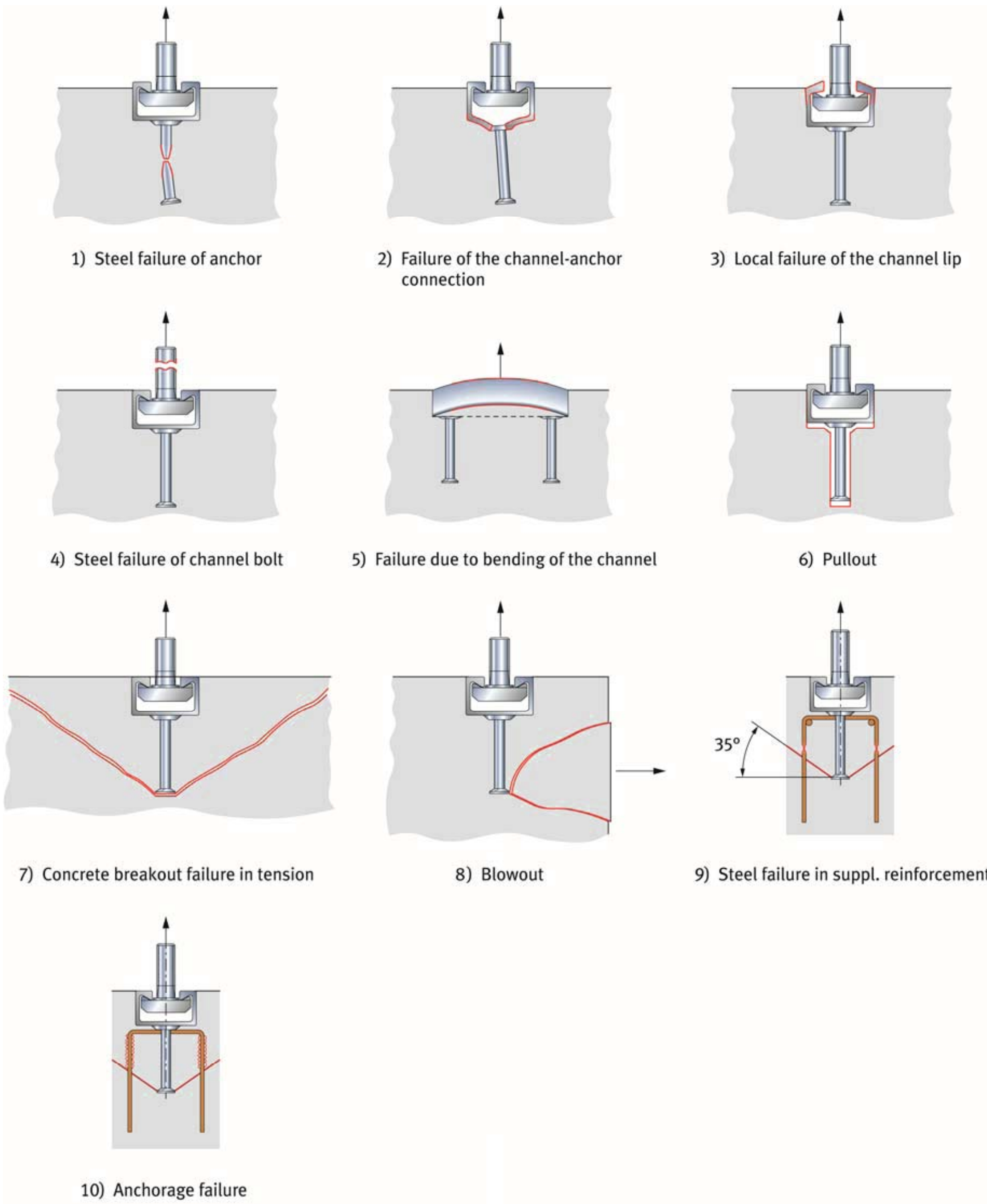


Figure 5.1: Possible failure modes for anchor channels under tensile load

	Failure types		Channel	Most unfavou-rable anchor or T-bolt
1	Steel failure	Anchor		$N_{ua}^{a} \leq \phi \cdot N_{s,a}$ b)
2		Connection between anchor and channel		$N_{ua}^{a} \leq \phi \cdot N_{s,c}$ b)
3		Local failure of the lip	$N_{ua} \leq \phi \cdot N_{s,l}$ b)	
4		Hook head or hammerhead T-bolt		$N_{ua} \leq \phi \cdot N_{s,c}$ b)
5		Bending of the channel	$M_{ua} \leq \phi \cdot M_{s,flex}$	
6	Pull-out			$N_{ua}^{a} \leq \phi \cdot N_{p}$ b)
7	Concrete breakout failure			$N_{ua}^{a} \leq \phi \cdot N_{cb}$ c)
8	Blow-out failure a)			$N_{ua}^{a} \leq \phi \cdot N_{sb}$ c)
9	Steel failure in supplementary reinforcement			$N_{ua}^{a} \leq \phi \cdot N_{ca}$ b)
10	Anchorage failure of the supplementary reinforcement			$N_{ua}^{a} \leq \phi \cdot N_{ca,a}$ b)

a) not required for anchors with edge distance c > 0.5hef

b) most heavily loaded anchor or T-bolt

c) an anchor with lower loading can also be decisive if the strength due to edge distance and anchor spacing is lower

Table 5.1: Required verification for anchor channels under tensile load

5.1.2 Steel failure of anchors, anchor channels or T-bolts

The nominal steel strengths N_{sa}, (anchor failure), N_{sc}, (failure of the connection between channel and anchor), N_{sl}, (local failure of the channel lip), N_{ss}, (T-bolt failure) and $M_{s,flex}$ (failure due to bending failure of the channel) and the corresponding Φ - strength reduction factors are shown in Table 4.

The value N_{sl} for local failure of the lip is valid only if the axial spacing between two channel T-bolts, s_{chb}, is at least $2b_{ch}$. If this requirement is not met then the value N_{sl} given in Table 4 shall be reduced by the factor

$$0.5\left(1+\frac{s_{chb}}{2b_{ch}}\right) \leq 1.0 \qquad (3.5)$$

with s_{chb} = axial spacing between two channel T-bolts

b_{ch} = channel width, see Table 1 of this report

5.1.3 Pull-out

The nominal pullout strength of anchor channels in cracked concrete, N_p, is calculated according to Equation (4.2.1.1). It is given in Table 5 of this report and valid for f_c' = 2500 psi (17.2 MPa).

$$N_p = 8 \cdot \lambda \cdot A_{brg} \cdot f_c' \text{ (lb, psi)} \qquad (4.2.1.1)$$

with

λ = modification factor for sand-lightweight concrete (0.85)

A_{brg} = net bearing area of the head of the anchor

$= \frac{\pi}{4}\left(d_h^2 - d^2\right)$ for round anchor heads

fc' = specified compressive concrete strength

The nominal pullout strength given in Table 5 may be adjusted by calculations according to Equation 4.2.1.2:

$$\Psi_{cp} \cdot N_{pn} = \Psi_{cp} \cdot N_p \left(\frac{fc'}{2.500}\right), \text{ (lb, psi)} \qquad (4.2.1.2)$$

$$\Psi_{cp} \cdot N_{pn} = \Psi_{cp} \cdot N_p \left(\frac{fc'}{17.2}\right), \text{ (N, MPa)} \qquad (4.2.1.2)$$

where:

fc' = specified concrete strength

For an anchor located in a region of a concrete member where analysis indicates no cracking at service load levels, the following modification factor shall be permitted:

$\Psi_{cp} = 1.4$

Where analysis indicates cracking at service load levels, Ψ_{cp} shall be taken as 1.0.

5.1.4 Concrete Breakout Strength in Tension

5.1.4.1

The nominal concrete breakout strength, N_{cb}, of a single anchor in tension of an anchor channel shall be determined in accordance with Eq. (4.2.2.1).

$$N_{cb} = N_b \cdot \Psi_{s,N} \cdot \Psi_{ed,N} \cdot \Psi_{co,N} \cdot \Psi_{c,N} \cdot \Psi_{cp,N} \qquad (4.2.2.1)$$

5.1.4.2

The basic concrete breakout strength of a single anchor in tension in cracked concrete N_b shall be determined in accordance with Eq. (4.2.2.2).

$$N_b = 24 \cdot \lambda \cdot \alpha_{ch,N} \cdot \sqrt{f'_c} \cdot h_{ef}^{1.5}, \quad \text{(lbf)} \qquad (4.2.2.2)$$

$$N_b = 10 \cdot \lambda \cdot \alpha_{ch,N} \cdot \sqrt{f'_c} \cdot h_{ef}^{1.5}, \quad \text{(N)} \qquad (4.2.2.2)$$

where

λ = modification factor for sand-lightweight concrete (0.85)

$$\alpha_{ch,N} = \left(\frac{h_{ef}}{7.1}\right)^{0.15} \leq 1, \text{ (inch-pound units)} \qquad (4.2.8.3)$$

$$\alpha_{ch,N} = \left(\frac{h_{ef}}{180}\right)^{0.15} \leq 1, \text{ (SI-units)} \qquad (4.2.8.3)$$

5.1.4.3

The modification factor to account for the influence of location and loading of adjacent anchors, $\psi_{s,N}$, shall be computed in accordance with Eq. (4.2.2.4)

$$\Psi_{s,N} = \frac{1}{1 + \sum_{i=2}^{n+1}\left[\left(1 - \frac{s_i}{s_{cr,N}}\right)^{1.5} \cdot \frac{N_{ua,i}^a}{N_{ua,1}^a}\right]} \qquad (4.2.2.4)$$

where (as illustrated in Fig. 5.2)

s_i = distance between the anchor under consideration and influencing anchor, (in, mm)

$s_i \leq s_{cr,N}$

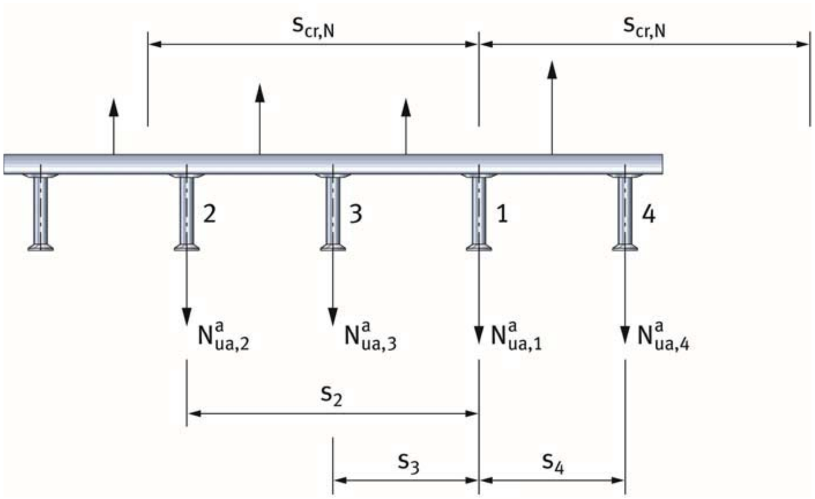
$$s_{cr,N} = 2\left(2.8 - \frac{1.3h_{ef}}{7.1}\right) h_{ef} \geq 3h_{ef}, \text{ (in)} \qquad (4.2.2.5)$$

$$s_{cr,N} = 2\left(2.8 - \frac{1.3h_{ef}}{180}\right) h_{ef} \geq 3h_{ef}, \text{ (mm)} \qquad (4.2.2.5)$$

$N^a_{ua,i}$ = Factored tension load of an influencing anchor, (lbf, N)

$N^a_{ua,1}$ = Factored tension load of the anchor under consideration, (lbf, N)

n = number of anchors within a distance $s_{cr,N}$ to both sides of the anchor under consideration



1 = anchor under consideration

2 to 4 = influencing anchors

Figure 5.2 – Example of an anchor channel with non-uniform anchor tension forces

5.1.4.4

The modification factor for edge effect of anchors loaded in tension, $\Psi_{ed,N}$, shall be computed in accordance with Eq. (4.2.2.6) or (4.2.2.7).

If $c_{a1} \geq c_{cr,N}$

then $\Psi_{ed,N} = 1.0$ (4.2.2.6)

If $c_{a1} < c_{cr,N}$

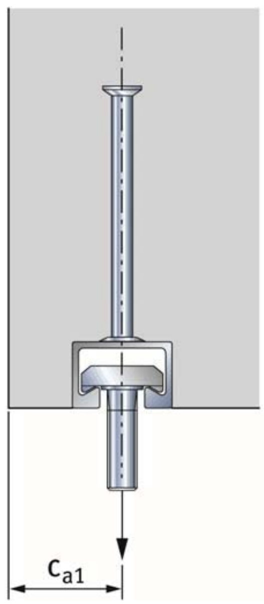
then $\Psi_{ed,N} = \left(\frac{c_{a1}}{c_{cr,N}}\right)^{0.5} \leq 1.0$ (4.2.2.7)

where

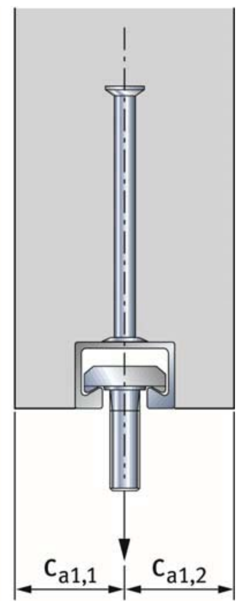
$c_{cr,N} = 0.5\ s_{cr,N} = (2.8 - 1.3\ h_{ef}\ /\ 7.1)\ h_{ef} \geq 1.5\ h_{ef}$, (in) (4.2.2.8)

$c_{cr,N} = 0.5\ s_{cr,N} = (2.8 - 1.3\ h_{ef}\ /\ 180)\ h_{ef} \geq 1.5\ h_{ef}$, (mm) (4.2.2.8)

If anchor channels are located in a narrow concrete member with multiple edge distances $c_{a1,1}$ and $c_{a1,2}$ (as shown in Figure 5.3), the minimum value of $c_{a1,1}$ and $c_{a1,2}$ shall be inserted in Eq. (4.2.2.7).



a) At an edge



b) In a narrow member

Figure 5.3 – Anchor channels

5.1.4.5

The modification factor for corner effect for anchors loaded in tension, $\Psi_{co,N}$, shall be computed in accordance with Eq. (4.2.2.8) and (4.2.2.9)

If $c_{a2} \geq c_{cr,N}$

then $\Psi_{co,N} = 1.0$ (4.2.2.8)

If $c_{a2} < c_{cr,N}$

then $\Psi_{co,N} = \left(\frac{c_{a2}}{c_{cr,N}}\right)^{0.5} \leq 1.0$ (4.2.2.9)

where

c_{a2} = distance of the anchor under consideration to the corner (see Figure 5.4 a, b)

If an anchor is influenced by two corners (as illustrated in Figure 5.4 c), the factor $\Psi_{co,N}$ shall be computed for each of the values $c_{a2,1}$ and $c_{a2,2}$ and the product of the factors, $\Psi_{co,N}$, shall be inserted in Eq. (4.2.2.1).

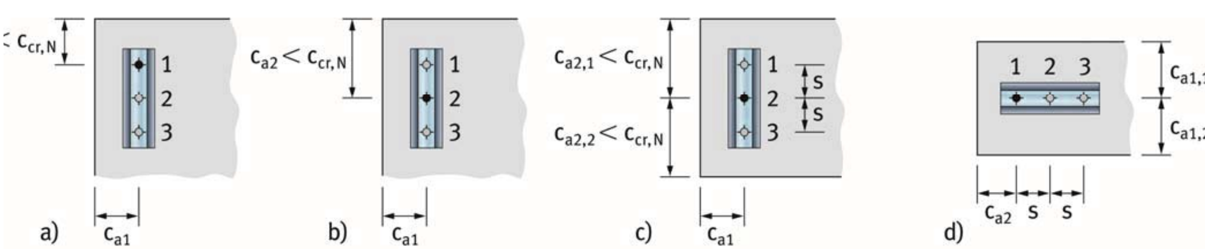


Figure 5.4: Anchor channel at a corner of a concrete member

○ anchor under consideration

● adjacent anchor

5.1.4.6

For anchor channels located in a region of a concrete member where analysis indicates no cracking at service load levels, the following modification factor shall be permitted

$\Psi_{c,N} = 1.25$

Where analysis indicates cracking at service load levels, $\Psi_{c,N}$ shall be taken as 1.0. The cracking in the concrete shall be controlled by flexural reinforcement distributed in accordance with ACI 318 Section 10.6.4., or equivalent crack control shall be provided by confining reinforcement.

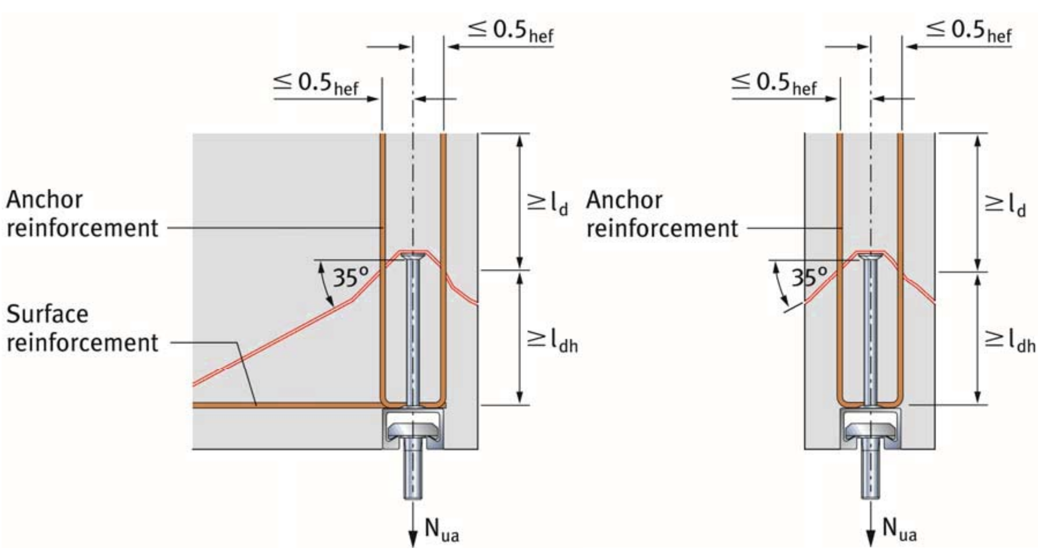
5.1.5 Concrete side-face blowout strength of anchor channels in tension

Only for anchor channels with deep embedment close to an edge ($h_{ef} > 2.0\ c_{a1}$) side-face blowout failure has to be considered. Since all JORDAHL JTA anchor channels have an effective embedment depth $h_{ef} < 2 \cdot c_{a1}$, this failure is excluded by the minimum edge distances given in Table 1.

5.1.6 Arrangement of supplementary reinforcement

Where anchor reinforcement is developed in accordance with Eq. 4.2.5.1 on both sides of the breakout surface for an anchor of an anchor channel, the design strength of the anchor reinforcement N_{ca} shall be permitted to be used instead of the concrete breakout strength N_{cb}. The anchor reinforcement for one anchor shall be designed for the tension force, N^{a}_{ua} on this anchor. The provisions in Figure 5.5 shall be taken into account when sizing and detailing the anchor reinforcement.

1. Anchor reinforcement shall consist of stirrups made from deformed reinforcing bars with a maximum diameter of 5/8 in. (No. 5 bar / 16 mm). A strength reduction factor ϕ of 0.9 for steel failure and 0.75 for anchorage failure shall be used in the design of the anchor reinforcement.
2. For anchor channels located parallel to the edge of a concrete member or in a narrow concrete member, the plane of the anchor reinforcement shall be arranged perpendicular to the longitudinal axis of the channel (as shown in Figure 5.5b).



a) b)

Figure 5.5: Arrangement of anchor reinforcement for anchor channels loaded by tension load

a) Anchor channel parallel to edge

b) Anchor channel in narrow member

5.1.6.1 Steel failure of supplementary reinforcement

The basic strength of the optional supplementary anchor reinforcement N_{ca} of an anchor is

$$N_{ca} = n \cdot A_s \cdot f_{ys} \quad \text{(lbf, N)} \qquad (4.2.4.1)$$

where

n = number of legs of the supplementary reinforcement for an anchor in the failure cone

A_s = Cross-section of a leg of the supplementary reinforcement

f_{ys} = nominal value of the yield point of the supplementary reinforcement

5.1.6.2 Anchorage failure of the supplementary reinforcement in the failure cone

Where anchor reinforcement is developed in accordance with Eq. 4.2.5.1 on both sides of the breakout surface for an anchor of an anchor channel, the design strength of the anchor reinforcement N_{ca} shall be permitted to be used instead of the concrete breakout strength N_{cb}. The basic strength of the supplementary reinforcement for failure due to anchorage failure is calculated according to equation (4.2.5.1).

$$N_{ca,a} = \sum_n \frac{l_{dh} \cdot \pi \cdot d_s \cdot f_{bd}}{\alpha} \quad \text{(lbf, N)} \qquad (4.2.5.1)$$

with

n = number of bars of the additional reinforcement effective for an anchor

l_{dh} = Anchoring length of the supplementary reinforcement in the failure cone

$\geq$ $l_{b,min}$ (see figure 5.2)

$l_{b,min}$ = minimum anchoring length

= $4d_s$ (hooks or angle hooks)

= $10\ d_s$ anchoring with straight bars

d_s = Diameter of the supplementary reinforcement

f_{bd} $= 2.3 \cdot \left(\frac{f_c'}{1.5}\right)^{\frac{2}{3}}$ (psi)

α = 1.0 for reinforcement bars with straight legs

= 0.7 for reinforcement bars with hooks (according to ACI 318 chapter 7.1)

5.2 Shear load

5.2.1 General

In this section, only shear loads acting perpendicular to the channel axis are taken into account. The potential failure types under shear load are shown in figure 5.6. The necessary proofs concerning shear loads are listed in table 5.2. For applications without supplementary reinforcement, the verification is to be provided according to table 5.2, lines 1 to 7. For applications with supplementary reinforcement, the load-bearing capacity must be verified in accordance with table 5.2, lines 1 to 6 and 8, the proof concerning concrete edge failure is replaced by the proof concerning failure of the supplementary reinforcement.

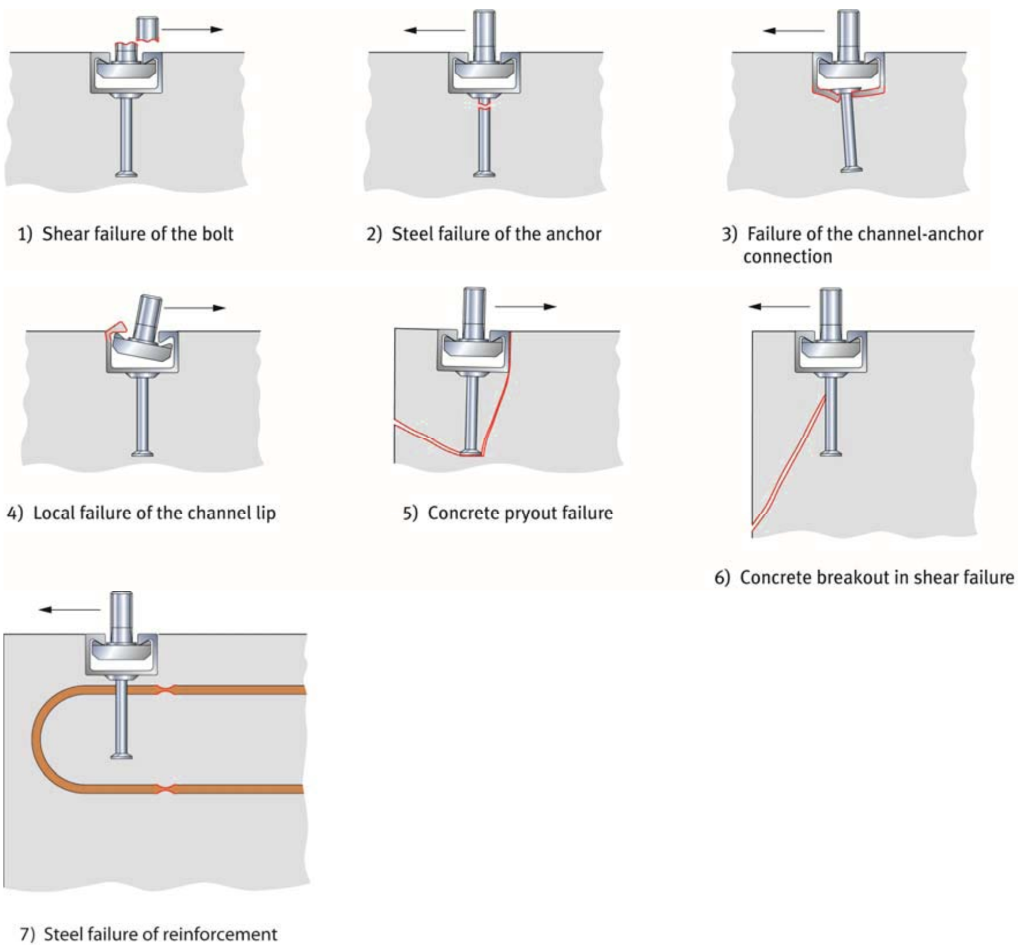


Figure 5.6: Possible failure modes for anchor channels under shear load

<table>
<tr><th></th><th colspan="3">Type of failure</th><th>Channel</th><th>Most unfavourable anchor or bolt</th></tr>
<tr><td>1</td><td rowspan="5">Steel failure</td><td rowspan="4">Shear load without lever arm</td><td>Channel bolt</td><td></td><td>$V_{ua}^{s} \leq \phi \cdot V_{ss}$ a)</td></tr>
<tr><td>2</td><td>Anchor</td><td></td><td>$V_{ua}^{s} \leq \phi \cdot V_{sa}$ a)</td></tr>
<tr><td>3</td><td>Anchors/ channel</td><td></td><td>$V_{ua}^{s} \leq \phi \cdot V_{sc}$ a)</td></tr>
<tr><td>4</td><td>Local failure of the channel lip</td><td>$V_{ua}^{a} \leq \phi \cdot V_{sl}$ a)</td><td></td></tr>
<tr><td>5</td><td>Shear load with lever arm</td><td>Channel bolt</td><td></td><td>$V_{ua}^{s} \leq \phi \cdot V_{ss}$ a)</td></tr>
<tr><td>6</td><td colspan="3">Pry out</td><td></td><td>$V_{ua}^{a} \leq \phi \cdot V_{cp}$ b)</td></tr>
<tr><td>7</td><td colspan="3">Concrete edge failure</td><td></td><td>$V_{ua}^{a} \leq \phi \cdot V_{cp}$ b)</td></tr>
<tr><td>8</td><td colspan="3">Steel failure of the additional reinforcement</td><td></td><td>$N_{ua}^{a} \leq \phi \cdot N_{ca}$ a)</td></tr>
<tr><td colspan="6">a) Most heavily loaded anchor or bolt
b) An anchor with lower loading can also be decisive if the strength due to edge distance and anchor spacing is lower.</td></tr>
</table>

Table 5.2 Required verification for anchor channels under shear load

The most unfavourable anchor is defined in the same way as for tensile load.

5.2.2 Steel failure of channel T-bolts

The nominal strength of a channel T-bolt in shear, V_{ss}, shall be taken from Table 6. The maximum value shall not exceed the value calculated according to Eq. (5.1.4.1).

$$V_{ss} = 0.6 \cdot A_{se,V} \cdot f_{uts}, \text{ (lbf, N)} \tag{5.1.4.1}$$

where:

f_{uts} shall be taken as the smaller of 1.9 f_{ys} and 125,000 psi (860 MPa).

If the fixture is not clamped against the concrete but secured to the channel T-bolt at a distance from the concrete surface (e.g. by double nuts), the nominal strength of a channel T-bolt in shear, V_{ss}, shall be computed in accordance with Eq. (5.1.4.2).

$$V_{ss} = \frac{\alpha_M \cdot M_{ss}}{l}, \text{ (lbf, N)} \qquad (5.1.4.2)$$

where

α_M = factor to take account of restraint of the fixture

= 1.0 if the fixture can rotate freely (no restraint, see Figure 5.7a)

= 2.0 if the fixture cannot rotate (full restraint, see Figure 5.7b)

$$M_{s,s} = M^0_{s,s} \left(1 - \frac{N_{ua}}{N_{ss}}\right), \text{ (lbf- in, N mm)} \qquad (5.1.4.3)$$

$M^0_{s,s}$ = nominal flexural strength of channel T-bolt

$= 1.2 \cdot S_{chb} \cdot f_{uts}$, (lbf in) (N mm) (5.1.4.4)

S_{chb} = elastic section modulus of the channel T-bolt, (in³, mm³)

f_{uts} = minimum [(1.9 f_{ys} or 125,000 (860 MPa)], (psi, MPa) (5.1.4.5)

l = lever arm, (in, mm)

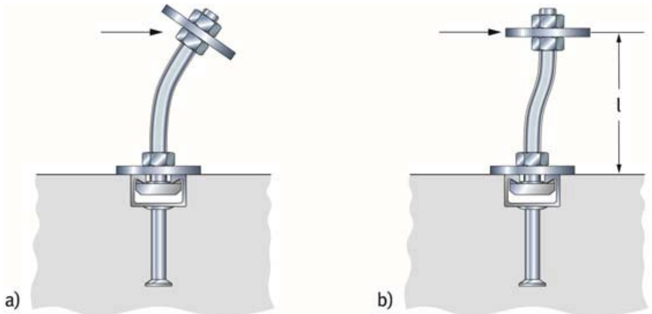


Figure 5.7: Anchor channel for which the shear load is applied with lever arm

a) freely rotatable attachment

b) non-rotatable attachment

5.2.3 Shear failure of the anchor, of channel lips and connection between anchor & channel

The nominal strength of the channel lips V_{sl}, the nominal strength of one anchor V_{sa} and nominal strength of the connection between one anchor & the channel V_{sc}, shall be taken from Table 7.

5.2.4 Concrete edge failure

Verification for concrete edge failure is not necessary if the edge distance in all directions is $c \geq 10h_{ef}$ and $c \geq 60$ d. The lower value governs.

5.2.4.1

The nominal concrete breakout strength, V_{cb}, in shear of a single anchor of an anchor channel in cracked concrete shall be computed as follows:

For a shear force perpendicular to the edge by Eq. (5.2.2.1)

$$V_{cb} = V_b \cdot \psi_{s,V} \cdot \psi_{co,V} \cdot \psi_{h,V}, \text{(lb,N)} \qquad (5.2.2.1)$$

5.2.4.2

For a shear force parallel to an edge (as shown in Figure 5.8), V_{cb}, shall be permitted to be 2.5 times the value of the shear force determined from Eq. (5.2.2.1) with the shear force assumed to act perpendicular to the edge.

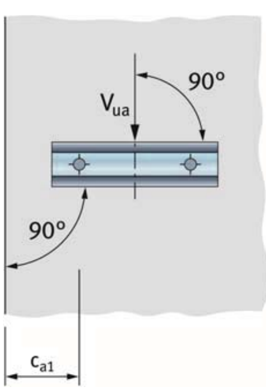


Figure 5.8: Anchor channel installed perpendicular to the edge and loaded parallel to the edge

V_b is the basic concrete breakout strength of a single anchor of an anchor channel. The modification factors $\Psi_{s,V}$, Ψ_{co},V and $\Psi_{h,V}$ are defined in 5.2.4.4, 5.2.4.5 and 5.2.4.6 respectively

5.2.4.3

The basic concrete breakout strength in shear of a single anchor in an anchor channel in cracked concrete, V_b, shall be computed in accordance with Eq. (5.2.2.2).

$$V_b = \lambda \cdot \alpha_{ch,V} \cdot \psi_{c,V} \cdot \sqrt{f'_c} \cdot c_{a1}{}^{4/3}, \text{ (lbf, N)} \tag{5.2.2.2}$$

where

λ = modification factor for sand-lightweight concrete = 0.65

The factor $\alpha_{ch,V} \cdot \psi_{c,V}$ accounts for the influence of channel size, anchor diameter and concrete conditions.

It shall be taken from Table 8 of this report.

5.2.4.4

The modification factor to account for the influence of location and loading of adjacent anchors, $\Psi_{s,V}$, shall be computed as

$$\Psi_{s,V} = \frac{1}{1+ \sum_{i=2}^{n+1}\left[\left(1-\frac{s_i}{s_{cr,V}}\right)^{1.5} \cdot \frac{V^a_{ua,i}}{V^a_{ua,1}}\right]} \tag{5.2.2.3}$$

where (as illustrated in Figure 5.9):

s_i = distance between the anchor under consideration and the adjacent anchors, (in, mm) $\leq s_{cr,v}$

$s_{cr,v}$ = $4c_{a1} + 2b_{ch}$, (in, mm) (5.2.2.4)

$V^a_{ua,i}$ = factored shear load of an influencing anchor, (lbf, N)

$V^a_{ua,1}$ = factored shear load of the anchor under consideration, (lbf, N)

n = number of anchors within a distance $s_{cr,V}$ to both sides of the anchor under consideration

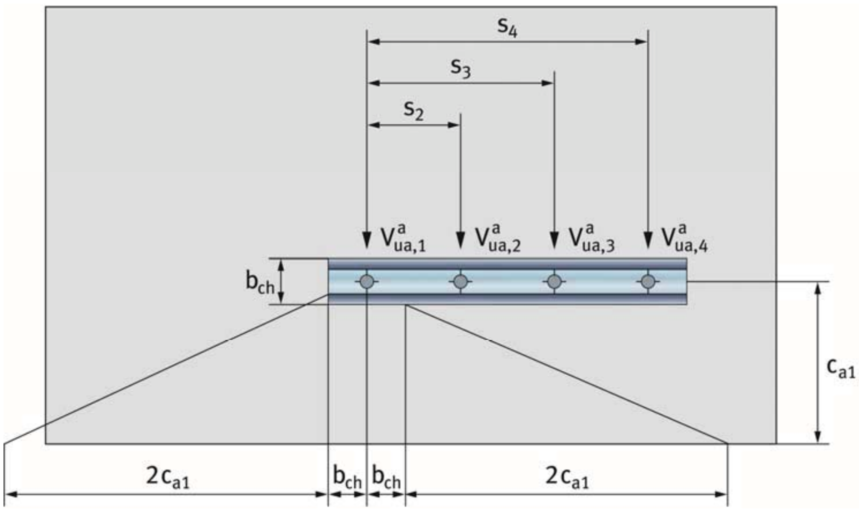


Figure 5.9: – Example of an anchor channel with different anchor shear forces

5.2.4.5

The modification factor for corner effect for an anchor loaded in shear, $\Psi_{co,V}$, shall be computed in accordance with Eq. (5.2.2.5) or (5.2.2.6).

If $c_{a2} \geq c_{cr,V}$

then $\Psi_{co,V} = 1.0$ (5.2.2.5)

If $c_{a2} < c_{cr,V}$

then $\Psi_{co,V} = \left(\frac{c_{a2}}{c_{cr,V}}\right)^{0.5}$ (5.2.2.6)

where

$c_{cr,V} = 2c_{a1} + b_{ch}$, (in, mm) (5.2.2.7)

If an anchor is influenced by two corners (as shown in Figure 5.10), then the factor $\Psi_{co,V}$ in accordance with Eq. (5.2.2.5) or (5.2.2.6) shall be computed for each corner and the product of each value of $\Psi_{co,V}$ shall be inserted in Eq. (5.2.2.2).

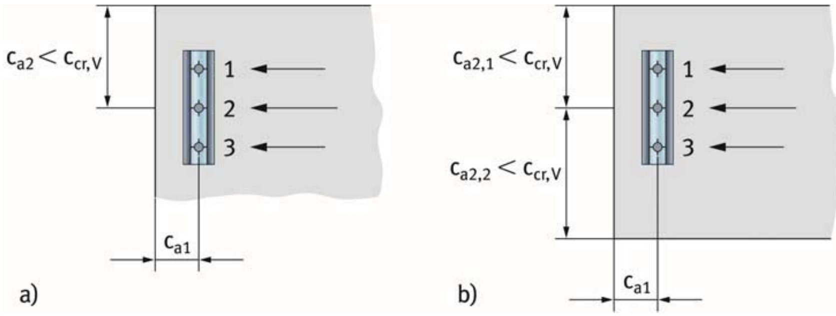


Figure 5.10 – Example of an anchor channel loaded in shear with anchors

a) Influenced by one corner or

b) Influenced by two corners

5.2.4.6

For anchor channels located in a region of a concrete member where analysis indicates no cracking at service load levels, the following modification factor shall be permitted:

$\Psi_{c,V}$ = 1.4

For anchor channels located in a region of a concrete member where analysis indicates cracking at service load levels, the following modifications shall be permitted:

$\Psi_{c,V}$ = 1.0 for anchor channels in cracked concrete with no supplementary reinforcement.

$\Psi_{c,V}$ = 1.2 for anchor channels in cracked concrete with reinforcement of a No. 4 bar (12.7 mm) or greater between the anchor channel and the edge.

$\Psi_{c,V}$ = 1.4 for anchor channels in cracked concrete containing edge reinforcement with a diameter of $^1/_2$ inch (12.7 mm) or greater (No. 4 bar or greater) between the anchor channel and the edge, and with the edge reinforcement enclosed within stirrups with a diameter of $^1/_2$ inch (12.7 mm) or greater (No. 4 or greater) spaced 4 inches (100 mm) maximum.

5.2.4.7

The modification factor for anchor channels located in a concrete member with a height $h < h_{cr,V}$, $\Psi_{h,V}$ (an example is given in Figure 5.11), shall be computed in accordance with Eq. (5.2.2.8).

$$\Psi_{h,V} = \left(\frac{h}{h_{cr,V}}\right)^{\beta_1} \leq 1.0 \qquad (5.2.2.8)$$

where

$$h_{cr,V} = 2_{ca1} + 2_{hch}, \text{ (in, mm)} \qquad (5.2.2.9)$$

$\beta_1 = 2/3$

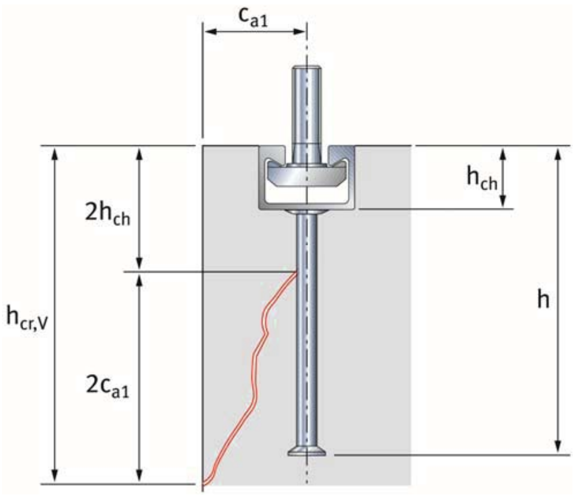


Figure 5.11 - Example of an anchor channel in a member with a thickness $h < h_{CR,V}$

Where an anchor channel is located in a narrow member ($c_{a2,max} < c_{cr,V}$) with a thickness $h < h_{cr,V}$ (see Figure 5.12), the edge distance c_{a1} in Eq. (5.2.2.2), (5.2.2.4), (5.2.2.7) and (5.2.2.9) may be replaced by the value $c_{a1,red}$ determined in accordance with Eq. (5.2.2.10).

$$c_{a1,red} = \max\left[\frac{c_{a2,max}-b_{ch}}{2}, \frac{h-2h_{ch}}{2}\right], \text{(in, mm)} \qquad (5.2.2.10)$$

where $c_{a2,max}$ is the largest of the edge distances perpendicular to the longitudinal axis of the channel.

○ anchor under consideration

● adjacent anchor

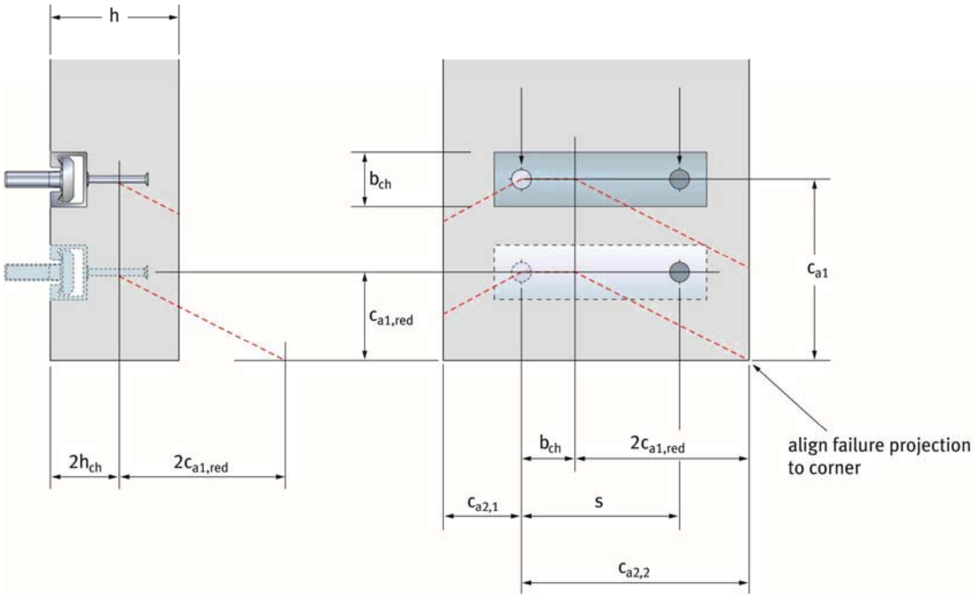


Figure 5.12 – Example of an anchor channel influenced by two corners and member thickness. For this example, the value of ca1,red is obtained by moving the failure surface forward until it intersects the corner as shown (in example $c_{a2,2}$ is decisive for the determination of $c_{a1,red}$).

5.2.5 Concrete Pryout Strength in Shear

The nominal pryout strength, V_{cp}, in shear of a single anchor of an anchor channel without supplementary anchor reinforcement shall be computed in accordance with Eq. (5.2.1.1).

$$V_{cp} = k_{cp} \cdot N_{cb}, \text{ (lbf, N)} \qquad (5.2.1.1)$$

where

k_{cp} = factor taken from table 8 of this booklet.

N_{cb} = nominal concrete breakout strength of the anchor under consideration, (lbf, N), determined in accordance with 5.1.4; however in the determination of the modification factor $\Psi_{s,N}$, the values $N^a_{ua,1}$ and $N^a_{ua,i}$ in Eq. (4.2.2.4) shall be replaced by $V^a_{ua,1}$ and $V^a_{ua,i}$, respectively.

The nominal pryout strength of a single anchor of an anchor channel with supplementary anchor reinforcement shall not exceed

$$V_{cp} = 0.75 \cdot k_{cp} \cdot N_{cb}, \text{ (lbf, N)} \quad (5.2.1.2)$$

where k_{cp} and N_{cb} as defined above.

5.2.6 Design of supplementary reinforcement

For anchor channels with b_{ch} greater than 1.1 inches (28 mm) and h_{ch} greater than 0.6 inches (15 mm) arranged parallel to the edge and loaded by a shear load perpendicular to the edge and anchor reinforcement developed in accordance with Chapter 12 on both sides of the concrete surface, the design strength of the anchor reinforcement, ϕV_{ca}, shall be permitted to be used instead of the concrete breakout strength, ϕV_{cb}, in determining ϕV_n. A strength reduction factor ϕ of 0.75 shall be used in the design of the anchor reinforcement.
The strength of the anchor reinforcement assumed in design shall not exceed the value in accordance with Eq. (5.2.3.1).

The maximum strength of the anchor reinforcement, $V_{ca,max}$, of a single anchor of an anchor channel shall be computed in accordance with Eq. (5.2.3.1).

$$V_{ca,max} = \frac{2.85}{(c_{a1})^{0.12}} \cdot V_{cb}, \text{ (lbf)} \quad (5.2.3.1)$$

$$V_{ca,max} = \frac{4.2}{(c_{a1})^{0.12}} \cdot V_{cb}, \text{ (N)} \quad (5.2.3.1)$$

where V_{cb} is determined in accordance with Eq. (5.2.2.1).

Only anchor reinforcement that complies with the following requirements shall be assumed as effective.

a) Anchor reinforcement shall consist of stirrups made from deformed reinforcing steel bars with a maximum diameter of $^{5}/_{8}$ inch (15.9 mm / No. 5 bar) and straight edge reinforcement with a diameter not smaller than the diameter of the stirrups (as shown in Figure 5.13).

b) Only one bar at both sides of each anchor shall be assumed as effective. The distance of this bar from the anchor shall not exceed 0.5 c_{a1} and the anchorage length in the breakout body shall be no less than 4 times the bar diameter. The distance between stirrups shall not exceed the smaller of anchor spacing or 6 inches (152 mm).

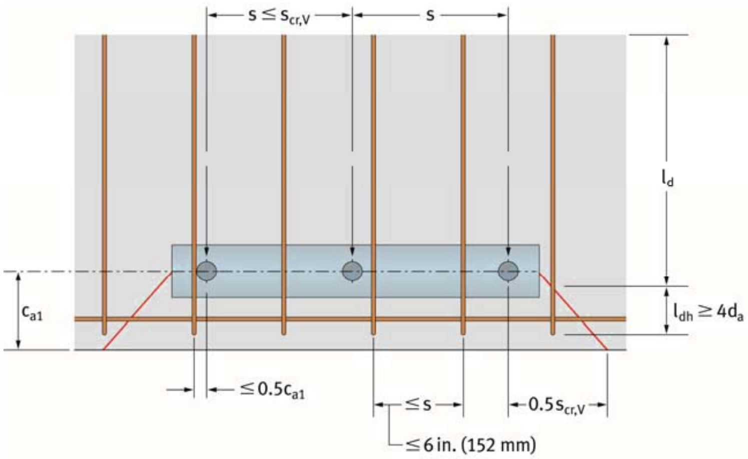


Figure 5.13— Requirements for detailing of anchor reinforcement of anchor channels

The anchor reinforcement of an anchor channel shall be designed for the highest anchor load, V_{ua}^{a} of all anchors but at least for the highest individual shear load, V_{ua} acting on the channel. This anchor reinforcement shall be arranged at all anchors of an anchor channel.

5.2.7 Steel failure in supplementary reinforcement

The determination of the nominal strength of the supplementary reinforcement during steel failure is carried out with the equation (5.2.4.1).

$$V_{ca} = n \cdot A_s \cdot f_y (\text{lbf, N}) \qquad (5.2.4.1)$$

with

n = number of legs of the supplementary reinforcement for an anchor in the failure cone

A_s = cross-section of a leg of the supplementary reinforcement

f_y = specified yield strength of reinforcement

5.3 Combined tensile and shear load

5.3.1 General

Anchor channels subjected to combined axial and shear loads shall be designed to satisfy the requirements of 5.3.1 and 5.3.3 for the channel T-bolts and all anchors of the anchor channel. In this case, it is not necessary to distinguish between the materials and failure modes (steel failure of the channel T-bolt, steel failure modes of the channel and concrete failure modes).

Furthermore if the design shear load V_{ua}^{s} is larger than V_{ua}^{a} then the value V_{ua}^{s} shall be inserted in Section 5.3.1 and 5.3.2 instead of V_{ua}^{a}. For anchor channels with anchor reinforcement, failure of the anchor reinforcement shall be treated as concrete failure. Alternatively, it shall be allowed to satisfy 5.3.3 for the channel T-bolts and all anchors of the anchor channel by distinguishing between the different failure modes.

For the equations below the following definitions are used:

ΦN_{ns} = steel strength of anchor channel loaded in tension (lowest value of N_{sa}, N_{sc} and N_{sl}) (lbf, N)
ΦV_{ns} = steel strength of anchor channel loaded in shear (lowest value of V_{sa}, V_{sc} and V_{sl}) (lbf, N)
ΦN_{n} = lowest tension strength from all appropriate failures modes under tension (lbf, N)
ΦV_{n} = lowest shear strength from all appropriate failures modes under shear (lbf, N)

5.3.2 Combination for $\Phi V_{ns} < \Phi N_{ns}$

Anchor channels with $\phi Vns \leq \phi Nns$ and where no anchor reinforcement is provided, or for anchor channels with $\phi Vns \leq \phi Nns$ and where anchor reinforcement is provided for both tension and shear loads, the following requirements shall be satisfied.

If $V_{ua}^{a} \leq 0.2 \cdot \phi V_{n}$,

the full strength in tension shall be permitted: $\phi N_{n} \geq N_{ua}^{a}$

If $N_{ua}^{a} \leq 0.2 \cdot \phi N_{n}$,

the full strength in shear shall be permitted: $\phi V_{n} \geq V_{ua}^{a}$

If $V_{ua}^{a} > 0.2\, \phi V_{n}$ and $N_{ua}^{a} > 0.2\, \phi N_{n}$

Then Eq. (6a) applies.

$$\frac{N_{ua}^{a}}{\phi N_{n}} + \frac{V_{ua}^{a}}{\phi V_{n}} \leq 1.2 \qquad (6a)$$

Alternatively, the interaction equation (6b) may be satisfied

$$\left(\frac{N_{ua}^{a}}{\phi N_{n}}\right)^{5/3} + \left(\frac{V_{ua}^{a}}{\phi V_{n}}\right)^{5/3} \leq 1.0 \qquad (6b)$$

5.3.3 Combination for $\Phi V_{ns} > \Phi N_{ns}$ or reinforced concrete

For anchor channels with ϕVns ≤ ϕNns where anchor reinforcement is provided for only one direction (tension or shear), Eq. (6c) shall be satisfied.

$$\frac{N_{ua}^{a}}{\phi N_n} + \frac{V_{ua}^{a}}{\phi V_n} \leq 1.0 \qquad (6c)$$

And for anchor channels with $\phi V_{ns} > \phi N_{ns}$ and where no anchor reinforcement is provided, or for anchor channels with $\phi V_{ns} > \phi N_{ns}$ and where anchor reinforcement is provided for both tension and shear loads, Eq. (6c) shall be satisfied.

5.3.4 Combination distinguishing between failure modes

Alternatively, it shall be allowed to satisfy the requirements according to 6.3.3.1 through 6.3.3.3 by distinguishing between steel failure of the channel T-bolt, steel failure modes of the channel and concrete failure modes.

5.3.4.1

For channel T-bolts, Eq. (6.5.1.1) shall be satisfied

$$\left(\frac{N_{ua}^{s}}{\phi N_{ss}}\right)^2 + \left(\frac{V_{ua}^{s}}{\phi V_{ss}}\right)^2 \leq 1.0 \qquad (6.5.1.1)$$

where N_{ua}^{s} and V_{ua}^{s} are the factored tension load and factored shear load on the channel T-bolt under consideration.

5.3.4.2

For steel failure modes of anchor channels Eq. (6.3.1.1) and (6.4.1.1) shall be satisfied.

a) For anchor and connection between anchor and channel

$$\left(\frac{N_{ua}^{a}}{\phi N_{ns,a}}\right)^{\alpha} + \left(\frac{V_{ua}^{a}}{\phi V_{ns,a}}\right)^{\alpha} \leq 1.0 \qquad (6.3.1.1)$$

where

$\alpha = 2$ for anchor channels with $\phi V_{ns,a} \leq \phi N_{ns,a}$. Shear strengths values acc. Table 7.1.

$\alpha < 2$ for anchor channels with $\phi V_{ns,a} > \phi N_{ns,a}$. The exponent α shall be taken from Table 7.2

b) At the point of load application

$$\left(\frac{N_{ua}^{s}}{\phi\, N_{ns,l}}\right)^{\alpha} + \left(\frac{V_{ua}^{s}}{\phi\, V_{sl}}\right)^{\alpha} \leq 1.0 \qquad (6.4.1.1)$$

where

$\alpha = 2$ for anchor channels with $\phi V_{sl} \leq \phi N_{ns,l}$. Shear strengths values acc. Table 7

5.3.4.3 For concrete failure modes of anchor channels Eq. (6.1.1.1) shall be satisfied

$$\left(\frac{N_{ua}^{a}}{\phi\, N_{nc}}\right)^{\alpha} + \left(\frac{V_{ua}^{a}}{\phi\, V_{nc}}\right)^{\alpha} \leq 1.0 \qquad (6.1.1.1)$$

where

$\alpha = 1.5$ anchor channels without anchor reinforcement or with anchor reinforcement to take up tension and shear loads

$\alpha = 1.0$ anchor channels with anchor reinforcement to take up tension or shear loads

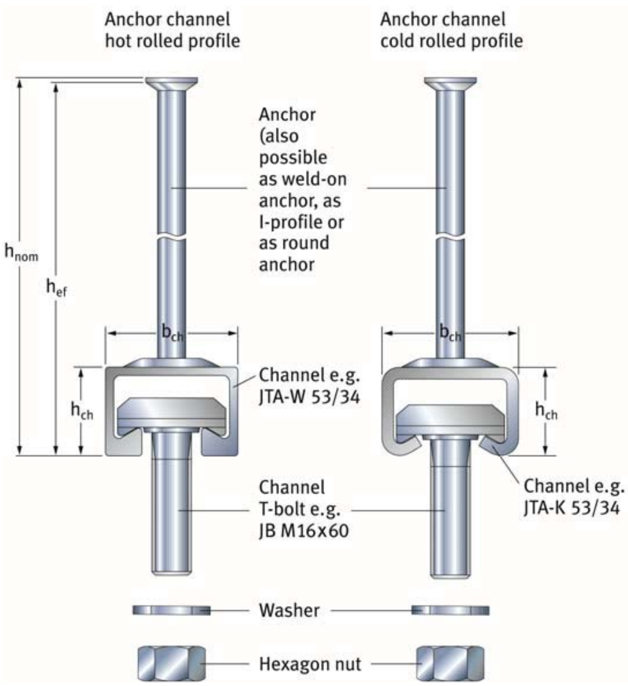
6 References

[1] Eligehausen, R.; Mallée, R. ; Silva, J.: Anchorage in Concrete Construction. Ernst & Sohn, Berlin, 2006

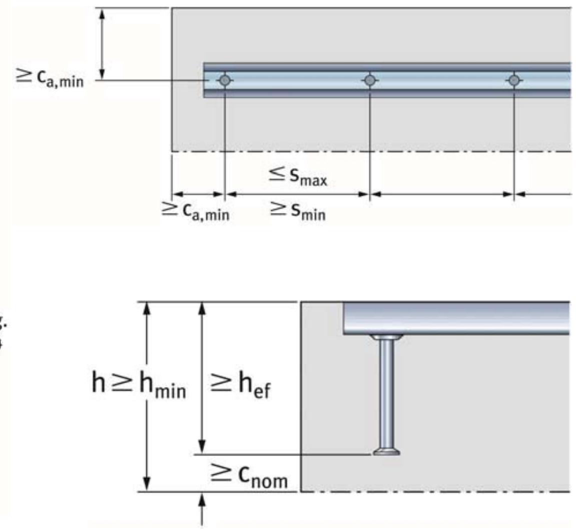
[2] American Concrete Institute: Building Code Requirements for Structural Concrete, (ACI 318-11), Farmington Hills, August 2011

[3] ICC Evaluation Service: Acceptance Criteria for Anchor Channels in Concrete Elements (AC 232), approved 2012

Anchor Channels



Installation parameters



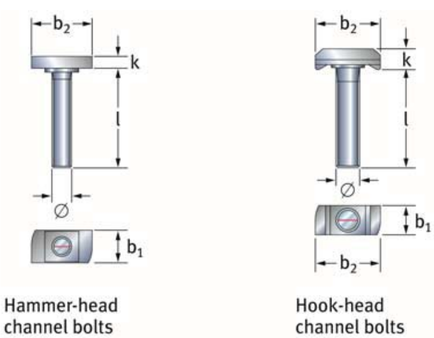


Figure 1: Installation Parameters for Anchor Channels and T-bolts

7 Specification and strength values JTA anchor channel system

Table 1: geometry and spacing of anchor channels

Criteria	Symbol	Units	Anchor channel sizes JTA						
			K 28/15	K 38/17	W 40/22[2]	W 50/30	W 53/34	W 55/42[3]	W 72/48
Channel height	h_{ch}	in	0.60	0.69	0.91	1.18	1.32	1.65	1.91
		(mm)	(15.25)	(17.5)	(23)	(30)	(33.5)	(42)	(48.5)
Channel width	b_{ch}	in	1.10	1.50	1.56	1.93	2.07	2.15	2.83
		(mm)	(28)	(38)	(39.5)	(49)	(52.5)	(54.5)	(72)
Moment of inertia, mild steel and stainless steel	I_y	in^4	0.010	0.021	0.047	0.125	0.224	0.450	0.840
		(mm^4)	(4060)	(8547)	(19703)	(51904)	(93262)	(187464)	(349721)
Minimum anchor spacing	s_{min}	in	1.97	1.97	1.97	1.97	3.15	3.15	3.15
		(mm)	(50)	(50)	(50)	(50)	(80)	(80)	(80)
Maximum anchor spacing	s_{max}	in	7.87	7.87	9.84	9.84	9.84	11.81	15.75
		(mm)	(200)	(200)	(250)	(250)	(250)	(300)	(400)
Installation height	h_{inst}	in	1.97	3.15	3.54	3.94	6.50	7.48	7.68
		(mm)	(50)	(80)	(90)	(100)	(165)	(190)	(195)
Minimum edge distance	$c_{a,min}$ [4]	in	1.60	2.00	2.00	3.00	4.00	4.00	6.00
		(mm)	(41)	(51)	(51)	(76)	(102)	(102)	(152)
Min member thickness	h_{min}	in (mm)	$h_{min} = h_{inst} + c_{nom}$						

[2] Iy in stainless steel = 19759 mm4 (0.05 in4)
[3] Available only in mild steel
[4] Taking c_{min} into account, splitting failure does not govern

Table 2: combination of channels and T-bolts

Criteria	Units	Anchor channel sizes JTA						
		K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42	W 72/48
T-bolt type	-	JD	JH	JC	JB	JB	JB/JE	JA
Diameter Ø	[mm]	6	-	-	-	-	-	-
		8	10	10	10	10	10	-
		10	12	12	12	12	12	-
		12	16	16	16	16	16	-
		-	-	-	20	20	20	20
		-	-	-	-	-	24	24
		-	-	-	-	-	-	27
		-	-	-	-	-	-	30

Table 3: steel strength values of T-bolts in tension

				M6	M8	M10	M12	M16	M20	M24	M27	M30
Nominal tensile strength	N_{ss}	(lbf, kN)	4.6[1]	1799	3282	5216	7576	14119	22032	31745	41277	50450
				(8)	(14.6)	(23.2)	(33.7)	(62.8)	(98)	(141.2)	(183.6)	(224.4)
			8.8[1]	-	6272	8768	15153	21358	40468	63489	-	-
				-	(27.9)	(39)	(67.4)	(95)	(180)	(282.4)	-	-
			A4-50[2], HCR-50[3,5]	-	-	-	7576	14119	22032	-	-	-
				-	-	-	(33.7)	(62.8)	(98)	-	-	-
			A4-70[2], HCR-70[3,6], FA-70[4,6]	-	5755	9128	13242	21358	38557	-	-	-
				-	(25.6)	(40.6)	(58.9)	(95)	(171.5)	-	-	-
Strength reduction factor for steel failure under tension	Φ	-	4.6, 8.8, A4-50, A4-70, HCR-50, HCR-70, FA-70	0.65								

For SI: 1 lbf = 4.448 N
For pound-inch units: 1 N = 0.2248 lbf

1 According to EN ISO 898-1
2 Material numbers 1.4401/1.4404/1.4571
3 Material numbers 1.4529/1.4547
4 Material numbers 1.4362/1.4462
5 The mechanical properties ($f_{ut,s}$, f_{ys}) of stainless steel A4-50 and HCR-50 are identical
6 The mechanical properties ($f_{ut,s}$, f_{ys}) of stainless steel A4-70, HCR-70 and FA-70 are identical

Table 4: steel strength values of channels in tension

Criteria	Symbol	Units	Anchor channel sizes						
			K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42[2]	W 72/48
Nominal strength for local failure of channel lips, tension	N_{sl}[1]	lbf	2023	4047	7868	8093	14613	17985	22481
		(kN)	(9)	(18)	(35)	(36)	(65)	(80)	(100)
Nominal steel strength of a single anchor in tension, round anchor	N_{sa}[1]	lbf	2023	4047	4496	6969	12365	17985	22481
		(kN)	(9)	(18)	(20)	(31)	(55)	(80)	(100)
Nominal steel strength of a single anchor in tension, I-anchor	N_{sa}[1]	lbf	2023	4047	4496	6969	12365	17985	22481
		(kN)	(9)	(18)	(20)	(31)	(55)	(80)	(100)
Nominal tension strength connection channel / anchor	N_{sc}[1]	lbf	2023	4047	4496	6969	12365	17985	22481
		(kN)	(9)	(18)	(20)	(31)	(55)	(80)	(100)
Strength reduction factor	Φ	0.75							
Nominal bending strength of channel, mild steel	$M_{s,flex}$	lbf in	2806	5133	9523	13524	22392	42793	76054
		(Nm)	(317)	(580)	(1076)	(1528)	(2530)	(4835)	(8593)
Nominal bending strength of channel, stainless steel	$M_{s,flex}$	lbf in	2868	5248	9559	13816	22870	-	77666
		(Nm)	(324)	(593)	(1080)	(1561)	(2584)	-	(8775)
Strength reduction factor	Φ	0.85							

For SI: 1 in = 25.4 mm, 1 lbf = 4.448 N
For pound-inch units: 1 mm = 0.03937 in, 1 N = 0.2248 lbf

[1] Values valid for mild steel and stainless steel
[2] Available only in mild steel

Table 5: concrete strength values (2500 PSI, cracked concrete) of channels in tension

Criteria	Symbol	Units	Anchor channel sizes K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42	W 72/48
Pullout strength round anchor	N_p [1]	lbf	2293	4991	3664	5418	10094	13062	17311
		(kN)	(10.2)	(22.2)	(16.3)	(24.1)	(44.9)	(58.1)	(77)
Pullout strength welded anchor	N_p [1]	lbf	2383	4766	5171	7554	8746	14996	18930
		(kN)	(10.6)	(21.2)	(23)	(33.6)	(38.9)	(66.7)	(84.2)
Strength reduction factor	Φ		0.70						
Embedment depth	h_{ef}	in	1.77	2.99	3.11	3.70	6.10	6.89	7.05
		(mm)	(45)	(76)	(79)	(94)	(155)	(175)	(179)

For SI: 1 in = 25.4 mm, 1 lbf = 4.448 N
For pound-inch units: 1 mm = 0.03937 in, 1 N = 0.2248 lbf

[1] Values for cracked concrete, concrete strength f_c' = 2500 psi (17.2 MPa). Modification for other concrete grades or non-cracked conditions see chapter 5.13.

Table 6: steel strength values of T-bolts in shear

Criteria	Symbol	Units	Grade / Material	T-bolt sizes								
				M6	M8	M10	M12	M16	M20	M24	M27	M30
Nominal shear strength	V_{ss}	lbf (kN)	4.6[1]	1079	1978	3125	4541	8476	13219	19042	24775	30261
				(4.8)	(8.8)	(13.9)	(20.2)	(37.7)	(58.8)	(84.7)	(110.2)	(134.6)
			8.8[1]	-	3957	6250	9098	16951	26439	38085	-	-
				-	(17.6)	(27.8)	(40.4)	(75.4)	(117.6)	(169.4)	-	-
			A4-50[2], HCR-50[3,5]	-	-	3125	4541	8476	13219	19042	-	-
				-	-	(13.9)	(20.2)	(37.7)	(58.8)	(84.7)	-	-
			A4-70[2], HCR-70[3,6], FA-70[4,6]	-	3462	5486	7959	14816	23134	-	-	-
				-	(15.4)	(24.4)	(35.4)	(65.9)	(102.9)	-	-	-
Strength reduction factor for steel failure under shear	Φ	-	4.6, 8.8, A4-50, A4-70, HCR-50, HCR-70, FA-70	0.60								
Nominal bending strength of T-bolt	M^0_{ss}	lbf,·in (Nm)	4.6[1]	56	133	265	463	1175	2295	3966	5900	7957
				(6.3)	(15)	(29.9)	(52.3)	(132.8)	(259.3)	(448.1)	(666.6)	(899)
			8.8[1]	-	266	529	926	2351	4590	7931	-	-
				-	(30)	(59.8)	(104.6)	(265.6)	(518.6)	(896.1)	-	-
			A4-50[2], HCR-50[3,5]	-	-	265	463	1175	2295	-	-	-
				-	-	(29.9)	(52.3)	(132.8)	(259.3)	-	-	-
			A4-70[2], HCR-70[3,6], FA-70[4,6]	-	233	464	811	2057	4016	-	-	-
				-	(26.3)	(52.4)	(91.6)	(232.4)	(453.8)	-	-	-
Strength reduction factor for bending failure	Φ	-	4.6, 8.8, A4-50, A4-70, HCR-50, HCR-70, FA-70	0.65								

For SI: 1 in = 25.4 mm, 1 lbf = 4.448 N
For pound-inch units: 1 mm = 0.03937 in, 1 N = 0.2248 lbf

[1] According to EN ISO 898-1
[2] Material numbers 1.4401/1.4404/1.4571
[3] Material numbers 1.4529/1.4547
[4] Material numbers 1.4362/1.4462
[5] The mechanical properties ($f_{ut,s}$, f_{ys}) of stainless steel A4-50 and HCR-50 are identical
[6] The mechanical properties ($f_{ut,s}$, f_{ys}) of stainless steel A4-70, HCR-70 and FA-70 are identical

Table 7: steel strength values for local bending of channel lips in shear, interaction α = 2.0

Criteria	Symbol	Units	Anchor channel sizes						
			K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42[2]	W 72/48
Nominal strength for local failure of channel lips, shear	V_{sl}[1]	lbf	2023	4047	7868	8094	14613	17985	22481
		(kN)	(9)	(18)	(35)	(36)	(65)	(80)	(100)
Interaction exponent	α	-	2						
Strength reduction factor	Φ	-	0.75						

For SI: 1 lbf = 4.448 N
For pound-inch units: 1 N = 0.2248 lbf

1 Values valid for structural steel and stainless steel
2 Available only in mild steel

Table 7.1: steel strength values for anchor and connection of anchor / channel, interaction α = 2.0

Criteria	Sym-bol	Units	Anchor channel sizes						
			K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42[2]	W 72/48
Nominal steel strength of a single anchor in shear, round anchor	V_{sa}[1]	lbf	2023	4047	4496	6969	12365	17986	22482
		(kN)	(9)	(18)	(20)	(31)	(55)	(80)	(100)
Nominal steel strength of a single anchor in shear, welded anchor	V_{sa}[1]	lbf	2023	4047	4496	6969	12365	17986	22482
		(kN)	(9)	(18)	(20)	(31)	(55)	(80)	(100)
Nominal shear strength for connection channel / anchor	V_{sc}[1]	lbf	2023	4047	4496	6969	12365	17986	22482
		(kN)	(9)	(18)	(20)	(31)	(55)	(80)	(100)
Interaction exponent	α	-	2	2	2	2	2	2	2
Strength reduction factor	Φ	-	0.75						

Table 7.2: steel strength values for anchor and connection of anchor channel, interaction α = 1.2

Criteria	Sym-bol	Units	Anchor channel sizes						
			K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42[2]	W 72/48
Nominal steel strength of a single anchor in shear, round anchor	V_{sa}[1]	lbf	-	-	8543	10116	15737	22482	28101
		(kN)	-	-	(38)	(45)	(70)	(100)	(125)
Nominal steel strength of a single anchor in shear, welded anchor	V_{sa}[1]	lbf	-	-	8543	10116	15737	22482	28101
		(kN)	-	-	(38)	(45)	(70)	(100)	(125)
Nominal shear strength for connection channel / anchor	V_{sc}[1]	lbf	-	-	8543	10116	15737	22482	28101
		(kN)	-	-	(38)	(45)	(70)	(100)	(125)
Interaction exponent	α	-	-	-	1.2	1.2	1.2	1.2	1.2
Strength reduction factor	Φ	-	0.75						

For SI: 1 lbf = 4.448 N
For pound-inch units: 1 N = 0.2248 lbf

[1] Values valid for mild steel and stainless steel
[2] Available only in mild steel

Table 8: concrete strength values in shear

Criteria		Symbol	Units	Anchor channel sizes						
				K 28/15	K 38/17	W 40/22	W 50/30	W 53/34	W 55/42	W 72/48
Product of factor $\alpha_{ch,V} \cdot \Psi_{c,V}$ [2]	Cracked concrete without reinforcement[1]	$\alpha_{ch,V} \cdot \Psi_{c,V}$	-	5.5 (4.0)	8.4 (6.0)	9.0 (6.5)	10.4 (7.5)	10.4 (7.5)	10.4 (7.5)	11.1 (8.0)
	Uncracked concrete [3]	$\alpha_{ch,V} \cdot \Psi_{c,V}$	-	7.9 (5.7)	11.9 (8.6)	12.9 (9.3)	14.9 (10.7)	14.9 (10.7)	14.9 (10.7)	15.8 (11.4)
Exponent		β_1	-	2/3						
Pryout Failure, factor		k_{cp}	-	1	2					
Strength reduction factor		Φ	-	0.7						

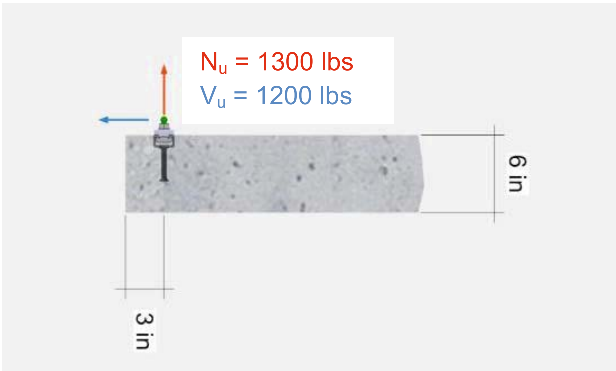
[1] For anchor channels in cracked concrete with no supplementary reinforcement

[2] For anchor channels in cracked concrete with reinforcement of a No. 4 bar (12.7 mm) or greater between the anchor channel and the edge multiply the values of cracked concrete without reinforcement by 1.2

[3] For anchor channels in uncracked concrete or cracked concrete containing edge reinforcement with a diameter of 1/2 in. (12.7 mm) or greater (No.4 bar or greater) between the anchor channel and the edge, and with the edge reinforcement enclosed within stirrups with a diameter of 1/2 in. (12.7 mm) or greater (No. 4 bar or greater) spaced 4 in. (100 mm) maximum

8 Design Examples

8.1 Example 1, single load acting on JTA W40/22, 2 anchors



Top View

<u>Channel and T-bolt:</u>

Profile W40/22, L = 6 in., 2 anchors

Anchor spacing: s = 4 in.

1 T-bolt M12 4.6

<u>Concrete conditions:</u>

Concrete 3500 psi, cracked concrete

Member thickness h = 6 in.

Edge distance c_1 = 3 in.

Edge distance c_2 = 8 in.

<u>Factored loads applied to T-bolt:</u>

N_u = 1300 lbs, V_u = 1200 lbs

In this example the critical load position for most design checks is over the anchor. To check for bending of the channel the load is applied at midspan (between the anchors).

Values

Characteristic values	Φ-Factor
I_y = 0.047 in ^{4}	
N_{sa} = 4496 lbs	0.75
N_{sc} = 4496 lbs	0.75
N_{sl} = 7868 lbs	0.75
N_{ss} = 7576 lbs	0.65
M_{sflex} = 9523 lbs in.	0.85
N_p = 3600 lbs (for 2500 psi)	0.7
h_{ef} = 3.11 in.	
α_{ch} = 0,88	
$s_{cr,N}$ = 13.9 in.	
$c_{cr,N}$ = 6.9 in.	
V_{sa} = 8543 lbs	0.75
V_{sc} = 8543 lbs	0.75
V_{sl} = 7868 lbs	0.75
V_{ss} = 4541 lbs	0.6
$\alpha_{ch,V} \cdot \Psi_{c,V}$= 9.0	
b_{ch} = 1.56 in.	
h_{ch} = 0.91 in.	

1. Load distribution

Calculation of anchor forces

$l_i = 4.93 \cdot I_y^{0,05} \cdot s^{0,5} = 4.93 \cdot 0.047^{0,05} \cdot 3.93^{0,5} = 8.39$ in. (eq. 3.3)

Load position: T-Bolt is located directly above the first anchor (all checks except 2.5)

		Anchor 1	Anchor 2
1.1	Distance of the load to the anchor (in.)	0	4
1.2	$A'_i = (l_i - s)/l_i$	(8.39-0)/8.39 = 1.000	(8.39-4)/8.39 = 0.531
1.3	$k = 1/\Sigma A'_i$	1/(1.00+0.531) = 0.653	
1.4	$N^a_{ua} = k \cdot A'_i \cdot N_{ua}$ (lbs)	0.653·1.000·1300= **850**	0.653·0.531·1300= **450**
	Analog for shear: V^a_{ua} (lbs)	**785**	**415**

For 2.5 below the load is applied at midspan (critical), the anchor load in tension is 1300/2 = 650 lbs.

2. Tension Loads

2.1 Check steel failure of anchor

N_{ua}^{a} = 850 lbs

ϕN_{sa} = $\phi \cdot N_{sa}$ = 0.75 ·4496 lbs = 3372 lbs

β_N = $N_{ua}^{a} / \phi N_{sa}$ = 0.25 ≤ 1 ✓

2.2 Check failure of connection between anchor and channel

N_{ua}^{a} = 850 lbs

ϕN_{sc} = $\phi \cdot N_{s,c}$ = 0.75 ·4496 lbs = 3372 lbs

β_N = $N_{ua}^{a} / \phi N_{sc}$ = 0.25 ≤ 1 ✓

2.3 Check failure of channel lip

N_{ua} = 1300 lbs

ϕN_{sl} = $\phi \cdot N_{sl}$ =0.75 ·7868 lbs = 5901 lbs

β_N = $N_{ua}^{a} / \phi N_{sl}$ = 0.22 ≤ 1 ✓

2.4 Check steel failure of T-bolt

N_{ua}^{s} = 1300 lbs

ϕN_{ss} = $\phi \cdot N_{ss}$ = 0.65 ·7576 lbs = 4924 lbs

β_N = $N_{ua}^{s} / \phi N_{ss}$ = 0.26 ≤ 1 ✓

2.5 Check bending of channel

Governing load position: centered between the anchors

M_{ua} = $\frac{1}{4}$ ·(1300 lbs ·3.93 in.) = 1277 lbs in.

M_{sflex} = 9523 lbs in.

ϕM_{sflex} = 0.85 · 9523 lbs = 8095 lbs

β_N = $\frac{1277 \text{ lbs in.}}{8095 \text{ lbs in.}}$ = 0.16 ≤ 1 ✓

2.6 Check pull out failure

N_{ua}^{a} = 850 lbs

ϕN_p = $\phi \cdot \Psi_{cp} \cdot N_p$ (3500 psi) = 0.7 ·1.0 ·3664 · $\frac{3500}{2500}$ = 3596 lbs (eq. 4.2.1.1)

β_N = $\frac{850 \text{ lbs}}{3591 \text{ lbs}}$ = 0.24 ≤ 1 ✓

2.7 Check concrete cone failure (Anchor 1)

N_{ua}^{a} = 850 lbs

$N_b = 24 \cdot \alpha_{ch,N} \cdot f_c'^{0.5} \cdot h_{ef}^{1.5} = 24 \cdot 0.88 \cdot 3500^{0.5} \cdot 3.11^{1.5} = 6880$ lbs (eq. 4.2.2.2)

Influence of adjacent anchors

$$\Psi_{s,N} = \frac{1}{1+\sum_{i=2}^{n+1}\left[\left(1-\frac{s_i}{s_{cr,N}}\right)^{1.5} \cdot \frac{N_{ua,i}^{a}}{N_{ua,1}^{a}}\right]}$$ (eq. 4.2.2.4)

$$S_{cr,N} = 2\left(2.8-\frac{1.3 \cdot 3.11}{7.1}\right) \cdot 3.11 = 13.87$$ (eq. 4.2.2.5)

$$\Psi_{s,N} = \frac{1}{1+\left(1-\frac{3.93}{13.87}\right)^{1.5} \cdot \frac{450}{850}} = 0.76$$

Influence of member edges

$c_{cr,N} = 0.5 \cdot s_{cr,N} = 0.5 \cdot 13.87$ in. = 6.94 in. (eq.4.2.2.8)

c_{a1} = 3 in < $c_{cr,N}$ (eq.4.2.2.7)

$$\Psi_{ed,N} = \left(\frac{3 \text{ in}}{6.94 \text{ in}}\right)^{0.5} = 0.66$$

Influence of corner

c_{a2} = 8 in > 6.94 in. (eq.4.2.2.9)

$\Psi_{co,N} = 1.0$

Influence of cracked concrete

$\Psi_{c,N} = 1.0$ (cracked concrete)

$\phi N_{cb} = \phi N_b \cdot \Psi_{s,N} \cdot \Psi_{ed,N} \cdot \Psi_{co,N} \cdot \Psi_{c,N} \cdot \Psi_{cp,N}$ (eq. 4.2.2.1)

$= 0.7 \cdot 6880 \text{ lbs} \cdot 0.76 \cdot 0.66 \cdot 1.00 \cdot 1.00 \cdot 1.00 = 2404$ lbs

$\beta_N = N_{ua}^{a} / \phi N_{cb} = 0.35 \leq 1$ ✓

3. Shear Loads

3.1 Check steel failure of anchor

V_{ua}^{a} = 785 lbs

ϕV_{sa} = $\phi \cdot V_{sa}$ = 0.75 · 4496 lbs = 3372 lbs

β_V = $V_{ua}^{a} / \phi V_{sa}$ = 0.23 ≤ 1.0 ✓

3.2 Check failure of connection between anchor and channel

V_{ua}^{a} = 785 lbs

ϕV_{sc} = $\phi \cdot V_{sc}$ = 0.75 · 4496 lbs = 3372 lbs

β_V = $V_{ua}^{ay} / \phi V_{sc}$ = 0.23 ≤ 1.0 ✓

3.3 Check failure of channel lip (Load 1)

V_{ua} = 1200 lbs

ϕV_{sl} = $\phi \cdot V_{sl}$ = 0.75 · 7868 lbs = 5901 lbs

β_V = $V_{ua} / \phi V_{sl}$ = 0.20 ≤ 1.0 ✓

3.4 Check steel failure of T-bolt

V_{ua}^{s} = 1200 lbs

ϕV_{ss} = $\phi \cdot V_{ss}$ = 0.60· 4541 lbs = 2725 lbs

β_V = $V_{ua}^{s} / \phi V_{ss}$ = 0.44 ≤ 1.0 ✓

3.5 Check concrete edge failure c_{11}

V_{ua}^{a} = 785 lbs

V_b = $\alpha_{ch,V} \cdot \Psi_{cV} \cdot \sqrt{f'_c} \cdot c_{a1}^{1.33}$

= $9.0 \cdot 3500^{0.5} \cdot 3.00^{1.33}$ = 2304 lbs

Influence of adjacent anchors

$\Psi_{s,V} = \frac{1}{1+\sum_{i=2}^{n+1}\left[\left(1-\frac{s_i}{s_{cr,V}}\right)^{1.5} \cdot \frac{V_{ua,i}^{a}}{V_{ua,1}^{a}}\right]}$ (eq. 5.2.2.3)

$s_{cr,v}$ = $4c_{a1} + 2b_{ch}$ = 12 in+2·1.56 in = 15.12 in (eq. 5.2.2.4)

$$\Psi_{s,v} = \frac{1}{1+\left(1-\frac{3.93}{15.12}\right)^{1.5}\cdot\frac{415}{785}} = 0{,}75$$

Influence of corner

$c_{cr,V} = 2c_{a1} + b_{ch}$

$= 2\cdot 3 \text{ in} + 1.56 \text{ in} = 7.56 \text{ in}$ (eq. 5.2.2.7)

$c_{a2} = 8 \text{ in} > 7.56 \text{ in}$

$\Psi_{co,v} = 1.0$ (eq. 5.2.2.5)

Influence of member thickness

$h_{cr,V} = 2ca_1 + 2h_{ch}$

$= 2 \cdot 3 + 2 \cdot 0.91 = 7.82 \text{ in}$ (eq. 5.2.2.9)

$\Psi_{h,V} = \left(\frac{h}{h_{cr,V}}\right)^{\beta_1}$ (eq. 5.2.2.8)

$= \left(\frac{6}{7.82}\right)^{\frac{2}{3}} = 0.84$

$V_{cb} = \phi\, V_b \cdot \Psi_{s,V} \cdot \Psi_{co,V} \cdot \Psi_{h,V} =$ (eq. 5.2.2.1)

$= 0.70 \cdot 2304 \text{ lbs} \cdot 0.75 \cdot 1.00 \cdot 0.84 = 1014 \text{ lbs}$

$\beta_V = \frac{V^a_{ua}}{\phi\, V_{cb}} = 0.77 \leq 1.0$ ✓

3.6 Check pry out failure

$V^a_{ua} = 785 \text{ lbs}$

$\phi V_{cp} = \phi \cdot k_{cp} \cdot N_{cb} = 0.7 \cdot 2 \cdot 3434 \text{ lbs} = 4808 \text{ lbs}$

$\beta_V = V^a_{ua} / \phi V_{cp} = 0.16 \leq 1.0$

4. Combined tension and shear loads

Concrete

$\beta_N^{1.5} + \beta_V^{1.5} = 0.35^{1.5} + 0.77^{1.5} = 0.89 \leq 1$ ✓ (eq. 6.1.1.1)

Steel

$\beta_N^{2.0} + \beta_V^{2.0} = 0.25^{2.0} + 0.23^{2.0} = 0.12 \leq 1$ ✓ (eq. 6.3.1.1)

Steel connection

$\beta_N^{2.0} + \beta_V^{2.0} = 0.25^{2.0} + 0.23^{2.0} = 0.12 \leq 1$ ✓ (eq. 6.3.1.1)

Anchor channel

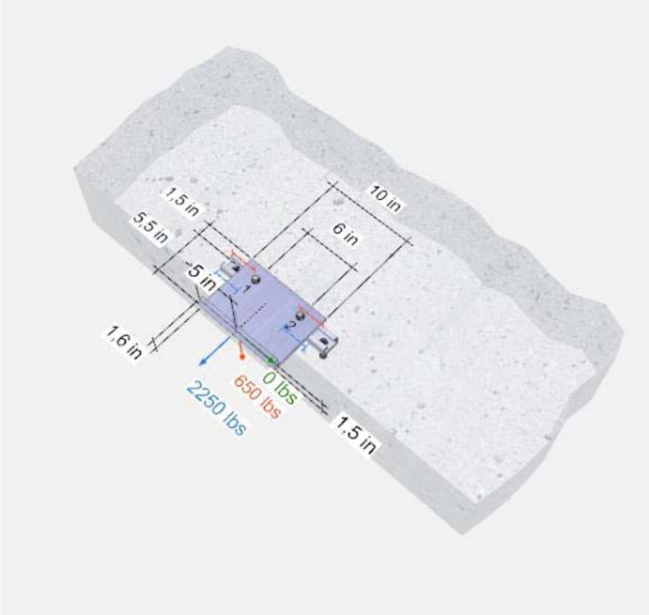
$\beta_N^{2.0} + \beta_V^{2.0} = 0.22^{2.0} + 0.20^{2.0} = 0.09 \leq 1$ ✓ (eq. 6.4.1.1)

T-bolt

$\beta_N^{2.0} + \beta_V^{2.0} = 0.26^{2.0} + 0.44^{2.0} = 0.26 \leq 1$ ✓ (eq. 6.5.1.1)

Verification fulfilled!

8.2 Example 2, curtain wall clip acting on JTA W50/30, 3 anchors



Channel and T-bolt:

Profile W50/30, L = 14 in., 3 anchors

Anchor spacing: s = 6 in.

2 T-bolt M16 4.6

Concrete conditions:

Concrete 2500 psi, uncracked concrete

Member thickness h = 10 in.

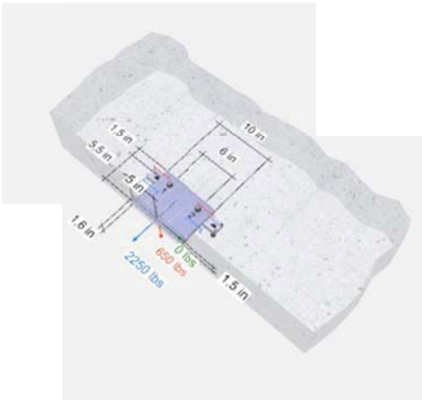
Edge distance c_1 = 3 in.

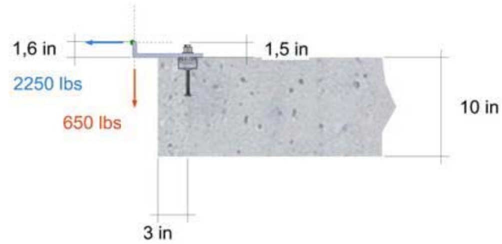
Factored forces acting on the bracket:

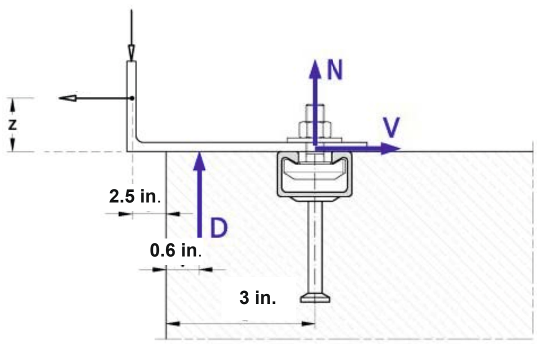
N_u = 650 lbs, V_u = 2250 lbs

Values

Characteristic values	Φ-Factor
$I_y = 0.125$ in ^{4}	
N_{sa} = 6969 lbs	0.75
N_{sc} = 6969 lbs	0.75
N_{sl} = 8093 lbs	0.75
N_{ss} = 14118 lbs	0.65
M_{sflex} = 13524 lbs in.	0.85
N_p = 5418 lbs (for 2500 psi)	0.7
h_{ef} = 3,7 in.	
α_{ch} = 0,91	
V_{sa} = 6969 lbs	0.75
V_{sc} = 6969 lbs	0.75
V_{sl} = 8093 lbs	0.75
V_{ss} = 8475 lbs	0.6
$\alpha_{ch,V} \cdot \Psi_{c,V}$= 14.9	
b_{ch} = 1.93 in	
h_{ch} = 1.18 in	







Factored Forces acting on the bracket:

Wind suction=2250 lbs;

Dead load = 650 lbs

1. Loads acting on the channel

Shear:

$\Sigma H = 0 \rightarrow V_{ua} = 2250$ lbs $\rightarrow V_{ua}$/T-bolt = 2250 lbs/2 = 1125 lbs

Tension:

Moment caused by eccentricities $M_{ua} = 2250$ lbs kN ·1.6 in + 650 lbs (5.5 in -3 in) = 5000 lbs in

Tension = 5000/(0.80 · 3 in.) = $N_{ua} = 2090$ lbs $\rightarrow N_{ua}$/T-bolt = 2090 lbs/2 = 1045 lbs

2. Load distribution

Calculation of anchor forces

$l_i = 4.93 \cdot I_y^{0,05} \cdot s^{0,5} = 4.93 \cdot 0.125^{0,05} \cdot 6^{0,5} = 10.88$ in (eq. 3.3)

Load position: T-bolts are positioned symmetrically with regard to the middle anchor.

	Anchor 1	Anchor 2	Anchor 3
Distance load at 100 mm to the anchor (in)	3	3	9
$A_i^{'}=(l_i\text{-}s)/\ l_i$	$1 - \frac{3}{10.88} = 0.724$	$1 - \frac{3}{10.88} = 0.7$	$1 - \frac{9}{10.88} = 0.173$
$k=1/\sum A_i^{'}$	$\frac{1}{0.724 + 0.724 + 0.173} = 0.617$		
$N_{au}^{a}=k \cdot A_i^{'} \cdot N_{ua}$ (lbs)	$0.617 \cdot 0.724 \cdot 1045 = 467$	467	$0.617 \cdot 0.173 \cdot 1045 = 111$
Distance load at 250 mm to the anchor (in)	9	3	3
$A_i^{'}= 1 - s/l$	1 – 225/274 = 0.173	1 – 75/224 = 0.724	1–75/224 = 0.724
$k=1/\sum A_i^{'}$	$\frac{1}{0.178+0.726+0.726} = 0.617$		
$N_{au}^{a}=k \cdot A_i^{'} \cdot N_{ua}$ (lbs)	111	467	467
Resulting anchor load N_{au}^{a} (line 1.4+2.4) (lbs)	578	935	578
Analog for shear load V_{au}^{a} (lbs)	622	1006	622

3.Tension loads

3.1 Check steel failure of anchor

N^a_{ua} = 935 lbs

ϕN_{sa} = $\phi \cdot N_{sa}$ = 0.75 ·6969 lbs = 5227 lbs

β_N = $N^a_{ua} / \phi N_{cb}$ = 0.18 ≤ 1 ✓

3.2 Check failure of connection between anchor and channel

N^a_{ua} = 935 lbs

ϕN_{sc} = $\phi \cdot N_{s,c}$ = 0.75 ·6969 lbs = 5227 lbs

β_N = $N^a_{ua} / \phi N_{sc}$ = 0.18 ≤ 1 ✓

3.3 Check failure of channel lip

N^a_{ua} = 1045 lbs

ϕN_{sl} = $\phi \cdot N_{sl}$ = 0.75 ·8093 lbs = 6070 lbs

β_N = $N^a_{ua} / \phi N_{sl}$ = 0.17 ≤ 1 ✓

3.4 Check steel failure of T-bolt

N^s_{ua} = 1045 lbs

ϕN_{ss} = $\phi \cdot N_{ss}$ = 0.65 ·14118 lbs = 9177 lbs

β_N = $N^s_{ua} / \phi N_{ss}$ = 0.11 ≤ 1 ✓

3.5 Check bending of channel

M_{ua} = 1568 lb-in

$\phi M_{s,flex}$ = $\phi M_{s,flex}$ = 0.85 ·13524 lb-in = 11495 lb-in

β_N = $M_{ua} / \phi M_{s,flex}$ = 0.14 ≤ 1 ✓

3.6 Check pull out failure

N^a_{ua} = 935 lbs

ϕN_p = $\phi N_{pn} \cdot \Psi_{cp}$ = 0.70 ·5418 lbs · 1.25 = 4741 lbs (eq. 4.2.2.1)

β_N = $N^a_{ua} / \phi N_p$ = 0.20 ≤ 1 ✓

3.7 Check concrete cone failure

N^a_{ua} = 935 lbs

$\phi N_b = 24 \cdot \alpha_{ch,N} \cdot f_c'^{0.5} \cdot h_{ef}^{1.5} = 24 \cdot 0.91 \cdot 2500^{0.5} \cdot 3.7 = 7745$ lbs

Influence of adjacent anchor:

$$\Psi_{s,N} = \frac{1}{1+\sum_{i=2}^{n+1}\left[\left(1-\frac{s_i}{s_{cr,N}}\right)^{1.5} \cdot \frac{N^a_{ua,i}}{N^a_{ua,1}}\right]}$$ (eq. 4.2.2.4)

$$s_{cr,N} = 2 \cdot \left(2.8 - \frac{13.37}{7.1}\right) \cdot 3.7 = 15.7$$

$$\Psi_{s,N} = \frac{1}{1+\left(1-\frac{6}{15.7}\right)^{1.5} \cdot \frac{578}{935} + \left(1-\frac{6}{15.7}\right)^{1.5} \cdot \frac{578}{935}} = 0.62$$

Influence of member edges

$c_{cr,N} = 0.5 \cdot s_{cr,N} = 0.5 \cdot 15.7 = 7.85$ in (eq. 4.2.2.8)

$c_{a1,1} = 3$ in $< c_{cr,n}$ (eq. 4.2.2.7)

$$\Psi_{ed,N} = \left(\frac{3\text{ in}}{7.85\text{ in}}\right)^{0.5} = 0.62$$

Influence of corner

$c_{a2} > 7.85$ in (eq.4.2.2.9)

$\Psi_{co,N} = 1.0$

Influence of cracked concrete

$\Psi_{c,N} = 1.25$ (uncracked concrete)

$\phi N_{cb} = \phi N_b \cdot \Psi_{s,N} \cdot \Psi_{ed,N} \cdot \Psi_{co,N} \cdot \Psi_{cN} \cdot \Psi_{co,N}$

$= 0.7 \cdot 7745 \text{ lbs} \cdot 0.62 \cdot 0.62 \cdot 1.00 \cdot 1.25 \cdot 1.00 = 2616$ lbs

$\beta_N = N^a_{ua} / \phi N_{cb} = 0.36 \leq 1$ ✓

4. Shear Loads

4.1 Check steel failure of anchor

V_{ua}^{a} = 1006 lbs

ϕV_{sa} = $\phi \cdot V_{sa}$ = 0.75 · 6969 lbs = 5227 lbs

β_V = $V_{ua}^{a} / \phi V_{sa}$ = 0.19 ≤ 1.0 ✓

4.2 Check failure of connection between anchor and channel

V_{ua}^{a} = 1006 lbs

ϕV_{sc} = $\phi \cdot V_{sc}$ = 0.75 · 6969 lbs = 5227 lbs

β_V = $V_{ua}^{a} / \phi V_{sc}$ = 0.19 ≤ 1.0 ✓

4.3 Check failure of channel lip

V_{ua}^{a} = 1125 lbs

ϕV_{sl} = $\phi \cdot V_{sl}$ = 0.75 ·8093 lbs · = 6070 lbs (eq. 4.2.2.1)

β_N = $V_{ua}^{a} / \phi V_{sl}$ = 0.19 ≤ 1 ✓

4.4 Check steel failure of T-bolt

V_{ua}^{s} = 1125 lbs

ϕV_{ss} = $\phi \cdot V_{ss}$ = 0.60 ·8475 lbs · = 5085 lbs

β_V = $V_{ua}^{s} / \phi V_{ss}$ = 0.22 ≤ 1 ✓

4.5 Check pry-out failure

V_{ua}^{a} = 1006 lbs

ϕV_{cp} = $\phi \cdot k_{cp} \cdot N_{cb}$ = 0.70 · 2.00 ·3738 lbs · = 5233 lbs (eq. 5.2.1.1)

β_V = $V_{ua}^{a} / \phi V_{cp}$ = 0.19 ≤ 1 ✓

4.6 Check concrete edge failure c11

V_{ua}^{a} = 1006 lbs

V_b = $(\alpha_{ch,V} \cdot \Psi_{c,V}) \cdot f_c'^{\,0.5} \cdot c_{a1}^{1.5}$ = 14,9 · $2500^{0.5}$ ·$3.00^{1.33}$ = 3223 lbs (eq. 5.2.2.3)

Influence of adjacent anchors

$$\Psi_{s,V} = \frac{1}{1+\sum_{i=2}^{n+1}\left[\left(1-\frac{s_i}{s_{cr,V}}\right)^{1.5}\cdot\frac{V_{ua,i}^{a}}{V_{ua,1}^{a}}\right]} \quad \text{(eq. 5.2.2.3)}$$

$$s_{cr} = 4c_{a1} + 2b_{ch} \quad \text{(eq. 5.2.2.4)}$$

$$= 12 \text{ in} + 2 \cdot 1.93 = 15.86 \text{ in}$$

$$\Psi_{s,V} = \frac{1}{1+\left(1-\frac{6}{15.82}\right)^{1.5}\cdot\frac{622}{1006}+\left(1-\frac{6}{15.86}\right)^{1.5}\cdot\frac{622}{1006}} = 0.62$$

Influence of corner

$c_{cr,V} = 2c_{a1} + b_{ch}$

$c_{cr,V} = 2c_{a1} + b_{ch}$

$= 2 \cdot 3 \text{ in} + 1.93 = 7.93 \text{ in}$ (eq. 5.2.2.7)

$c_{a2} > 7.93 \text{ in}$ (eq. 5.2.2.5)

$\Psi_{co,V} = 1.0$

Influence of member thickness

$h_{cr,V} = 2c_{a1} + 2h_{ch}$

$= 2 \cdot 3 + 2 \cdot 1.18 = 8.36 \text{ in}$ (eq. 5.2.2.9)

$$\Psi_{h,V} = \left(\frac{h}{h_{cr,V}}\right)^{\beta_1} = \left(\frac{10}{8.36}\right)^{\frac{2}{3}} = 1.12$$

$\Psi_{h,V}$ must be ≤ 1.0

➔ $\Psi_{h,V} = 1.0$

$\phi V_{cb} = \phi \cdot V_b \cdot \Psi_{s,V} \cdot \Psi_{co,V} \cdot \Psi_{h,V}$

$= 0.70 \cdot 3223 \text{ lbs} \cdot 0.62 \cdot 1.00 \cdot 1.0 = 1405 \text{ lbs}$

$\beta_V = V_{ua}^{a} / \phi V_{cb} = 0.72 \leq 1$ ✓

5. Combined Tension and Shear Loads

Concrete

$\beta_N^{1.5} + \beta_V^{1.5} = 0.36^{1.5} + 0.72^{1.5} = 0.82 \leq 1$ ✓ (eq. 6.1.1.1)

Steel

$\beta_N^{2.0} + \beta_V^{y\,2.0} = 0.18^{2.0} + 0.19^{2.0} = 0.07 \leq 1$ ✓ (eq. 6.3.1.1)

Steel connection

$\beta_N^{2.0} + \beta_V^{y\,2.0} = 0.18^{2.0} + 0.19^{2.0} = 0.07 \leq 1$ ✓ (eq. 6.3.1.1)

Anchor channel

$\beta_N^{2.0} + \beta_V^{y\,2.0} = 0.17^{2.0} + 0.19^{2.0} = 0.06 \leq 1$ ✓ (eq. 6.4.1.1)

T-bolt

$\beta_N^{2.0} + \beta_V^{y\,2.0} = 0.11^{2.0} + 0.22^{2.0} = 0.06 \leq 1$ ✓ (eq. 6.5.1.1.)

Verification fulfilled!

9 Software Expert JTA

JORDAHL® EXPERT JTA software allows a comfortable and safe verification of all necessary calculations for anchoring in concrete with JTA anchor channels. In addition, the software features a technical and economical optimization of the design for each individual connection.

Thanks to interactive 3D graphics JORDAHL® EXPERT JTA is easy to use and allows a fast and simple input of all necessary data, e.g. anchor channel, loads and the geometrical boundary conditions of the construction member. Once the input information is entered and the calculation is done, multiple results for all channel sizes are shown in a list with the corresponding maximum usage. Upon choosing the most economical anchor channel and T-bolt, the design results appear on screen along with a printable calculation for record.

The software is based on ACI 318-11 Appendix D in combination with AC 232 for the design of anchor channels. The design provisions of codes are summarized in this booklet.
This allows the state-of-the-art design of anchoring in concrete with JORDAHL® anchor channels.

The JORDAHL® EXPERT JTA software can be downloaded for free from our website www.deconusa.com

On the following pages you will find output examples from the JORDAHL® EXPERT JTA software calculating examples 1 and 2 from chapter 8 of this manual. In these examples the same parameters as in the hand calculations are used. In order to compare the individual results of all calculations, the first output shows a full print out. This format allows the user full traceability of all intermediate steps in the design of a connection using a JTA anchor channel. The second example summarizes the most important information of the design in an ecofriendly and paper saving short print out.

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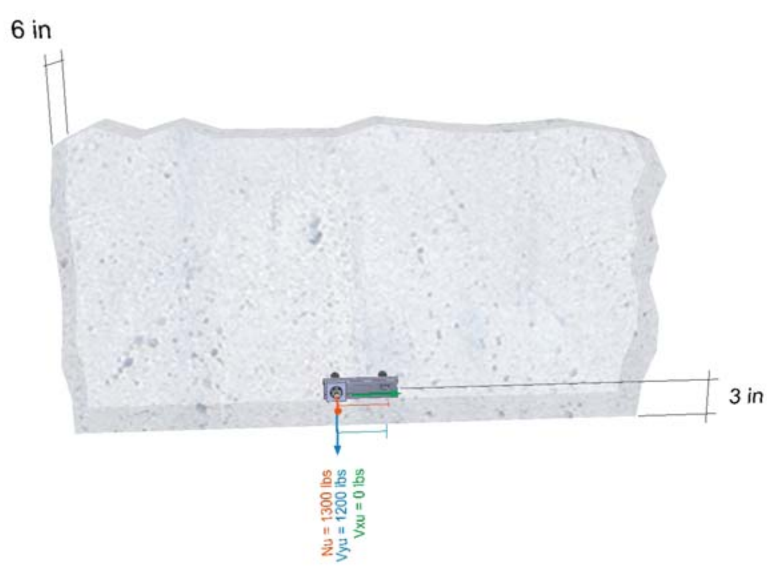
Example 1

1. Input information:

Anchor channel:	JTA W 40/22-0150-2A-hdg, l = 6,000 in*, 2 Anchor
Bolt:	JC M12 x 40 (1,600 in), hdg 4.6, standard
Anchorage depth:	h_{ef} = 3,110 in
Stand-off installation	Distances = 0 in (No spacing), Attaching part thickness = 0,400 in
Concrete:	3500 psi, Cracked concrete, f'_c = 3500 psi, d = 6,000 in, c = 1,000 in, c_s = 1,000 in, $c_{a1,1}$ = 3,000 in, $c_{a1,2}$ Not available, $c_{a2,1}$ Not available, $c_{a2,2}$ Not available x = channel overhang = 1,000 in*
Tension reinforcement:	Not available
Shear reinforcement:	Not available



Overall result: OK (Maximum utilisation 89,19 %)

* Hard conversion 1″ = 25 mm

2. Loads

Load point	x [in]	N_{ua} [lbs]	V^y_{ua} [lbs]	V^x_{ua} [lbs]	
1	1,000	1300	1200	0	(1)

Note:
The specified load positions correspond to the critical load positions (-2,000 in) within the displacement range Δx = ±2,000 in.
Pair- and continuous loads will be shifted on the channel with constant load spacings.

(1) load point 1 is relevant concerning the calculation.
Hard conversion 1″ = 25 mm

3. Anchor positions and resulting anchor loads (AC232, chapter D.3.1.1.1 + D.3.1.1.4)

Anchor	x [in]	N^a_{ua} [lbs]	V^{ay}_{ua} [lbs]	V^{ax}_{ua} [lbs]	
1	1,000	850	785	0	(2)
2	5,000	450	415	0	

(2) anchor 1 is relevant concerning the calculation.
Hard conversion 1″ = 25 mm

4. Tension Loads (AC232 and ACI 318-11, chapter D.5)

4.1 Steel failure

Proof steel failure anchor (Anchor 1) OK

N^a_{ua} = 850 lbs

ΦN_{sa} = $\Phi \cdot N_{sa}$ = 0,75 · 4496 lbs = 3372 lbs

β_N = $N^a_{ua} / \Phi N_{sa}$ = 0,25 ≤ 1,00

Proof connection between anchor and channel (Anchor 1) OK

N^a_{ua} = 850 lbs

$\Phi N_{s,c}$ = $\Phi \cdot N_{s,c}$ = 0,75 · 4496 lbs = 3372 lbs

β_N = $N^a_{ua} / \Phi N_{s,c}$ = 0,25 ≤ 1,00

Proof local flexure (Load 1) OK

N_{ua} = 1300 lbs

ΦN_{sl} = $\Phi \cdot N_{sl}$ = 0,75 · 7868 lbs = 5901 lbs

β_N = $N_{ua} / \Phi N_{sl}$ = 0,22 ≤ 1,00

Proof steel failure bolt (Load 1) OK

N^s_{ua} = 1300 lbs

ΦN_{ss} = $\Phi \cdot N_{ss}$ = 0,65 · 7576 lbs = 4924 lbs

β_N = $N^s_{ua} / \Phi N_{ss}$ = 0,26 ≤ 1,00

Proof flexure of channel (Load 1)

Not decisive

4.2 Concrete failure

Proof pull-out (Anchor 1) OK

N^{a}_{ua} = 850 lbs

ΦN_{p} = $\Phi \cdot N_{pn} \cdot \psi_{cp}$ = 0,70 · 5137 lbs · 1,00 = 3596 lbs

β_{N} = $N^{a}_{ua} / \Phi N_{p}$ = 0,24 ≤ 1,00

Proof concrete cone (Anchor 1) OK

N^{a}_{ua} = 850 lbs

N_{b} = $24 \cdot \alpha_{ch,N} \cdot f'_{c}{}^{0,5} \cdot h_{ef}{}^{1,5}$ = $24 \cdot 0{,}88 \cdot 3500^{0,5} \cdot 3{,}110^{1,5}$ = 6880 lbs

ΦN_{cb} = $\Phi \cdot N_{b} \cdot \psi_{s,N} \cdot \psi_{ed,N} \cdot \psi_{co,N} \cdot \psi_{c,N} \cdot \psi_{cp,N}$

= 0,70 · 6880 lbs · 0,76 · 0,66 · 1,00 · 1,00 · 1,00 = 2404 lbs

β_{N} = $N^{a}_{ua} / \Phi N_{cb}$ = 0,35 ≤ 1,00

5. Shear Loads (AC232 and ACI 318-11, chapter D.6)

5.1 Steel failure

Proof steel failure anchor Y (Anchor 1) OK

V^{ay}_{ua} = 785 lbs

ΦV_{sa} = $\Phi \cdot V_{sa}$ = 0,75 · 4496 lbs = 3372 lbs

β_{V} = $V^{ay}_{ua} / \Phi V_{sa}$ = 0,23 ≤ 1,00

Proof steel failure anchor X (Anchor 1)

Not decisive

Proof connection between anchor and channel Y (Anchor 1) OK

V^{ay}_{ua} = 785 lbs

$\Phi V_{s,c}$ = $\Phi \cdot V_{s,c}$ = 0,75 · 4496 lbs = 3372 lbs

β^{y}_{V} = $V^{ay}_{ua} / \Phi V_{s,c}$ = 0,23 ≤ 1,00

Proof connection between anchor and channel X (Anchor 1)

Not decisive

Proof flexure of channel lip Y (Load 1) OK

V^{y}_{ua} = 1200 lbs

ΦV^{y}_{sl} = $\Phi \cdot V_{sl}$ = 0,75 · 7868 lbs = 5901 lbs

β^{y}_{V} = $V^{y}_{ua} / \Phi V^{y}_{sl}$ = 0,20 ≤ 1,00

Proof flexure of channel lip X (Load 1)

Not decisive

Proof steel failure bolt (Load 1) OK

V^{sy}_{ua} = 1200 lbs

ΦV^{y}_{ss} = $\Phi \cdot V_{ss}$ = 0,60 · 4541 lbs = 2725 lbs

β^{y}_{V} = $V^{sy}_{ua} / \Phi V^{y}_{ss}$ = 0,44 ≤ 1,00

5.2 Concrete failure

Proof pry-out (Anchor 1) OK

V^{ay}_{ua} = 785 lbs

V^{ax}_{ua} = 0 lbs

V^{a}_{ua} = 785 lbs

N_b = $24 \cdot \alpha_{ch,N} \cdot f'_c{}^{0,5} \cdot h_{ef}{}^{1,5}$ = $24 \cdot 0,88 \cdot 3500^{0,5} \cdot 3,110^{1,5}$ = 6880 lbs

N_{cb} = $N_b \cdot \psi_{s,N} \cdot \psi_{ed,N} \cdot \psi_{co,N} \cdot \psi_{c,N} \cdot \psi_{cp,N}$
= 6880 lbs · 0,76 · 0,66 · 1,00 · 1,00 · 1,00 = 3434 lbs

ΦV_{cp} = $\Phi \cdot k_{cp} \cdot N_{cb}$ = 0,70 · 2,00 · 3434 lbs = 4808 lbs

β_V = $V^{a}_{ua} / \Phi V_{cp}$ = 0,16 ≤ 1,00

Proof concrete edge c11 (Anchor 1) OK

V^{ay}_{ua} = 785 lbs

V^{ax}_{ua} = 0 lbs

V^{a}_{ua} = 785 lbs

V_b = $(\alpha_{ch,V} \cdot \psi_{c,V}) \cdot f'_c{}^{0,5} \cdot c_{a1}{}^{1,33}$ = $9,00 \cdot 3500^{0,5} \cdot 3,000^{1,33}$ = 2304 lbs

ΦV_{cb} = $\Phi \cdot V_b \cdot \psi_{s,V} \cdot \psi_{co,V} \cdot \psi_{h,V} \cdot 1,0$
= 0,70 · 2304 lbs · 0,75 · 1,00 · 0,84 · 1,0 = 1014 lbs

β_V = $V^{a}_{ua} / \Phi V_{cb}$ = 0,77 ≤ 1,00

Proof concrete edge c12 (Anchor 1)

Not decisive

Proof concrete edge c21 (Anchor 1)

Not decisive

Proof concrete edge c22 (Anchor 1)

Not decisive

6. Combined Tension and Shear Loads (AC232 and ACI 318-11, chapter D.7)

Concrete (Anchor 1)

n $= \beta_N^{1,5} + \beta_V^{1,5} = 0,35^{1,5} + 0,77^{1,5} = 0,89 \leq 1,00$

Steel (Anchor 1)

n $= \beta_N^{2,0} + \beta^{y}_{V}{}^{2,0} = 0,25^{2,0} + 0,23^{2,0} = 0,12 \leq 1,00$

Steel connection (Anchor 1)

n $= \beta_N^{2,0} + \beta^{y}_{V}{}^{2,0} = 0,25^{2,0} + 0,23^{2,0} = 0,12 \leq 1,00$

Anchor channel (Load 1)

n $= \beta_N^{2,0} + \beta^{y}_{V}{}^{2,0} = 0,22^{2,0} + 0,20^{2,0} = 0,09 \leq 1,00$

Bolt (Load 1)

n $= \beta_N^{2,0} + \beta^{y}_{V}{}^{2,0} = 0,26^{2,0} + 0,44^{2,0} = 0,26 \leq 1,00$

7. Summary of the calculations

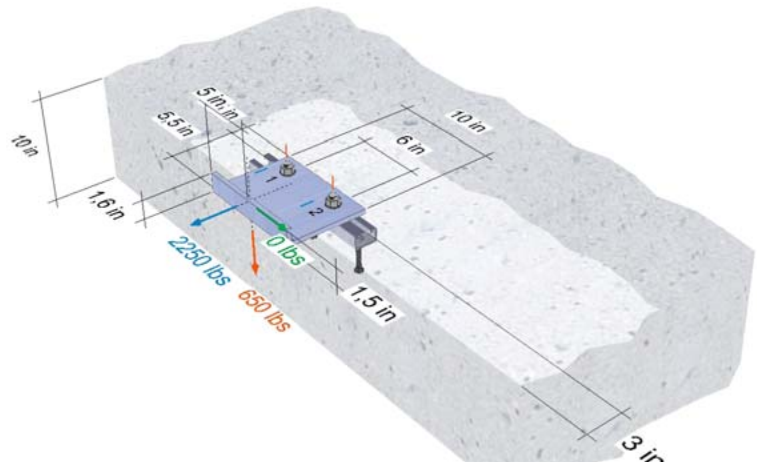
All proofs are okay. The maximum utilisation is 89,19 %.

- Applied Design Method: AC 232
- The acting loads can be passed into the concrete member, the transfer of the loads has to be verified separately
- This calculation bases on product specific properties. Changes, even to similar products are only possible with new calculations.
- All data have to be checked with the given edge boundaries and the feasibility. JORDAHL GmbH assumes no ability for the input data of the user

Example 2

1. Input information:

Anchor channel:	JTA W 50/30-0350-3A-hdg, l = 14,000 in*, 3 Anchor
Bolt:	JB M16 x 40 (1,600 in), hdg 4.6, On request
Anchorage depth:	h_{ef} = 3,700 in
Stand-off installation	bracket without slotted holes, Thickness of bracket = 0,400 in
Concrete:	2500 psi, Uncracked concrete, f'_c = 2500 psi, d = 10,000 in, c = 1,000 in, c_s = 1,000 in, $c_{a1,1}$ = 3,000 in, $c_{a1,2}$ Not available, $c_{a2,1}$ Not available, $c_{a2,2}$ Not available x = channel overhang = 1,000 in*
Tension reinforcement:	Not available
Shear reinforcement:	Not available
Top of slab bracket:	Back protrusion = 1,500 in, Front protrusion = 5,500 in, Height = 1,600 in, Width = 10,000 in, Bolt distance = 6,000 in, Number of bolts = 2, Sliding tolerance of bracket = ± 2,000 in, Load distance point from left = 5,000 in, Load distance point from below = 1,500 in



Overall result: OK (Maximum utilisation 81,94 %)

* Hard conversion 1″ = 25 mm

2. Loads

2.1 Loading / resulting loads at T-bolts

Load point	x [in]	N_{ua} [lbs]	V^y_{ua} [lbs]	V^x_{ua} [lbs]	
1	4,000	1045	1125	0	(1)
2	10,000	1045	1125	0	

Remarks:
x - Distance from the left channel end
The given load positions correspond to the critical load condition (0,000 in) within the given sliding field from Δx = ±2,000 in.
The maximum concrete compressive strength is 2 lbs/in²

(1) load point 1 is relevant concerning the calculation.
Hard conversion 1″ = 25 mm

3. Decisive proof

Anchor 2	**81,94 %**	
Tension - Steel failure anchor	17,88 %	$N^a_{ua} = 935 \text{ lbs} \le \Phi \cdot N_{sa} = 5227 \text{ lbs}$
Tension - Connection between anchor and channel	17,88 %	$N^a_{ua} = 935 \text{ lbs} \le \Phi \cdot N_{s,c} = 5227 \text{ lbs}$
Tension - Pullout failure	19,75 %	$N^a_{ua} = 935 \text{ lbs} \le \Phi \cdot N_p = 4741 \text{ lbs}$
Tension - Concrete cone failure	35,72 %	$N^a_{ua} = 935 \text{ lbs} \le \Phi \cdot N_{c,b} = 2616 \text{ lbs}$
Proof steel failure anchor Y	19,25 %	$V^{ay}_{ua} = 1006 \text{ lbs} \le \Phi \cdot V_{sa} = 5227 \text{ lbs}$
Shear - Steel failure anchor	19,25 %	$V^{ay}_{ua} = 1006 \text{ lbs} \le \Phi \cdot V_{s,c} = 5227 \text{ lbs}$
Shear - Pry-Out failure	19,22 %	$V^a_{ua} = 1006 \text{ lbs} \le \Phi \cdot V_{cp} = 5233 \text{ lbs}$
Shear - Concrete edge failure c11	71,61 %	$V^a_{ua} = 1006 \text{ kN} \le \Phi V_{cb} = 1405 \text{ kN}$
Interaction anchor concrete	81,94 %	$\beta_N^{1,5} + \beta_V^{1,5} = 81,94\ \%$
Interaction anchor steel	6,90 %	$\beta_N^{2,0} + \beta^{y\ 2,0}_V + \beta^{x\ 2,0}_V = 6,90\ \%$
Interaction Anchor- channel steel	6,90 %	$\beta_N^{2,0} + \beta^{y\ 2,0}_V + \beta^{x\ 2,0}_V = 6,90\ \%$
Load 1	**22,12 %**	
Tension - Local flexure of channel lip	17,22 %	$N_{ua} = 1045 \text{ lbs} \le \Phi \cdot N_{sl} = 6070 \text{ lbs}$
Tension - Steel failure bolt	11,39 %	$N_{ua} = 1045 \text{ lbs} \le \Phi \cdot N_{ss} = 9177 \text{ lbs}$
Tension - Flexure of channel	13,64 %	$M_{mua} = 1568 \text{ lb-in} \le \Phi \cdot M_{s,flex} = 11495 \text{ lb-in}$
Shear - Steel failure bolt	22,12 %	$V^y_{ua} = 1125 \text{ lbs} \le \Phi \cdot V^y_{ss} = 5085 \text{ lbs}$
Shear - Local flexure of channel lip	18,53 %	$V^y_{ua} = 1125 \text{ lbs} \le \Phi \cdot V_{sl} = 6070 \text{ lbs}$
Interaction at the load point	6,40 %	$\beta_N^{2,0} + \beta_V^{2,0} = 6,40\ \%$
Interaction bolt	6,19 %	$\beta_N^{2,0} + \beta_V^{2,0} = 6,19\ \%$

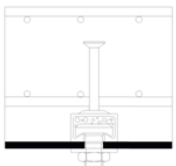
4. Summary of the calculations

All proofs are okay. The maximum utilisation is 81,94 %.

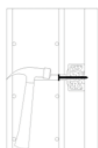
- Applied Design Method: AC 232
- The acting loads can be passed into the concrete member, the transfer of the loads has to be verified separately
- This calculation bases on product specific properties. Changes, even to similar products are only possible with new calculations.
- All data have to be checked with the given edge boundaries and the feasibility. JORDAHL GmbH assumes no ability for the input data of the user
- By elaborating the application of the forces, the program calculates with the hypothesis of the rigidity of the anchor plate / bracket. The designer must separately proof the anchor plate / bracket.

10 Installation instruction for JORDAHL JTA anchor channel system

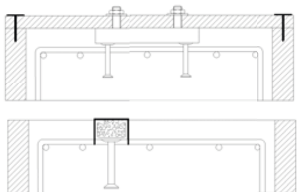
1. Fixing anchor channel
Install the channel surface flush and fix the channel undisplaceable to the formwork or to the reinforcement.



b) Fixing to steel formwork
With JORDAHL-T-bolts and nuts, with rivets, cramps or with magneting fixings.
or

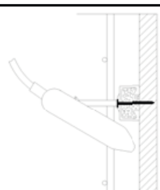


a) Fixing to timber formwork
With nails through the pre punched holes in the back of the the channels and with staples.
or



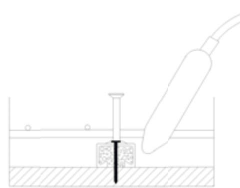
c) Fixing to anchor channels at the top
- To timber batten on the side formwork (e.g. with JORDAHL-T-bolts).
- Fixing from above directly to the reinforcement or to a mounting rebar, attach the channel by wire binding.

2. Pouring concrete and regular compacting of concrete
Compact the concrete properly around the channel and the anchors.



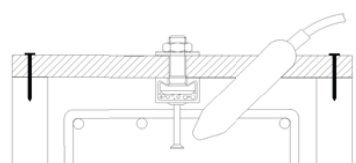
a) sidefaces to the formwork

or



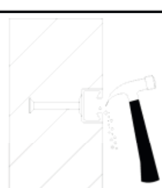
b) in soffits

or

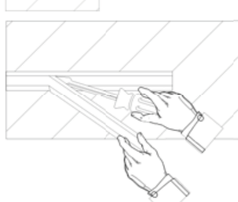


c) into top surfaces of concrete up stands

3. Removing of the channel infill
Clean the channel on the outside after removing the formwork.



a) Foam infill
With a hammer or a hook.
or



b) PE - foam infill
By hand or with help of a screw driver in one piece.

4. Fastening the JORDAHL-T-bolt to the anchor channel

Fig. 1

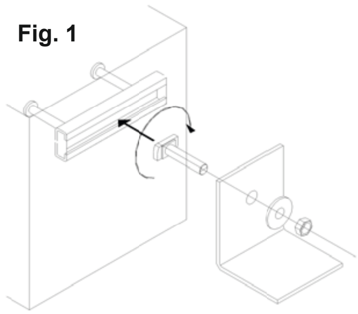
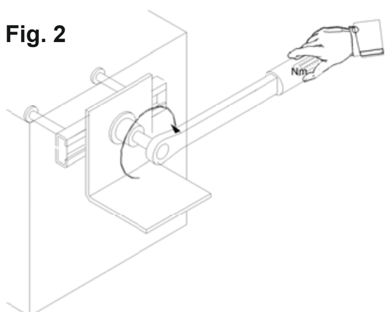


Fig. 2



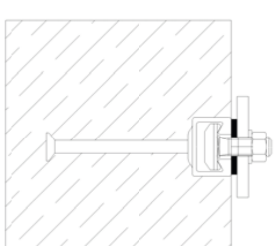
a) Setting torques (General)

1. Insert the JORDAHL-T-bolt into the channel slot at any point along the channel length (Fig. 1).
2. Turn the T-bolt 90° clockwise and the head of the bolt locks into position (Fig. 1).
3. Do not mount the t-bolt closer than 25 mm from the end of the channel.
4. Use the washer under the nut (Fig. 1).
5. Check the correct fit of the JORDAHL-T-bolt. The groove on the shank end of the T-bolt must be perpendicular to the channel longitudinal axis.
6. Tighten the nuts to the setting torque according to Table A (Fig. 2). The setting torque must not be exceeded.

Table A	**Anchor channel**	**T_{inst} [Nm]**								
		M6	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Strength Grade	K 28/15	2.5	7	13	15	-	-	-	-	-
	K 38/17	-	-	13	24	30	-	-	-	-
4.6 8.8 A4-50 HC-50 A4-70 HC-70 F4-70 L4-70	W 40/22	-	-	13	24	30	-	-	-	-
	W 50/30	-	-	13	24	55	70	-	-	-
	W 53/34	-	-	13	24	55	115	-	-	-
	W 55/42	-	-	13	24	55	115	180	-	-
	W 72/48	-	-	-	-		115	200	300	345

or

Fig. 3



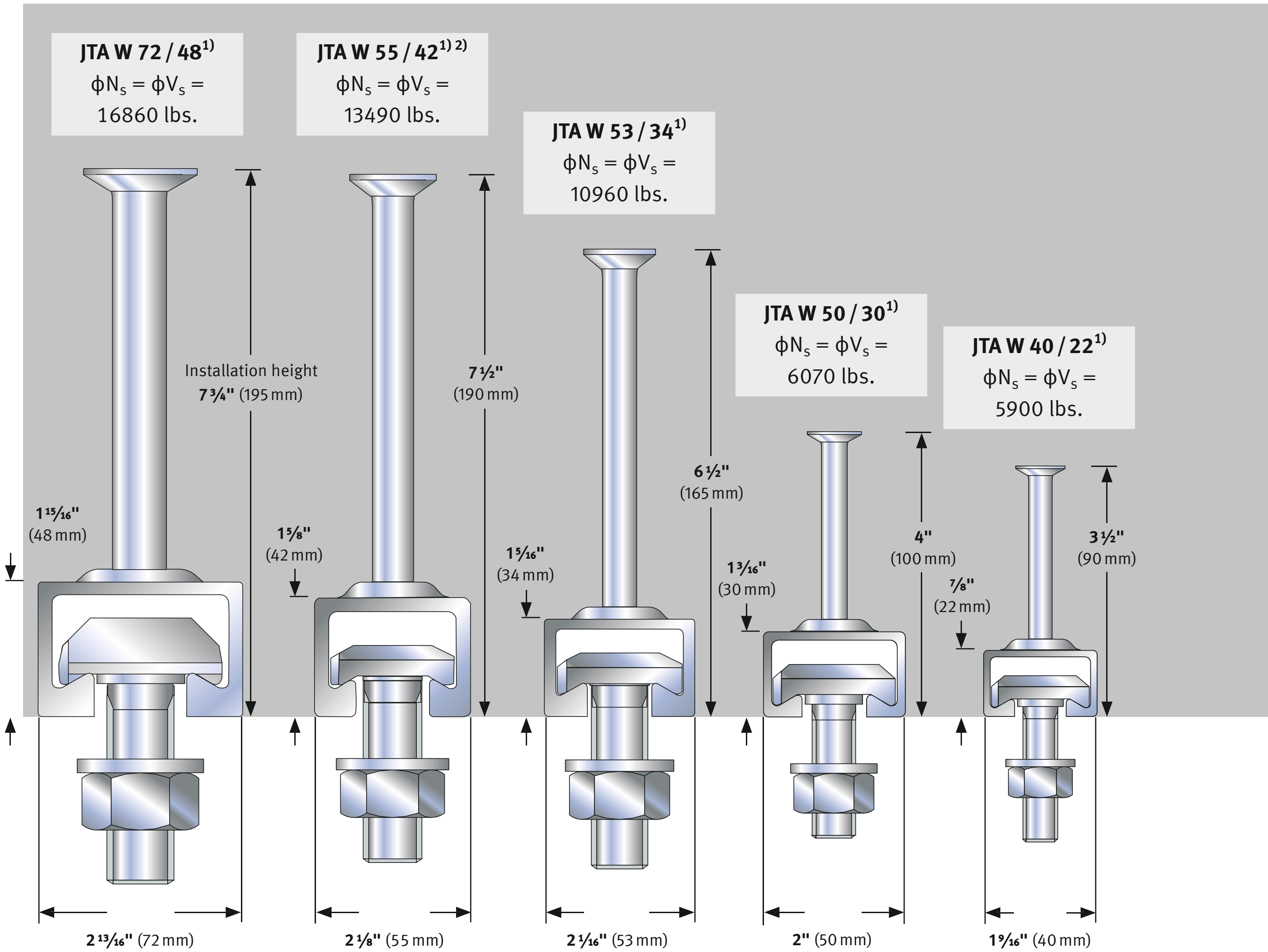
b) Setting torques (Steel-to-steel contact)

1. Use washers between the channel and the fixture to create a defined contact.
2. Tighten the nuts to the setting torque according to Table B. The setting torque must not be exceeded.

Table B	**Strength/ Material grade**	**T_{inst} [Nm]**								
		M6	M8	M10	M12	M16	M20	M24	M27	M30
JA, JB	4.6	3	8	15	25	65	130	230	340	460
JC, JE	A4-50	-	-	13	24	60	115	-	-	-
JD/JUD	8.8	-	20	40	70	180	360	620	-	-
JH/JUH	A4-70, F4-70	-	15	30	50	130	250	-	-	-

11 JORDAHL® Anchor Channels JTA

Hot-Rolled Anchor Channels



hard conversion 1" = 25 mm

T-Bolts

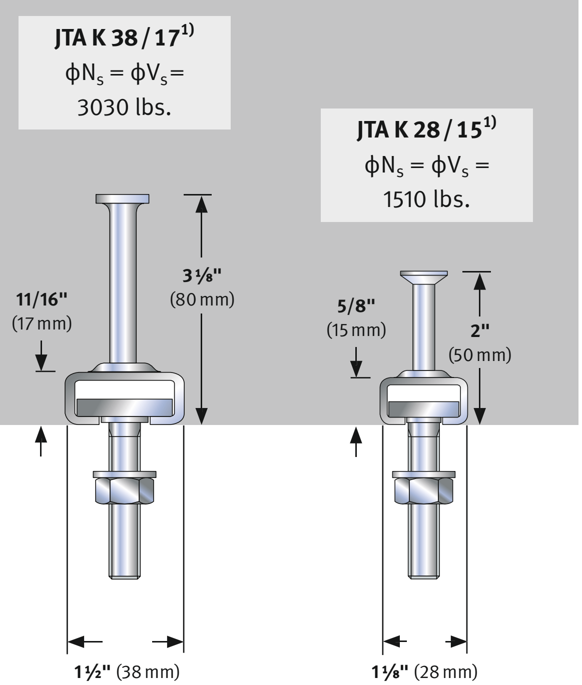
JA	JB	JB	JB	JC
M 20	M 16	M 10	M 10	M 10
M 24	M 20	M 12	M 12	M 12
M 27	M 24[3]	M 16	M 16	M 16
M 30		M 20	M 20	

[1] Max. design load per point. Individual conditions might reduce the capacity.
[2] Only in hot-dip galvanized (HDG).
[3] JB M 24 is equivalent to JE M 24.
Profile dimensions may exhibit tolerances.

Material and design of profile
- Hot-dip galvanized steel (HDG)
- Stainless steel 316 (A4)
- Standard filler polyethylene (PE) or polystyrene (PS)

Material and design of T-bolts
- Electro zinc plated (ZP) or hot-dip galvanized steel (HDG)
- Stainless steel

Cold-Formed Anchor Channels

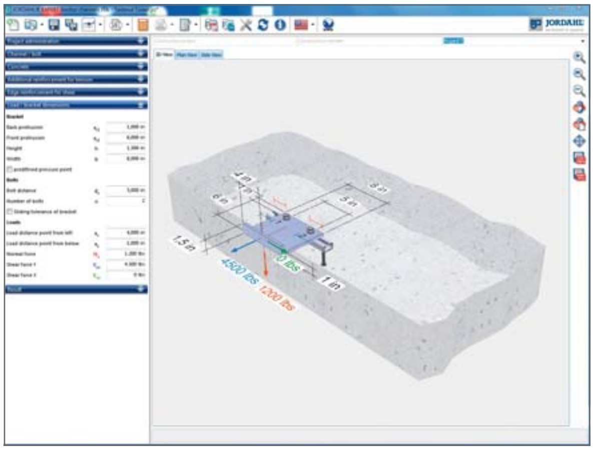


JH	JD
M 10	M 6
M 12	M 8
M 16	M 10
	M 12

- ϕN_s = factored nominal tension strength
- ϕV_s = factored nominal shear strength

JORDAHL® EXPERT Design Software

JORDAHL® EXPERT JTA allows an easy and safe calculation for anchoring in concrete with JTA anchor channels. In addition, the software features a technical and economical optimization of the design for each individual connection.



Thanks to interactive 3D graphics JORDAHL® EXPERT JTA is easy to use allowing fast and clear input of all necessary data, e. g. anchor channel, loads and the geometrical boundary conditions of the construction member.

Designation	Maximum utilisation
JTA W 40/22-0300-2A-hdg	119,99 %
JTA W 50/30-0300-2A-hdg	86,88 %
Anchor	86,88 %
Anchor 1	86,88 %
Anchor 2	64,31 %
Load position	29,66 %
JTA W 53/34-0300-2A-hdg	74,64 %
JTA W 55/42-0300-2A-hdg	76,75 %
JTA W 72/48-0300-2A-hdg	79,05 %
JTA K 28/15-0300-3A-hdg	236,80 %
JTA K 38/17-0300-3A-hdg	113,00 %

Once the input information is entered and the calculation is completed, multiple results for all channel sizes are shown in a list with the corresponding maximum utilisation. Upon choosing the most economical anchor channel and T-bolt, the design results appear on screen along with a printable calculation for record.

The JORDAHL® EXPERT JTA software can be downloaded for free from our website www.deconusa.com

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