Design of JORDAHL® Anchor Channels

Technical Information
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.
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 \( \Phi \)-Strength reduction factors

<table>
<thead>
<tr>
<th>Type of failure</th>
<th>( \Phi )-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchors</td>
<td>0.75</td>
</tr>
<tr>
<td>Connection</td>
<td>0.75</td>
</tr>
<tr>
<td>between anchor</td>
<td></td>
</tr>
<tr>
<td>and channel</td>
<td></td>
</tr>
<tr>
<td>Local failure</td>
<td>0.75</td>
</tr>
<tr>
<td>of the channel</td>
<td></td>
</tr>
<tr>
<td>lip</td>
<td></td>
</tr>
<tr>
<td>Channel</td>
<td>0.65</td>
</tr>
<tr>
<td>T-bolts</td>
<td></td>
</tr>
<tr>
<td>Bending of the</td>
<td>0.85</td>
</tr>
<tr>
<td>channel</td>
<td></td>
</tr>
<tr>
<td>Pull-out</td>
<td>0.70</td>
</tr>
<tr>
<td>Concrete cone</td>
<td>0.70</td>
</tr>
<tr>
<td>failure</td>
<td></td>
</tr>
<tr>
<td>Steel failure</td>
<td>0.90</td>
</tr>
<tr>
<td>of supplementary reinforcement</td>
<td></td>
</tr>
<tr>
<td>Anchorage failure of the supplementary reinforcement</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Table 2.1 \( \Phi \)-Strength reduction factors for anchor channels under tensile loads

<table>
<thead>
<tr>
<th>Type of failure</th>
<th>( \Phi )-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without lever</td>
<td>0.60</td>
</tr>
<tr>
<td>arm</td>
<td></td>
</tr>
<tr>
<td>Channel T-bolts</td>
<td></td>
</tr>
<tr>
<td>Pry-out failure</td>
<td>0.70</td>
</tr>
<tr>
<td>Concrete edge</td>
<td>0.70</td>
</tr>
<tr>
<td>failure</td>
<td></td>
</tr>
<tr>
<td>Steel failure</td>
<td>0.90</td>
</tr>
<tr>
<td>in supplementary reinforcement</td>
<td></td>
</tr>
<tr>
<td>Anchorage failure of the supplementary reinforcement in the failure cone</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Table 2.2 \( \Phi \)-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 \( \lambda \) appears as a multiplier of \( \sqrt{f'c} \) in all applicable equations, with \( \lambda = 0.85 \) 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 \( N_{ui}^a \) 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

\[
N_{ui}^a = k \cdot A_i' \cdot N_{ua} \quad \text{(3.1)}
\]

where:
\( A_i' = \text{ordinate at the position of the anchor } i \text{ assuming a triangle with the unit height at the position of load } N_{ua} \) and the base length 2 \( l_i \), with \( l_i \) determined in accordance with Equation (3.3). Examples are provided in Fig. 4.1

\[
k = \frac{1}{\Sigma A_i} \quad \text{(3.2)}
\]

\[
l_i = 4.93 \left( f_y \right)^{0.05} \cdot \sqrt{\delta} \geq s, \text{ (inch)} \quad \text{(3.3)}
\]
\[ l_i = 13 \left( I_y \right)^{\frac{1}{6}} \cdot \sqrt{s} \geq s, \text{ (mm)} \]  

(3.4)

\[ s = \text{anchor spacing, (inch, mm)} \]

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

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).

\[ A'_2 = 1 - \frac{1.25s}{l_{in}} \]

\[ A'_3 = 1 - \frac{0.25s}{l_{in}} \]

\[ A'_4 = 1 - \frac{0.75s}{l_{in}} \]

\[ k = \frac{1}{A'_2 + A'_3 + A'_4} \]

\[ N_{ua, 1} = N_{ua, s} = 0 \]

\[ N_{ua, 2} = \frac{1}{6} \cdot \frac{2}{3} \cdot N = \frac{1}{9} N_{ua} \]

\[ N_{ua, 3} = \frac{5}{6} \cdot \frac{2}{3} \cdot N = \frac{5}{9} N_{ua} \]

\[ N_{ua, 4} = \frac{1}{2} \cdot \frac{2}{3} \cdot N = \frac{1}{3} N_{ua} \]

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.

<table>
<thead>
<tr>
<th>bolt diameter $d$ [mm]</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>27</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter $d_f$ of clearance hole in the fixture [mm]</td>
<td>7</td>
<td>9</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>24</td>
<td>26</td>
<td>30</td>
<td>33</td>
</tr>
</tbody>
</table>

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 $N_{ua,i}$ 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.

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

(3.4)

where (as illustrated in Figure 4.2):

- $e_s = \text{distance between reinforcement and shear force acting on the fixture, in. (mm)}$
- $z = \text{internal lever arm of the concrete member, (in, mm)}$

$$z = 0.85 \cdot (h' - h_{ch} - 0.5d_b) \leq \min \left( \frac{2h_{ef}}{2c_{ua}} \right)$$

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
<table>
<thead>
<tr>
<th>Failure types</th>
<th>Channel</th>
<th>Most unfavourable anchor or T-bolt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anchor</td>
<td>$N_{ua} \leq \phi \cdot N_{s,a}$</td>
</tr>
<tr>
<td>2</td>
<td>Connection between anchor and channel</td>
<td>$N_{ua} \leq \phi \cdot N_{s,c}$</td>
</tr>
<tr>
<td>3</td>
<td>Steel failure in supplementary reinforcement</td>
<td>$N_{ua} \leq \phi \cdot N_{s,b}$</td>
</tr>
<tr>
<td>4</td>
<td>Hook head or hammerhead and T-bolt</td>
<td>$N_{ua} \leq \phi \cdot N_{s,c}$</td>
</tr>
<tr>
<td>5</td>
<td>Bending of the channel</td>
<td>$M_{ua} \leq \phi \cdot M_{s,flex}$</td>
</tr>
<tr>
<td>6</td>
<td>Pull-out</td>
<td>$N_{ua} \leq \phi \cdot N_{p}$</td>
</tr>
<tr>
<td>7</td>
<td>Concrete breakout failure</td>
<td>$N_{ua} \leq \phi \cdot N_{cb}$</td>
</tr>
<tr>
<td>8</td>
<td>Blow-out failure</td>
<td>$N_{ua} \leq \phi \cdot N_{sb}$</td>
</tr>
<tr>
<td>9</td>
<td>Steel failure in supplementary reinforcement</td>
<td>$N_{ua} \leq \phi \cdot N_{ca}$</td>
</tr>
<tr>
<td>10</td>
<td>Anchorage failure of the supplementary reinforcement</td>
<td>$N_{ua} \leq \phi \cdot N_{ca,a}$</td>
</tr>
</tbody>
</table>

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

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 $M_{s,\text{flex}}$ (failure due to bending failure of the channel) and the corresponding $\Phi$ - 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

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

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).

$$N_p = 8 \cdot \lambda \cdot A_{brg} \cdot f_{c'} \ (\text{lb, psi})$$

with

$\lambda$ = 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

$f_{c'}$ = specified compressive concrete strength

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

$$\Psi_{cp} \cdot N_{pn} = \Psi_{cp} \cdot N_p \left( \frac{f_{c'}}{2,500} \right), \ (\text{lb, psi})$$

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

where:

$f_{c'}$ = 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, \( \Psi_{cp} \) 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).

\[
N_{cb} = N_b \cdot \Psi_{s,N} \cdot \Psi_{ed,N} \cdot \Psi_{co,N} \cdot \Psi_{c,N} \cdot \Psi_{cp,N} \quad (4.2.2.1)
\]

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).

\[
N_b = 24 \cdot \lambda \cdot a_{ch,N} \cdot \sqrt{f_c \cdot h_{ef}^{1.5}} \quad \text{(lbf)} \quad (4.2.2.2)
\]

\[
N_b = 10 \cdot \lambda \cdot a_{ch,N} \cdot \sqrt{f_c \cdot h_{ef}^{1.5}} \quad \text{(N)} \quad (4.2.2.2)
\]

where

\( \lambda \) = modification factor for sand-lightweight concrete (0.85)

\[
a_{ch,N} = \left( \frac{h_{ef}}{7.1} \right)^{0.15} \leq 1, \quad \text{(inch-pound units)} \quad (4.2.8.3)
\]

\[
a_{ch,N} = \left( \frac{h_{ef}}{150} \right)^{0.15} \leq 1, \quad \text{(SI-units)} \quad (4.2.8.3)
\]

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)

\[
\Psi_{s,N} = \frac{1}{1 + \sum_{i=2}^{n} \left( 1 - \frac{S_i}{S_{ch,N}} \right) \cdot \frac{N_{ua,i}}{N_{ua,1}}} \quad (4.2.2.4)
\]
where (as illustrated in Fig. 5.2)

\[ s_i = \text{distance between the anchor under consideration and influencing anchor, (in, mm)} \]

\[ s_i \leq s_{cr,N} \]

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

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

\[ N_{ua,i} = \text{Factored tension load of an influencing anchor, (lbf, N)} \]

\[ N_{ua,1} = \text{Factored tension load of the anchor under consideration, (lbf, N)} \]

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

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 \( c_{at} \geq c_{cr,N} \)

then \[ \Psi_{ed,N} = 1.0 \]
If $c_{a1} < c_{cr,N}$

then $\Psi_{zd,N} = \left(\frac{c_{a1}}{c_{cr,N}}\right)^{0.5} \leq 1.0$  \hspace{1cm} (4.2.2.7)

where

$$c_{cr,N} = 0.5 s_{cr,N} = (2.8 - 1.3 h_{ef} / 7.1) h_{ef} \geq 1.5 h_{ef}, \text{ (in)}$$ \hspace{1cm} (4.2.2.8)

$$c_{cr,N} = 0.5 s_{cr,N} = (2.8 - 1.3 h_{ef} / 180) h_{ef} \geq 1.5 h_{ef}, \text{ (mm)}$$ \hspace{1cm} (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).

![Figure 5.3 – Anchor channels](image)

a) At an edge  
b) In a narrow member
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 $\Psi_{co,N} = 1.0$  \hspace{1cm} (4.2.2.8)

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

then $\Psi_{co,N} = \left( \frac{c_{a2}}{c_{cr,N}} \right)^{0.5} \leq 1.0$  \hspace{1cm} (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](image)

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 \( h_{ef} > 2.0 \, c_{as} \) side-face blowout failure has to be considered. Since all JORDAHL JTA anchor channels have an effective embedment depth \( h_{ef} < 2 \, c_{as} \), 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, \( N_{ua} \), 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 \( \phi \) 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).

![Diagram of anchor reinforcement](image)

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

$$N_{ca} = n \cdot A_s \cdot f_{ys} \text{ (lbf, N)}$$  \hspace{1cm} (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).

$$N_{ca,a} = \sum n \frac{l_{ah}\cdot d_s\cdot f_{bd}}{\alpha} \text{ (lbf, N)}$$  \hspace{1cm} (4.2.5.1)

with

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

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

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

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

$= 4d_s$ (hooks or angle hooks)

$= 10d_s$ anchoring with straight bars

$d_s$ = Diameter of the supplementary reinforcement

$f_{bd} = 2.3 \cdot \left(\frac{f_{\text{c}}^\prime}{1.5}\right)^{\frac{2}{3}} \text{ (psi)}$

$\alpha$ = 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>
<thead>
<tr>
<th>Type of failure</th>
<th>Channel</th>
<th>Most unfavourable anchor or bolt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Channel bolt</td>
<td>$V_{ua} \leq \phi \cdot V_{ss}$ a)</td>
</tr>
<tr>
<td>2</td>
<td>Anchor</td>
<td>$V_{ua} \leq \phi \cdot V_{sa}$ a)</td>
</tr>
<tr>
<td>3</td>
<td>Anchors/ channel</td>
<td>$V_{ua} \leq \phi \cdot V_{sc}$ a)</td>
</tr>
<tr>
<td>4</td>
<td>Local failure of the channel lip</td>
<td>$V_{ua} \leq \phi \cdot V_{sl}$ a)</td>
</tr>
<tr>
<td>5</td>
<td>Channel bolt</td>
<td>$V_{ua} \leq \phi \cdot V_{ss}$ a)</td>
</tr>
<tr>
<td>6</td>
<td>Pry out</td>
<td>$V_{ua} \leq \phi \cdot V_{cp}$ b)</td>
</tr>
<tr>
<td>7</td>
<td>Concrete edge failure</td>
<td>$V_{ua} \leq \phi \cdot V_{cp}$ b)</td>
</tr>
<tr>
<td>8</td>
<td>Steel failure of the additional reinforcement</td>
<td>$N_{ua} \leq \phi \cdot N_{ca}$ a)</td>
</tr>
</tbody>
</table>

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.

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).

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

\( f_{\text{uts}} \) shall be taken as the smaller of 1.9 \( f_{\text{ys}} \) 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, \( V_{\text{ss}} \), shall be computed in accordance with Eq. (5.1.4.2).

\[
V_{\text{ss}} = \frac{\alpha_{\text{m}} M_{\text{s,s}}}{l}, \text{ (lbf, N)}
\]  

(5.1.4.2)

where

\( \alpha_{\text{m}} \) = factor to take account of restraint of the fixture

\( \alpha_{\text{m}} = 1.0 \) if the fixture can rotate freely (no restraint, see Figure 5.7a)

\( \alpha_{\text{m}} = 2.0 \) if the fixture cannot rotate (full restraint, see Figure 5.7b)

\[
M_{\text{s,s}} = M_{\text{s,s}}^{0} \left( \frac{N_{\text{ub}}}{N_{\text{s,s}}} \right), \text{ (lbf-in, N-mm)}
\]  

(5.1.4.3)

\( M_{\text{s,s}}^{0} \) = nominal flexural strength of channel T-bolt

\( M_{\text{s,s}}^{0} = 1.2 \cdot S_{\text{chb}} \cdot f_{\text{uts}}, \text{ (lbf-in, N-mm)} \)  

(5.1.4.4)

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

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

$$V_{cb} = V_b \cdot \psi_s \cdot \psi_c \cdot \psi_h \cdot \psi_e \cdot (lb, N)$$  \hspace{1cm} (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](image-url)
\( V_b \) is the basic concrete breakout strength of a single anchor of an anchor channel. The modification factors \( \Psi_{s,V}, \Psi_{co,V} \) 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).

\[
V_b = \lambda \cdot \alpha_{ch,V} \cdot \psi_{c,V} \cdot \sqrt{f'_{c} \cdot c_{at}^{4/3}}, \text{ (lbf, N)}
\]  

(5.2.2.2)

where

\( \lambda = \text{modification factor for sand-lightweight concrete} = 0.65 \)

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

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

(5.2.2.3)

where (as illustrated in Figure 5.9):

- \( s_i = \text{distance between the anchor under consideration and the adjacent anchors, (in, mm)} \)
- \( s_{cr,V} = 4c_{at} + 2b_{ch}, \text{ (in, mm)} \)
- \( V_{ua,i} = \text{factored shear load of an influencing anchor, (lbf, N)} \)
- \( V_{ua,1} = \text{factored shear load of the anchor under consideration, (lbf, N)} \)
- \( n = \text{number of anchors within a distance } s_{cr,V} \text{ to both sides of the anchor under consideration} \)
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 $c_{a2} \geq c_{cr,V}$
\[ \Psi_{co,V} = 1.0 \] (5.2.2.5)

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

where
\[ c_{cr,V} = 2c_{a1} + b_{ch} \text{ (in, mm)} \] (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).
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 \( \frac{1}{2} \) inch (12.7 mm) or greater (No. 4 bar or greater) between the anchor channel and the edge, and with the edge reinforcement enclosed with stirrups with a diameter of \( \frac{1}{2} \) 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).

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

where

\[ h_{cr,V} = 2c_{a1} + 2h_{ch}, \text{ (in, mm)} \] \tag{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).

$$c_{a1,red} = \max \left( \frac{c_{a2,max}-b_{ch}}{2}, \frac{h-2h_{ch}}{2} \right), \text{ (in, mm)}$$  \hspace{1cm} (5.2.2.10)

where $c_{a2,max}$ is the largest of the edge distances perpendicular to the longitudinal axis of the channel.
Figure 5.12 – Example of an anchor channel influenced by two corners and member thickness. For this example, the value of $ca_{1,\text{red}}$ is obtained by moving the failure surface forward until it intersects the corner as shown (in example $ca_{2,2}$ is decisive for the determination of $ca_{1,\text{red}}$).

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).

$$V_{cp} = k_{cp} \cdot N_{cb}, \text{ (lbf, N)}$$  \hspace{1cm} (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 $N_{ua,1}^a$ and $N_{ua,i}^a$ in Eq. (4.2.2.4) shall be replaced by $V_{ua,1}^a$ and $V_{ua,i}^a$, respectively.
The nominal pryout strength of a single anchor of an anchor channel with supplementary anchor reinforcement shall not exceed

\[ V_{cp} = 0.75 \cdot k_{cp} \cdot N_{cb}, \text{ (lbf, N)} \]  

(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, \( \phi V_{ca} \), shall be permitted to be used instead of the concrete breakout strength, \( \phi V_{cb} \), in determining \( \phi V_{n} \). A strength reduction factor \( \phi \) 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).

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

(5.2.3.1)

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

(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.

i) 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).

ii) 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, $V_{ua}$ 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).

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

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 $V_{ua}$ is larger than $V_{ua}^0$ then the value $V_{ua}$ shall be inserted in Section 5.3.1 and 5.3.2 instead of $V_{ua}^0$. 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:

- $\Phi V_{ns} = $ steel strength of anchor channel loaded in shear (lowest value of $V_{sa}$, $V_{sc}$ and $V_{sl}$) (lbf, N)
- $\Phi N_{ns} = $ steel strength of anchor channel loaded in tension (lowest value of $N_{sa}$, $N_{sc}$ and $N_{sl}$) (lbf, N)
- $\Phi N_n = $ lowest tension strength from all appropriate failures modes under tension (lbf, N)
- $\Phi V_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 $\Phi V_{ns} \leq \Phi N_{ns}$ and where no anchor reinforcement is provided, or for anchor channels with $\Phi V_{ns} \leq \Phi N_{ns}$ and where anchor reinforcement is provided for both tension and shear loads, the following requirements shall be satisfied.

If $V_{ua} > 0.2 \cdot \Phi V_n$, 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 $V_{ua}^a > 0.2 \cdot \Phi V_n$ and $N_{ua}^a > 0.2 \cdot \Phi N_n$

Then Eq. (6a) applies.

$$\frac{N_{ua}^a}{\Phi N_n} + \frac{V_{ua}^a}{\Phi V_n} \leq 1.2 \quad \text{(6a)}$$

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

$$\left(\frac{N_{ua}^a}{\Phi N_n}\right)^{5/3} + \left(\frac{V_{ua}^a}{\Phi V_n}\right)^{5/3} \leq 1.0 \quad \text{(6b)}$$
5.3.3 Combination for \( V_{ns} > \phi N_{ns} \) or reinforced concrete

For anchor channels with \( \phi V_{ns} \leq \phi N_{ns} \) where anchor reinforcement is provided for only one direction (tension or shear), Eq. (6c) shall be satisfied.

\[
\frac{N_{ua}}{\phi N_n} + \frac{V_{ua}}{\phi V_n} \leq 1.0
\]  

Eq. (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

\[
\left( \frac{N_{ua}}{\phi N_{ss}} \right)^2 + \left( \frac{V_{ua}}{\phi V_{ss}} \right)^2 \leq 1.0
\]  

Eq. (6.5.1.1)

where \( N_{ua} \) and \( V_{ua} \) 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

\[
\left( \frac{N_{ua}}{\phi N_{ns,a}} \right)^a + \left( \frac{V_{ua}}{\phi V_{ns,a}} \right)^a \leq 1.0
\]  

Eq. (6.3.1.1)
where
\[
\alpha = 2 \quad \text{for anchor channels with } \phi V_{n.s,a} \leq \phi N_{n.s,a}. \text{ Shear strengths values acc. Table 7.1.}
\]
\[
\alpha < 2 \quad \text{for anchor channels with } \phi V_{n.s,a} > \phi N_{n.s,a}. \text{ The exponent } \alpha \text{ shall be taken from Table 7.2}
\]

b) At the point of load application

\[
\left( \frac{N_{ua}}{\phi_{N_{ns,l}}} \right)^\alpha + \left( \frac{V_{ua}}{\phi_{V_{sl}}} \right)^\alpha \leq 1.0
\]  \hspace{1cm} (6.4.1.1)

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

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

\[
\left( \frac{N_{ua}}{\phi_{N_{nc}}} \right)^\alpha + \left( \frac{V_{ua}}{\phi_{V_{nc}}} \right)^\alpha \leq 1.0
\]  \hspace{1cm} (6.1.1.1)

where
\[
\alpha = 1.5 \quad \text{anchor channels without anchor reinforcement or with anchor reinforcement to take up tension and shear loads}
\]
\[
\alpha = 1.0 \quad \text{anchor channels with anchor reinforcement to take up tension or shear loads}
\]

6 References

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Anchor channel sizes JTA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>K28/15</td>
</tr>
<tr>
<td>Channel height h_{ch}</td>
<td>in</td>
<td>(mm)</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(15.25)</td>
</tr>
<tr>
<td>Channel width d_{ch}</td>
<td>in</td>
<td>(mm)</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(28)</td>
</tr>
<tr>
<td>Moment of inertia,</td>
<td>I_{p}</td>
<td>(mm^4)</td>
<td>0.010</td>
</tr>
<tr>
<td>mild steel and</td>
<td></td>
<td></td>
<td>(4059)</td>
</tr>
<tr>
<td>stainless steel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum anchor spacing a_{min}</td>
<td>in</td>
<td>(mm)</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(50)</td>
</tr>
<tr>
<td>Maximum anchor spacing a_{max}</td>
<td>in</td>
<td>(mm)</td>
<td>7.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(200)</td>
</tr>
<tr>
<td>Installation height h_{inst}</td>
<td>in</td>
<td>(mm)</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(50)</td>
</tr>
<tr>
<td>Minimum edge distance c_{min}</td>
<td>in</td>
<td>(mm)</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(41)</td>
</tr>
</tbody>
</table>

2 I_{p} in stainless steel = 19759 mm^4 (0.05 in^4)
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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Units</th>
<th>Anchor channel sizes JTA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>K28/15</td>
</tr>
<tr>
<td>T-bolt type</td>
<td>JD</td>
<td>JH</td>
</tr>
<tr>
<td>Diameter Ø [mm]</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 3: steel strength values of T-bolts in tension

<table>
<thead>
<tr>
<th>Nominal tensile strength</th>
<th>$N_{ts}$ (lbf, kN)</th>
<th>$f_{ut}$</th>
<th>$f_{ys}$</th>
<th>$f_{ts}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>1799 (8)</td>
<td>4.6(^1)</td>
<td>7576 (33.7)</td>
<td>14119 (62.8)</td>
</tr>
<tr>
<td>M8</td>
<td>3282 (14.6)</td>
<td>8.8(^1)</td>
<td>5216 (23.2)</td>
<td>22032 (98)</td>
</tr>
<tr>
<td>M10</td>
<td>5216 (23.2)</td>
<td>-</td>
<td>9128 (40.6)</td>
<td>31745 (141.2)</td>
</tr>
<tr>
<td>M12</td>
<td>7576 (33.7)</td>
<td>-</td>
<td>13242 (58.9)</td>
<td>41277 (183.6)</td>
</tr>
<tr>
<td>M16</td>
<td>14119 (62.8)</td>
<td>-</td>
<td>21385 (95)</td>
<td>50450 (224.4)</td>
</tr>
<tr>
<td>M20</td>
<td>22032 (98)</td>
<td>A4-50(^2)</td>
<td>40468 (180)</td>
<td>-</td>
</tr>
<tr>
<td>M24</td>
<td>31745 (141.2)</td>
<td>A4-70(^3), HCR-70(^4), FA-70(^5)</td>
<td>63489 (282.4)</td>
<td>-</td>
</tr>
<tr>
<td>M27</td>
<td>41277 (183.6)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>M30</td>
<td>50450 (224.4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Strength reduction factor for steel failure under tension

\[ \Phi = 0.65 \]

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 ($f_{ut}$, $f_{ys}$) of stainless steel A4-50 and HCR-50 are identical
\(^{6}\) The mechanical properties ($f_{ut}$, $f_{ys}$) of stainless steel A4-70, HCR-70 and FA-70 are identical
### Table 4: steel strength values of channels in tension

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Anchor channel sizes</th>
</tr>
</thead>
</table>
| Nominal strength for local failure of channel lips, tension             |        |       | K 28/15  
                                                                  |        |       | W 38/17  
                                                                  |        |       | W 40/22  
                                                                  |        |       | W 50/30  
                                                                  |        |       | W 53/34  
                                                                  |        |       | W 55/42  
                                                                  |        |       | W 72/48  |
| Nominal steel strength of a single anchor in tension, round anchor       |        |       | lbf 2023  
                                                                  |        |       | W 4047  |
|                                                                         |        |       | (kN) (9)  
                                                                  |        |       | (18)  |
|                                                                         |        |       | (35)  |
|                                                                         |        |       | (36)  |
|                                                                         |        |       | (65)  |
|                                                                         |        |       | (80)  |
|                                                                         |        |       | (100)  |
| Nominal steel strength of a single anchor in tension, I-anchor           |        |       | lbf 2023  
                                                                  |        |       | W 4047  |
|                                                                         |        |       | (kN) (9)  
                                                                  |        |       | (18)  |
|                                                                         |        |       | (20)  |
|                                                                         |        |       | (31)  |
|                                                                         |        |       | (55)  |
|                                                                         |        |       | (80)  |
|                                                                         |        |       | (100)  |
| Nominal tension strength connection channel / anchor                     |        |       | lbf 2023  
                                                                  |        |       | W 4047  |
|                                                                         |        |       | (kN) (9)  
                                                                  |        |       | (18)  |
|                                                                         |        |       | (20)  |
|                                                                         |        |       | (31)  |
|                                                                         |        |       | (55)  |
|                                                                         |        |       | (80)  |
|                                                                         |        |       | (100)  |
| Strength reduction factor                                                |        |       | $\Phi$ | 0.75 |
| Nominal bending strength of channel, mild steel                          |        |       | lbf in 2806  
                                                                  |        |       | M_s,flex  |
|                                                                         |        |       | (Nm) (317)  |
| Nominal bending strength of channel, stainless steel                     |        |       | lbf in 2868  
                                                                  |        |       | M_s,flex  |
|                                                                         |        |       | (Nm) (324)  |
| Strength reduction factor                                                |        |       | $\Phi$ | 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

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

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Grade / Material</th>
<th>T-bolt sizes</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M16</th>
<th>M20</th>
<th>M24</th>
<th>M27</th>
<th>M30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal shear strength</td>
<td>$V_{ss}$</td>
<td>lbf (kN)</td>
<td>4.6(^1)</td>
<td>1079 (4.8)</td>
<td>1978 (8.8)</td>
<td>3125 (13.9)</td>
<td>4541 (20.2)</td>
<td>8476 (37.7)</td>
<td>13219 (58.6)</td>
<td>19042 (84.7)</td>
<td>24775 (110.2)</td>
<td>30261 (134.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.8(^1)</td>
<td>3957 (17.6)</td>
<td>6250 (27.8)</td>
<td>9098 (40.4)</td>
<td>16951 (75.4)</td>
<td>26439 (117.6)</td>
<td>38085 (169.4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A4-50(^2), HCR-50(^3), FA-70(^4), HCR-70(^5), FA-70(^6)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strength reduction factor for steel failure under shear</td>
<td>$\Phi$</td>
<td>-</td>
<td>4.6, 8.8, A4-50, HCR-50, HCR-70, FA-70</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal bending strength of T-bolt</td>
<td>$M_{bs}$</td>
<td>lbf-in (Nm)</td>
<td>4.6(^1)</td>
<td>56 (6.3)</td>
<td>133 (15)</td>
<td>265 (29.9)</td>
<td>463 (52.3)</td>
<td>1175 (132.8)</td>
<td>2205 (259.3)</td>
<td>3966 (448.1)</td>
<td>5900 (666.6)</td>
<td>7957 (899)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.8(^1)</td>
<td>-</td>
<td>266 (30)</td>
<td>529 (59.6)</td>
<td>926 (104.6)</td>
<td>2351 (265.6)</td>
<td>4590 (516.6)</td>
<td>7931 (896.1)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A4-50(^2), HCR-50(^3), FA-70(^4), HCR-70(^5), FA-70(^6)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strength reduction factor for bending failure</td>
<td>$\Phi$</td>
<td>-</td>
<td>4.6, 8.8, A4-50, HCR-50, HCR-70, FA-70</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 ($f_{uts}$, $f_{us}$) of stainless steel A4-50 and HCR-50 are identical
6 The mechanical properties ($f_{uts}$, $f_{us}$) 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 $\alpha = 2.0$

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Anchor channel sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>K 28/15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>K 38/17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>W 40/22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>W 50/30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>W 53/34</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>W 55/422</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>W 72/48</td>
</tr>
<tr>
<td>Nominal strength for local failure of channel lips, shear</td>
<td>$V_u^1$</td>
<td>lbf/kN</td>
<td>2023 (kN) (9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4047 (18)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7868 (35)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8094 (36)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14613 (65)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17985 (80)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22481 (100)</td>
</tr>
<tr>
<td>Interaction exponent</td>
<td>$\alpha$</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Strength reduction factor</td>
<td>$\Phi$</td>
<td>-</td>
<td>0.75</td>
</tr>
</tbody>
</table>

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 $\alpha = 2.0$

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Anchor channel sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>K 28/15</td>
</tr>
<tr>
<td>Nominal steel strength of a single anchor in shear, round anchor</td>
<td>$V_{sa1}$</td>
<td>lbf</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kN</td>
<td>(9)</td>
</tr>
<tr>
<td>Nominal steel strength of a single anchor in shear, welded anchor</td>
<td>$V_{sa1}$</td>
<td>lbf</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kN</td>
<td>(9)</td>
</tr>
<tr>
<td>Nominal shear strength for connection channel / anchor</td>
<td>$V_{sc1}$</td>
<td>lbf</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kN</td>
<td>(9)</td>
</tr>
</tbody>
</table>

Interaction exponent $\alpha$ - 2 2 2 2 2 2 2

Strength reduction factor $\Phi$ - 0.75

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Anchor channel sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>K 28/15</td>
</tr>
<tr>
<td>Nominal steel strength of a single anchor in shear, round anchor</td>
<td>$V_{sa1}$</td>
<td>lbf</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kN</td>
<td>-</td>
</tr>
<tr>
<td>Nominal steel strength of a single anchor in shear, welded anchor</td>
<td>$V_{sa1}$</td>
<td>lbf</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kN</td>
<td>-</td>
</tr>
<tr>
<td>Nominal shear strength for connection channel / anchor</td>
<td>$V_{sc1}$</td>
<td>lbf</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kN</td>
<td>-</td>
</tr>
</tbody>
</table>

Interaction exponent $\alpha$ - - 1.2 1.2 1.2 1.2 1.2

Strength reduction factor $\Phi$ - 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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Symbol</th>
<th>Units</th>
<th>Anchor channel sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>K 28/15</td>
</tr>
<tr>
<td>Product of factor $\alpha_{\text{ch},V} \cdot \Psi_{\text{ch}}$</td>
<td>-</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.0)</td>
</tr>
<tr>
<td>Uncracked concrete $^1$</td>
<td>-</td>
<td></td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(5.7)</td>
</tr>
<tr>
<td>Exponent $\beta_1$</td>
<td>-</td>
<td></td>
<td>2/3</td>
</tr>
<tr>
<td>Pryout Failure, factor $k_{\text{Pp}}$</td>
<td>-</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Strength reduction factor $\Phi$</td>
<td>-</td>
<td></td>
<td>0.7</td>
</tr>
</tbody>
</table>

---

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

Channel and T-bolt:
Profile W40/22, L = 6 in., 2 anchors
Anchor spacing: s = 4 in.
1 T-bolt M12 4.6

Concrete conditions:
Concrete 3500 psi, cracked concrete
Member thickness h = 6 in.
Edge distance c1 = 3 in.
Edge distance c2 = 8 in.

Factored loads applied to T-bolt:
Nu = 1300 lbs, Vu = 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

<table>
<thead>
<tr>
<th>Characteristic values</th>
<th>Φ-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_y = 0.047 \text{ in}^4$</td>
<td></td>
</tr>
<tr>
<td>$N_{sa} = 4496 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{sc} = 4496 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{sl} = 7868 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{ss} = 7576 \text{ lbs}$</td>
<td>0.65</td>
</tr>
<tr>
<td>$M_{flex} = 9523 \text{ lbs in.}$</td>
<td>0.85</td>
</tr>
<tr>
<td>$N_p = 3600 \text{ lbs (for 2500 psi)}$</td>
<td>0.7</td>
</tr>
<tr>
<td>$h_{ef} = 3.11 \text{ in.}$</td>
<td></td>
</tr>
<tr>
<td>$\alpha_{ch} = 0.88$</td>
<td></td>
</tr>
<tr>
<td>$s_{cr,N} = 13.9 \text{ in.}$</td>
<td></td>
</tr>
<tr>
<td>$c_{cr,N} = 6.9 \text{ in.}$</td>
<td></td>
</tr>
<tr>
<td>$V_{sa} = 8543 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$V_{sc} = 8543 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$V_{sl} = 7868 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$V_{ss} = 4541 \text{ lbs}$</td>
<td>0.6</td>
</tr>
<tr>
<td>$\alpha_{ch,V} \cdot \Psi_{c,V} = 9.0$</td>
<td></td>
</tr>
<tr>
<td>$b_{ch} = 1.56 \text{ in.}$</td>
<td></td>
</tr>
<tr>
<td>$h_{ch} = 0.91 \text{ in.}$</td>
<td></td>
</tr>
</tbody>
</table>
1. Load distribution

Calculation of anchor forces

\[ l_i = 4.93 \cdot t_y^{0.05} \cdot s^{0.5} \]  
\[ = 4.93 \cdot 0.047^{0.05} \cdot 3.93^{0.5} = 8.39 \text{ in.} \quad \text{(eq. 3.3)} \]

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

<table>
<thead>
<tr>
<th></th>
<th>Anchor 1</th>
<th>Anchor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Distance of the load to the anchor (in.)</td>
<td>0</td>
</tr>
<tr>
<td>1.2</td>
<td>( A_i' = (l_i+s)/l_i )</td>
<td>( (8.39-0)/8.39 = 1.000 )</td>
</tr>
<tr>
<td>1.3</td>
<td>( k = 1/\Sigma A_i' )</td>
<td>( 1/(1.00+0.531) = 0.653 )</td>
</tr>
<tr>
<td>1.4</td>
<td>( N^a_{ua} = k \cdot A_i' \cdot N_{ua} ) (lbs)</td>
<td>( 0.653 \cdot 1.000 \cdot 1300 = 850 )</td>
</tr>
</tbody>
</table>

Analog for shear: \( V^a_{ua} \) (lbs)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>785</td>
</tr>
<tr>
<td></td>
<td>415</td>
</tr>
</tbody>
</table>

For 2.5 below the load is applied at midspan (critical), the anchor load in tension is \( 1300/2 = 650 \text{ lbs.} \)
2. Tension Loads

2.1 Check steel failure of anchor
\[ N_{ua} = 850 \text{ lbs} \]
\[ \phi N_{sa} = \phi \cdot N_{sa} = 0.75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_N = N_{ua} / \phi N_{sa} = 0.25 \leq 1 \quad \checkmark \]

2.2 Check failure of connection between anchor and channel
\[ N_{ua} = 850 \text{ lbs} \]
\[ \phi N_{sc} = \phi \cdot N_{sc} = 0.75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_N = N_{ua} / \phi N_{sc} = 0.25 \leq 1 \quad \checkmark \]

2.3 Check failure of channel lip
\[ N_{ua} = 1300 \text{ lbs} \]
\[ \phi N_{sl} = \phi \cdot N_{sl} = 0.75 \cdot 7868 \text{ lbs} = 5901 \text{ lbs} \]
\[ \beta_N = N_{ua} / \phi N_{sl} = 0.22 \leq 1 \quad \checkmark \]

2.4 Check steel failure of T-bolt
\[ N_{ua} = 1300 \text{ lbs} \]
\[ \phi N_{ss} = \phi \cdot N_{ss} = 0.65 \cdot 7576 \text{ lbs} = 4924 \text{ lbs} \]
\[ \beta_N = N_{ua} / \phi N_{ss} = 0.26 \leq 1 \quad \checkmark \]

2.5 Check bending of channel
Governing load position: centered between the anchors
\[ M_{ua} = \frac{1}{4} \cdot (1300 \text{ lbs} \cdot 3.93 \text{ in.}) = 1277 \text{ lbs in.} \]
\[ M_{sflex} = 9523 \text{ lbs in.} \]
\[ \phi M_{sflex} = 0.85 \cdot 9523 \text{ lbs} = 8095 \text{ lbs} \]
\[ \beta_N = \frac{1277 \text{ lbs in.}}{8095 \text{ lbs in.}} = 0.16 \leq 1 \quad \checkmark \]

2.6 Check pull out failure
\[ N_{ua} = 850 \text{ lbs} \]
\[ \phi N_p = \phi \cdot \Psi_{cp} \cdot N_p (3500 \text{ psi}) = 0.7 \cdot 1.0 \cdot 3664 \cdot \frac{3500}{2500} = 3596 \text{ lbs} \]
\[ (\text{eq. 4.2.1.1}) \]
\[ \beta_N = \frac{850 \text{ lbs}}{3591 \text{ lbs}} = 0.24 \leq 1 \quad \checkmark \]
2.7 Check concrete cone failure (Anchor 1)

\[ N_{\text{ub}} = 850 \text{ lbs} \]

\[ N_b = 24 \cdot a_{\text{ch,N}} \cdot f_c^{0.5} \cdot h_{\text{ef}}^{1.5} = 24 \cdot 0.88 \cdot 3500^{0.5} \cdot 3.11^{1.5} = 6880 \text{ lbs} \quad (\text{eq. 4.2.2.2}) \]

*Influence of adjacent anchors*

\[
\Psi_{s,N} = \frac{1}{1 + \sum_{i=2}^{n} \left( \left( \frac{S_{\text{cr,N}}}{S_{\text{cr,1}}} \right)^{1.5} \frac{N_{\text{ub,i}}}{N_{\text{ub,1}}} \right)^{1.5}} \\
S_{\text{cr,N}} = 2 \left( 2.8 \cdot \frac{3.11}{7.1} \right) \cdot 3.11 = 13.87 \quad (\text{eq. 4.2.2.4})
\]

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

*Influence of member edges*

\[ c_{\text{cr,N}} = 0.5 \cdot s_{\text{cr,N}} = 0.5 \cdot 13.87 \text{ in.} = 6.94 \text{ in.} \quad (\text{eq. 4.2.2.5}) \]

\[ c_{\text{a1}} = 3 \text{ in} < c_{\text{cr,N}} \quad (\text{eq. 4.2.2.7}) \]

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

*Influence of corner*

\[ c_{\text{a2}} = 8 \text{ in} > 6.94 \text{ in.} \quad (\text{eq. 4.2.2.9}) \]

\[ \Psi_{\text{co,N}} = 1.0 \]

*Influence of cracked concrete*

\[ \Psi_{\text{c,N}} = 1.0 \quad \text{(cracked concrete)} \]

\[ \phi_{N_{\text{cb}}} = \phi_{N_b} \cdot \Psi_{s,N} \cdot \Psi_{\text{ed,N}} \cdot \Psi_{\text{co,N}} \cdot \Psi_{\text{c,N}} \cdot \Psi_{\text{cp,N}} \quad (\text{eq. 4.2.2.1}) \]

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

\[ \beta_N = \frac{N_{\text{ub}}}{\phi_{N_{\text{cb}}}} = 0.35 \leq 1 \quad \checkmark \]
3. Shear Loads

3.1 Check steel failure of anchor

\[ V^a_{ua} = 785 \text{ lbs} \]
\[ \phi V_{sa} = \phi \cdot V_{sa} = 0.75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_V = V^a_{ua} / \phi V_{sa} = 0.23 \leq 1.0 \checkmark \]

3.2 Check failure of connection between anchor and channel

\[ V^a_{ua} = 785 \text{ lbs} \]
\[ \phi V_{sc} = \phi \cdot V_{sc} = 0.75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_V = V^a_{ua} / \phi V_{sc} = 0.23 \leq 1.0 \checkmark \]

3.3 Check failure of channel lip (Load 1)

\[ V_{ua} = 1200 \text{ lbs} \]
\[ \phi V_{sl} = \phi \cdot V_{sl} = 0.75 \cdot 7868 \text{ lbs} = 5901 \text{ lbs} \]
\[ \beta_V = V_{ua} / \phi V_{sl} = 0.20 \leq 1.0 \checkmark \]

3.4 Check steel failure of T-bolt

\[ V^a_{ua} = 1200 \text{ lbs} \]
\[ \phi V_{ss} = \phi \cdot V_{ss} = 0.60 \cdot 4541 \text{ lbs} = 2725 \text{ lbs} \]
\[ \beta_V = V^a_{ua} / \phi V_{ss} = 0.44 \leq 1.0 \checkmark \]

3.5 Check concrete edge failure c_{11}

\[ V^c_{ua} = 785 \text{ lbs} \]
\[ V_b = \alpha_{ch,V} \cdot \Psi_{cV} \cdot \sqrt{f_c \cdot c_{a1}^{1.33}} \]
\[ = 9.0 \cdot 3500^{0.5} \cdot 3.00^{1.33} = 2304 \text{ lbs} \]

Influence of adjacent anchors

\[ \Psi_{s,V} = \frac{1}{1 + \sum_{\ell=1}^{n} \left( \frac{1}{s_{cr,V}} \right)^{1.5} \frac{V^{a}_{ua, \ell}}{V^{a}_{ua, 1}}} \]  \hspace{1cm} (eq. 5.2.2.3)

\[ s_{cr,V} = 4c_{a1} + 2b_{ch} = 12 \text{ in} + 2 \cdot 1.56 \text{ in} = 15.12 \text{ in} \]  \hspace{1cm} (eq. 5.2.2.4)
\[ \psi_{s, v} = \frac{1}{1 + \left(\frac{1.5}{1.12}\right)^{1.5}} = 0.75 \]

**Influence of corner**
\[ c_{cr,v} = 2c_{a1} + b_{ch} \]
\[ = 2 \cdot 3 \text{ in} + 1.56 \text{ in} = 7.56 \text{ in} \]
\[ c_{a2} = 8 \text{ in} > 7.56 \text{ in} \]
\[ \psi_{co,v} = 1.0 \] (eq. 5.2.2.5)

**Influence of member thickness**
\[ h_{cr,v} = 2c_{a1} + 2h_{ch} \]
\[ = 2 \cdot 3 + 2 \cdot 0.91 = 7.82 \text{ in} \]
\[ \psi_{h,v} = \left( \frac{n}{h_{cr,v}} \right)^{\beta_1} \]
\[ = \left( \frac{6}{7.82} \right)^{\frac{3}{2}} = 0.84 \]
\[ V_{cb} = \phi V_b \psi_{s,v} \cdot \psi_{co,v} \cdot \psi_{h,v} = \]
\[ = 0.70 \cdot 2304 \text{ lbs} \cdot 0.75 \cdot 1.00 \cdot 0.84 = 1014 \text{ lbs} \]
\[ \beta_V = \frac{V_{cb}}{\phi V_b} = 0.77 \leq 1.0 \] ✓

3.6 Check pry out failure
\[ V_{ua}^a = 785 \text{ lbs} \]
\[ \phi V_{cp} = \phi \cdot k_{cp} \cdot N_{cb} = 0.7 \cdot 2 \cdot 3434 \text{ lbs} = 4808 \text{ lbs} \]
\[ \beta_V = V_{ua}^a / \phi V_{cp} = 0.16 \leq 1.0 \]

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 c₁ = 3 in.

Factored forces acting on the bracket:
Nₓ = 650 lbs, Vᵧ = 2250 lbs
## Values

<table>
<thead>
<tr>
<th>Characteristic values</th>
<th>Φ-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_y = 0.125 \text{ in}^4$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{sa} = 6969 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{sc} = 6969 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{sl} = 8093 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$N_{ss} = 14118 \text{ lbs}$</td>
<td>0.65</td>
</tr>
<tr>
<td>$M_{flex} = 13524 \text{ lbs in.}$</td>
<td>0.85</td>
</tr>
<tr>
<td>$N_p = 5418 \text{ lbs (for 2500 psi)}$</td>
<td>0.7</td>
</tr>
<tr>
<td>$h_{ef} = 3.7 \text{ in.}$</td>
<td></td>
</tr>
<tr>
<td>$\alpha_{ch} = 0.91$</td>
<td></td>
</tr>
<tr>
<td>$V_{sa} = 6969 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$V_{sc} = 6969 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$V_{sl} = 8093 \text{ lbs}$</td>
<td>0.75</td>
</tr>
<tr>
<td>$V_{ss} = 8475 \text{ lbs}$</td>
<td>0.6</td>
</tr>
<tr>
<td>$\alpha_{ch,V} \cdot \psi_{c,v} = 14.9$</td>
<td></td>
</tr>
<tr>
<td>$b_{ch} = 1.93 \text{ in}$</td>
<td></td>
</tr>
<tr>
<td>$h_{ch} = 1.18 \text{ in}$</td>
<td></td>
</tr>
</tbody>
</table>
Factored Forces acting on the bracket:
Wind suction = 2250 lbs;
Dead load = 650 lbs

1. Loads acting on the channel

Shear:
\[ \Sigma H = 0 \rightarrow V_{ud} = 2250 \text{ lbs} \rightarrow V_{ud}/T-bolt = 2250 \text{ lbs/2} = 1125 \text{ lbs} \]

Tension:
Moment caused by eccentricities \( M_{ud} = 2250 \text{ lbs kN} \cdot 1.6 \text{ in} + 650 \text{ lbs (5.5 in - 3 in)} = 5000 \text{ lbs in} \)

\[ \text{Tension} = \frac{5000}{(0.80 \cdot 3 \text{ in.})} = N_{ud} = 2090 \text{ lbs} \rightarrow N_{ud}/T-bolt = 2090 \text{ lbs/2} = 1045 \text{ lbs} \]
## 2. Load distribution

### Calculation of anchor forces

\[ l_i = 4.93 1_y^{0.05} s^{0.5} = 4.93 0.125^{0.05} 6^{0.5} = 10.88 \text{ in} \]  
(eq. 3.3)

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

<table>
<thead>
<tr>
<th>Distance load at 100 mm to the anchor (in)</th>
<th>Anchor 1</th>
<th>Anchor 2</th>
<th>Anchor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A_i = (l_i - s) / l_i)</td>
<td>1 - (\frac{3}{10.88}) = 0.724</td>
<td>1 - (\frac{3}{10.88}) = 0.7</td>
<td>1 - (\frac{9}{10.88}) = 0.173</td>
</tr>
<tr>
<td>(k = 1 / \sum A_i)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N_{au} = k \cdot A_i \cdot N_{ua}) (lbs)</td>
<td>0.617 \cdot 0.724 \cdot 1045 = 467</td>
<td>467</td>
<td>0.617 \cdot 0.173 \cdot 1045 = 111</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance load at 250 mm to the anchor (in)</th>
<th>Anchor 1</th>
<th>Anchor 2</th>
<th>Anchor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A_i = 1 - s/l)</td>
<td>1 - (\frac{225}{274}) = 0.173</td>
<td>1 - (\frac{75}{224}) = 0.724</td>
<td></td>
</tr>
<tr>
<td>(k = 1 / \sum A_i)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N_{au} = k \cdot A_i \cdot N_{ua}) (lbs)</td>
<td>0.173 \cdot 0.724 \cdot 0.724 = \text{Varies}</td>
<td>467</td>
<td>467</td>
</tr>
</tbody>
</table>

Resulting anchor load \(N_{au}\) (line 1.4+2.4) (lbs)

<table>
<thead>
<tr>
<th>Anchor 1</th>
<th>Anchor 2</th>
<th>Anchor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>578</td>
<td>935</td>
<td>578</td>
</tr>
</tbody>
</table>

Analog for shear load \(V_{au}\) (lbs)

<table>
<thead>
<tr>
<th>Anchor 1</th>
<th>Anchor 2</th>
<th>Anchor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>622</td>
<td>1006</td>
<td>622</td>
</tr>
</tbody>
</table>
3. Tension loads

3.1 Check steel failure of anchor

\[ N_{ua}^a = 935 \text{ lbs} \]

\[ \phi N_{sa} = \phi N_{sa} = 0.75 \cdot 6969 \text{ lbs} = 5227 \text{ lbs} \]

\[ \beta_N = N_{ua}^a / \phi N_{cb} = 0.18 \leq 1 \quad \checkmark \]

3.2 Check failure of connection between anchor and channel

\[ N_{ua}^a = 935 \text{ lbs} \]

\[ \phi N_{sc} = \phi N_{sc} = 0.75 \cdot 6969 \text{ lbs} = 5227 \text{ lbs} \]

\[ \beta_N = N_{ua}^a / \phi N_{sc} = 0.18 \leq 1 \quad \checkmark \]

3.3 Check failure of channel lip

\[ N_{ua}^a = 1045 \text{ lbs} \]

\[ \phi N_{sl} = \phi N_{sl} = 0.75 \cdot 8093 \text{ lbs} = 6070 \text{ lbs} \]

\[ \beta_N = N_{ua}^a / \phi N_{sl} = 0.17 \leq 1 \quad \checkmark \]

3.4 Check steel failure of T-bolt

\[ N_{ua}^s = 1045 \text{ lbs} \]

\[ \phi N_{ss} = \phi N_{ss} = 0.65 \cdot 14118 \text{ lbs} = 9177 \text{ lbs} \]

\[ \beta_N = N_{ua}^s / \phi N_{ss} = 0.11 \leq 1 \quad \checkmark \]

3.5 Check bending of channel

\[ M_{ua} = 1568 \text{ lb-in} \]

\[ \phi M_{s,\text{flex}} = \phi M_{s,\text{flex}} = 0.85 \cdot 13524 \text{ lb-in} = 11495 \text{ lb-in} \]

\[ \beta_N = M_{ua} / \phi M_{s,\text{flex}} = 0.14 \leq 1 \quad \checkmark \]

3.6 Check pull out failure

\[ N_{ua}^a = 935 \text{ lbs} \]

\[ \phi N_p = \phi N_{pn} \cdot \psi_{cp} = 0.70 \cdot 5418 \text{ lbs} \cdot 1.25 = 4741 \text{ lbs} \quad \text{(eq. 4.2.2.1)} \]

\[ \beta_N = N_{ua}^a / \phi N_p = 0.20 \leq 1 \quad \checkmark \]
3.7 Check concrete cone failure

\[ N_{ua}^b = 935 \text{ lbs} \]

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

\[ \text{Influence of adjacent anchor:} \]

\[ \psi_{s,N} = \frac{1}{1 + \sum_{i=2}^{n} \left( \frac{N_{ua,i}}{N_{ua,1}} \right)^{1.5}} \quad \text{(eq. 4.2.2.4)} \]

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

\[ \psi_{s,N} = \frac{1}{1 + \left( \frac{6}{15.7} \right)^{1.5} \cdot \frac{578}{935} + \left( \frac{6}{15.7} \right)^{1.5} \cdot \frac{578}{935}} = 0.62 \]

\[ \text{Influence of member edges} \]

\[ c_{cr,N} = 0.5 \cdot s_{cr,N} = 0.5 \cdot 15.7 = 7.85 \text{ in} \quad \text{(eq. 4.2.2.8)} \]

\[ c_{a1,1} = 3 \text{ in} < c_{cr,N} \quad \text{(eq. 4.2.2.7)} \]

\[ \psi_{ed,N} = \left( \frac{3 \text{ in}}{7.85 \text{ in}} \right)^{0.5} = 0.62 \]

\[ \text{Influence of corner} \]

\[ c_{a2} > 7.85 \text{ in} \quad \text{(eq. 4.2.2.9)} \]

\[ \psi_{co,N} = 1.0 \]

\[ \text{Influence of cracked concrete} \]

\[ \psi_{c,N} = 1.25 \quad \text{(uncracked concrete)} \]

\[ \phi N_{cb} = \phi N_b \cdot \psi_{s,N} \cdot \psi_{ed,N} \cdot \psi_{co,N} \cdot \psi_{c,N} \cdot \psi_{co,N} \]

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

\[ \beta_N = \frac{N_{ua}^b}{\phi N_{cb}} = 0.36 \leq 1 \quad \checkmark \]
4. Shear Loads

4.1 Check steel failure of anchor

\[ V_{sa}^a = 1006 \text{ lbs} \]
\[ \phi V_{sa} = \phi \cdot V_{sa} = 0.75 \cdot 6969 \text{ lbs} = 5227 \text{ lbs} \]
\[ \beta_V = \frac{V_{sa}^a}{\phi V_{sa}} = 0.19 \leq 1 \]

4.2 Check failure of connection between anchor and channel

\[ V_{ua}^a = 1006 \text{ lbs} \]
\[ \phi V_{sc} = \phi \cdot V_{sc} = 0.75 \cdot 6969 \text{ lbs} = 5227 \text{ lbs} \]
\[ \beta_V = \frac{V_{ua}^a}{\phi V_{sc}} = 0.19 \leq 1 \]

4.3 Check failure of channel lip

\[ V_{ua}^a = 1125 \text{ lbs} \]
\[ \phi V_{sl} = \phi \cdot V_{sl} = 0.75 \cdot 8093 \text{ lbs} = 6070 \text{ lbs} \]  
(eq. 4.2.2.1)
\[ \beta_N = \frac{V_{ua}^a}{\phi V_{sl}} = 0.19 \leq 1 \]

4.4 Check steel failure of T-bolt

\[ V_{ua}^a = 1125 \text{ lbs} \]
\[ \phi V_{ss} = \phi \cdot V_{ss} = 0.60 \cdot 8475 \text{ lbs} = 5085 \text{ lbs} \]
\[ \beta_V = \frac{V_{ua}^a}{\phi V_{ss}} = 0.22 \leq 1 \]

4.5 Check pry-out failure

\[ V_{ua}^a = 1006 \text{ lbs} \]
\[ \phi V_{cp} = \phi \cdot k_{cp} \cdot N_{cb} = 0.70 \cdot 2.00 \cdot 3738 \text{ lbs} = 5233 \text{ lbs} \]  
(eq. 5.2.1.1)
\[ \beta_V = \frac{V_{ua}^a}{\phi V_{cp}} = 0.19 \leq 1 \]

4.6 Check concrete edge failure c11

\[ V_{ub} = \left( a_{ch, V} \cdot \Psi_{c, V} \right) \cdot f_c^{0.5} \cdot c_{a1}^{1.5} = 14.9 \cdot 2500^{0.5} \cdot 3.00^{1.33} = 3223 \text{ lbs} \]  
(eq. 5.2.2.3)
Influence of adjacent anchors

\[
\psi_{s,V} = \frac{1}{1 + \sum_{i=2}^{n+1} \left( \frac{\sigma_{i} \cdot V_{ua,i}}{\sigma_{\text{cr,V}}} \right)^{1.5}} 
\]

(eq. 5.2.2.3)

\[
\sigma_{\text{cr}} = 4c_{a1} + 2b_{ch} 
\]

(eq. 5.2.2.4)

\[
\psi_{s,V} = \frac{1}{1 + \left( \frac{6}{15.82} \right)^{1.5} \cdot \frac{622}{1006} \cdot \left( \frac{6}{15.86} \right)^{1.5} \cdot \frac{622}{1006}} = 0.62 
\]

Influence of corner

\[
c_{cr,V} = 2c_{a1} + b_{ch} 
\]

(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

\[
h_{cr,V} = 2c_{a1} + 2h_{ch} 
\]

(eq. 5.2.2.9)

\[
\psi_{h,V} = \left( \frac{h}{h_{cr,V}} \right)^{\beta_{1}} = \left( \frac{3}{8.36} \right)^{2} = 1.12 
\]

\[
\psi_{h,V} \text{ must be} \leq 1.0 
\]

\[
\Rightarrow \psi_{h,V} = 1.0 
\]

\[
\phi V_{cb} = \phi V_{b} \cdot \psi_{s,V} \cdot \psi_{co,V} \cdot \psi_{h,V} 
\]

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

\[
\beta_{V} = \frac{V_{ua}}{\phi V_{cb}} = 0.72 \leq 1 \quad \checkmark 
\]
5. Combined Tension and Shear Loads

Concrete
\[ \beta_N^{1.5} + \beta_V^{1.5} = 0.36^{1.5} + 0.72^{1.5} = 0.82 \leq 1 \quad \checkmark \quad (eq. \ 6.1.1.1) \]

Steel
\[ \beta_N^{2.0} + \beta_V^{2.0} = 0.18^{2.0} + 0.19^{2.0} = 0.07 \leq 1 \quad \checkmark \quad (eq. \ 6.3.1.1) \]

Steel connection
\[ \beta_N^{2.0} + \beta_V^{2.0} = 0.18^{2.0} + 0.19^{2.0} = 0.07 \leq 1 \quad \checkmark \quad (eq. \ 6.3.1.1) \]

Anchor channel
\[ \beta_N^{2.0} + \beta_V^{2.0} = 0.17^{2.0} + 0.19^{2.0} = 0.06 \leq 1 \quad \checkmark \quad (eq. \ 6.4.1.1) \]

T-bolt
\[ \beta_N^{2.0} + \beta_V^{2.0} = 0.11^{2.0} + 0.22^{2.0} = 0.06 \leq 1 \quad \checkmark \quad (eq. \ 6.5.1.1) \]

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.
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,
\( f'_c = 3500 \text{ psi}, d = 6,000 \text{ in}, \)
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

<table>
<thead>
<tr>
<th>Load point</th>
<th>x [in]</th>
<th>N_{ua} [lbs]</th>
<th>V_{ua}^{y} [lbs]</th>
<th>V_{ua}^{a} [lbs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,000</td>
<td>1300</td>
<td>1200</td>
<td>0</td>
</tr>
</tbody>
</table>

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.

(*) 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)

<table>
<thead>
<tr>
<th>Anchor</th>
<th>x [in]</th>
<th>N_{ua}^{a} [lbs]</th>
<th>V_{ua}^{ay} [lbs]</th>
<th>V_{ua}^{ax} [lbs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,000</td>
<td>850</td>
<td>785</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>5,000</td>
<td>450</td>
<td>415</td>
<td>0</td>
</tr>
</tbody>
</table>

(*) 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)

\[ N_{ua}^{a} = 850 \text{ lbs} \]
\[ \Phi N_{sa} = \Phi \cdot N_{sa} = 0,75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_{N} = N_{ua}^{a} / \Phi N_{sa} = 0,25 \leq 1,00 \]

Proof connection between anchor and channel (Anchor 1)

\[ N_{ua}^{a} = 850 \text{ lbs} \]
\[ \Phi N_{sa} = \Phi \cdot N_{sa} = 0,75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_{N} = N_{ua}^{a} / \Phi N_{sa} = 0,25 \leq 1,00 \]

Proof local flexure (Load 1)

\[ N_{ua} = 1300 \text{ lbs} \]
\[ \Phi N_{sl} = \Phi \cdot N_{sl} = 0,75 \cdot 7868 \text{ lbs} = 5901 \text{ lbs} \]
\[ \beta_{N} = N_{ua} / \Phi N_{sl} = 0,22 \leq 1,00 \]

Proof steel failure bolt (Load 1)

\[ N_{ua}^{s} = 1300 \text{ lbs} \]
\[ \Phi N_{ss} = \Phi \cdot N_{ss} = 0,65 \cdot 7576 \text{ lbs} = 4924 \text{ lbs} \]
\[ \beta_{N} = N_{ua}^{s} / \Phi N_{ss} = 0,26 \leq 1,00 \]
4.2 Concrete failure

Proof pull-out (Anchor 1)

\[ N_{ua}^p = 850 \text{ lbs} \]
\[ \Phi N_p = \Phi \cdot N_{pp} \cdot \psi_{cp} = 0.70 \cdot 5137 \text{ lbs} \cdot 1.00 = 3596 \text{ lbs} \]
\[ \beta_N = \frac{N_{ua}^p}{\Phi N_p} = 0.24 \leq 1.00 \]

Proof concrete cone (Anchor 1)

\[ N_{sa}^w = 850 \text{ lbs} \]
\[ N_b = 24 \cdot a_{ch,N} \cdot f_c^{0.5} \cdot h_{ef}^{1.5} = 24 \cdot 0.88 \cdot 3500^{0.5} \cdot 3110^{1.5} = 6880 \text{ lbs} \]
\[ \Phi N_{sc} = \Phi \cdot N_b \cdot \psi_{s,N} \cdot \psi_{ed,N} \cdot \psi_{ca,N} \cdot \psi_{cp,N} \]
\[ = 0.70 \cdot 6880 \text{ lbs} \cdot 0.76 \cdot 0.66 \cdot 1.00 \cdot 1.00 = 2404 \text{ lbs} \]
\[ \beta_N = \frac{N_{sa}^w}{\Phi N_{sc}} = 0.35 \leq 1.00 \]

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

5.1 Steel failure

Proof steel failure anchor Y (Anchor 1)

\[ V_{ua}^{wy} = 785 \text{ lbs} \]
\[ \Phi V_{sa} = \Phi \cdot V_{sa} = 0.75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_v = \frac{V_{ua}^{wy}}{\Phi V_{sa}} = 0.23 \leq 1.00 \]

Proof steel failure anchor X (Anchor 1)

Not decisive

Proof connection between anchor and channel Y (Anchor 1)

\[ V_{ua}^{wy} = 785 \text{ lbs} \]
\[ \Phi V_{sc} = \Phi \cdot V_{sc} = 0.75 \cdot 4496 \text{ lbs} = 3372 \text{ lbs} \]
\[ \beta_v = \frac{V_{ua}^{wy}}{\Phi V_{sc}} = 0.23 \leq 1.00 \]

Proof connection between anchor and channel X (Anchor 1)

Not decisive

Proof flexure of channel lip Y (Load 1)

\[ V_{ua}^{y} = 1200 \text{ lbs} \]
\[ \Phi V_{sl} = \Phi \cdot V_{sl} = 0.75 \cdot 7868 \text{ lbs} = 5901 \text{ lbs} \]
\[ \beta_v = \frac{V_{ua}^{y}}{\Phi V_{sl}} = 0.20 \leq 1.00 \]
Proof flexure of channel lip X (Load 1)

Not decisive

Proof steel failure bolt (Load 1)

\[ V_{u}^{\text{sy}} = 1200 \text{ lbs} \]

\[ \Phi V_{u}^{\text{sy}} = \Phi \cdot V_{u}^{\text{sy}} = 0.60 \cdot 4541 \text{ lbs} = 2725 \text{ lbs} \]

\[ \beta_{V}^{y} = \frac{V_{u}^{\text{sy}}}{\Phi V_{u}^{\text{sy}}} = 0.44 \leq 1.00 \]

5.2 Concrete failure

Proof pry-out (Anchor 1)

\[ V_{u}^{\text{ay}} = 785 \text{ lbs} \]

\[ V_{u}^{\text{ax}} = 0 \text{ lbs} \]

\[ V_{u}^{a} = 785 \text{ lbs} \]

\[ N_{b} = 24 \cdot a_{ch,N} \cdot f_{c}^{0.5} \cdot h_{ed}^{1.5} = 24 \cdot 0.88 \cdot 3500^{0.5} \cdot 3110^{1.5} = 6880 \text{ lbs} \]

\[ N_{cb} = N_{b} \cdot \psi_{s,N} \cdot \psi_{ed,N} \cdot \psi_{co,N} \cdot \psi_{c,N} \cdot \psi_{cp,N} \]

\[ = 6880 \text{ lbs} \cdot 0.76 \cdot 0.66 \cdot 1.00 \cdot 1.00 \cdot 1.00 = 3434 \text{ lbs} \]

\[ \Phi V_{cp} = \Phi \cdot k_{cp} \cdot N_{cb} = 0.70 \cdot 2.00 \cdot 3434 \text{ lbs} = 4808 \text{ lbs} \]

\[ \beta_{V}^{cp} = \frac{V_{u}^{a}}{\Phi V_{cp}} = 0.16 \leq 1.00 \]

Proof concrete edge c11 (Anchor 1)

\[ V_{u}^{\text{ay}} = 785 \text{ lbs} \]

\[ V_{u}^{\text{ax}} = 0 \text{ lbs} \]

\[ V_{u}^{a} = 785 \text{ lbs} \]

\[ V_{b} = (a_{ch,Y} \cdot \psi_{c,Y}) \cdot f_{c}^{0.5} \cdot c_{x1}^{1.33} = 9.00 \cdot 3500^{0.5} \cdot 3,000^{1.33} = 2304 \text{ lbs} \]

\[ \Phi V_{cb} = \Phi \cdot V_{b} \cdot \psi_{s,Y} \cdot \psi_{co,Y} \cdot \psi_{h,Y} \cdot 1.0 \]

\[ = 0.70 \cdot 2304 \text{ lbs} \cdot 0.75 \cdot 1.00 \cdot 0.84 \cdot 1.0 = 1014 \text{ lbs} \]

\[ \beta_{V}^{cb} = \frac{V_{u}^{a}}{\Phi V_{cb}} = 0.77 \leq 1.00 \]

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)
\[ n = \beta_N^{2.0} + \beta_V^{2.0} = 0.25^{2.0} + 0.23^{2.0} = 0.12 \leq 1.00 \]

Steel connection (Anchor 1)
\[ n = \beta_N^{2.0} + \beta_V^{2.0} = 0.25^{2.0} + 0.23^{2.0} = 0.12 \leq 1.00 \]

Anchor channel (Load 1)
\[ n = \beta_N^{2.0} + \beta_V^{2.0} = 0.22^{2.0} + 0.20^{2.0} = 0.09 \leq 1.00 \]

Bolt (Load 1)
\[ n = \beta_N^{2.0} + \beta_V^{2.0} = 0.26^{2.0} + 0.44^{2.0} = 0.26 \leq 1.00 \]

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: \( h_{ef} = 3,700 \text{ in} \)
   Stand-off installation bracket without slotted holes, Thickness of bracket = 0.400 in
   Concrete: 2500 psi, Uncracked concrete, \( f'_c = 2500 \text{ psi} \), \( d = 10,000 \text{ in} \),
   \( c = 1,000 \text{ in} \), \( c_y = 1,000 \text{ in} \),
   \( c_{a_{1,1}} = 3,000 \text{ in} \), \( c_{a_{1,2}} \) Not available,
   \( c_{a_{2,1}} \) Not available, \( c_{a_{2,2}} \) 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

<table>
<thead>
<tr>
<th>Load point</th>
<th>x [in]</th>
<th>( N_{ua} ) [lbs]</th>
<th>( V'_{ua} ) [lbs]</th>
<th>( V^x_{ua} ) [lbs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4,000</td>
<td>1045</td>
<td>1125</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>10,000</td>
<td>1045</td>
<td>1125</td>
<td>0</td>
</tr>
</tbody>
</table>

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 \( \Delta x = \pm 2,000 \) in.
The maximum concrete compressive strength is 2 lbs/in²

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

3. Decisive proof

Anchor 2 | 81,94 %

- Tension - Steel failure anchor: \( N_{ua}^a = 935 \text{ lbs} \leq \Phi \cdot N_s = 5227 \text{ lbs} \)
- Tension - Connection between anchor and channel: \( N_{ua}^b = 935 \text{ lbs} \leq \Phi \cdot N_{sc} = 5227 \text{ lbs} \)
- Tension - Pullout failure: \( N_{ua}^p = 935 \text{ lbs} \leq \Phi \cdot N_p = 4741 \text{ lbs} \)
- Tension - Concrete cone failure: \( N_{ua}^c = 935 \text{ lbs} \leq \Phi \cdot N_{pb} = 2616 \text{ lbs} \)
- Proof steel failure anchor Y: \( V'_{ua}^y = 1006 \text{ lbs} \leq \Phi \cdot V_{sl} = 5227 \text{ lbs} \)
- Shear - Steel failure anchor: \( V'_{ua}^s = 1006 \text{ lbs} \leq \Phi \cdot V_{sc} = 5227 \text{ lbs} \)
- Shear - Pry-Out failure: \( V'_{ua}^{py} = 1006 \text{ lbs} \leq \Phi \cdot V_{cp} = 5233 \text{ lbs} \)
- Shear - Concrete edge failure c11: \( V_{ua} = 1006 \text{ kN} \leq \Phi \cdot V_{cn} = 1405 \text{ kN} \)
- Interaction anchor concrete: \( \beta_{N,1} \cdot \beta_{V,1} \geq 81,94 \% \)
- Interaction anchor steel: \( \beta_{N,2} + \beta_{V,2} \geq 6,90 \% \)
- Interaction Anchor- channel steel: \( \beta_{N,2} + \beta_{V,2} \geq 6,90 \% \)

Load 1 | 22,12 %

- Tension - Local flexure of channel lip: \( N_{ua} = 1045 \text{ lbs} \leq \Phi \cdot N_{si} = 6070 \text{ lbs} \)
- Tension - Steel failure bolt: \( N_{ua} = 1045 \text{ lbs} \leq \Phi \cdot N_{ss} = 9177 \text{ lbs} \)
- Tension - Flexure of channel: \( M_{iu} = 1568 \text{ lb-in} \leq \Phi \cdot M_{sl} = 11495 \text{ lb-in} \)
- Shear - Steel failure bolt: \( V'_{ua} = 1125 \text{ lbs} \leq \Phi \cdot V'_{ss} = 5085 \text{ lbs} \)
- Shear - Local flexure of channel lip: \( V'_{ua} = 1125 \text{ lbs} \leq \Phi \cdot V'_{sl} = 6070 \text{ lbs} \)
- Interaction at the load point: \( \beta_{N,2} + \beta_{V,2} = 6,40 \% \)
- Interaction bolt: \( \beta_{N,2} + \beta_{V,2} = 6,19 \% \)

4. Summary of the calculations

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

© JORDAHL GmbH and Decon USA Inc. | Design of JORDAHL® Anchor Channels | 06-2013
- 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 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]

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

or

![Fig. 2]

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>
<thead>
<tr>
<th>Table B</th>
<th>Strength/ Material grade</th>
<th>T_{inst} [Nm]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M6</td>
<td>M8</td>
</tr>
<tr>
<td>JA, JB</td>
<td>4.6</td>
<td>3 8 15 25 65 130 230 340 460</td>
</tr>
<tr>
<td>JC, JE</td>
<td>A4-50</td>
<td>- - 13 24 60 115 - - -</td>
</tr>
<tr>
<td>JD/JUD</td>
<td>8.8</td>
<td>- 20 40 70 180 360 620 - - -</td>
</tr>
<tr>
<td>JH/JUH</td>
<td>A4-70, F4-70</td>
<td>- 15 30 50 130 250 - - - -</td>
</tr>
</tbody>
</table>
11 JORDAHL® Anchor Channels JTA

Hot-Rolled Anchor Channels

JTA W 72 / 48\(^1\)  
\(\phi N_s = \phi V_s = 16860 \text{ lbs.}\)

JTA W 55 / 42\(^1,2\)  
\(\phi N_s = \phi V_s = 13490 \text{ lbs.}\)

JTA W 53 / 34\(^1\)  
\(\phi N_s = \phi V_s = 10960 \text{ lbs.}\)

JTA W 50 / 30\(^1\)  
\(\phi N_s = \phi V_s = 6070 \text{ lbs.}\)

JTA W 40 / 22\(^1\)  
\(\phi N_s = \phi V_s = 5900 \text{ lbs.}\)

Installation height 7\(\frac{3}{4}\)" (195 mm)

7\(\frac{1}{2}\)" (190 mm)

6\(\frac{1}{2}\)" (165 mm)

4" (100 mm)

3\(\frac{1}{2}\)" (90 mm)

Material and design of T-bolts

- Electro zinc plated (ZP) or hot-dip galvanized steel (HDG)
- Stainless steel

Material and design of profile

- Hot-dip galvanized steel (HDG)
- Stainless steel 316 (A4)
- Standard filler polyethylene (PE) or polystyrene (PS)

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.
Cold-Formed Anchor Channels

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.

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

<table>
<thead>
<tr>
<th>JH</th>
<th>JD</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 10</td>
<td>M 6</td>
</tr>
<tr>
<td>M 12</td>
<td>M 8</td>
</tr>
<tr>
<td>M 16</td>
<td>M 10</td>
</tr>
<tr>
<td>M 12</td>
<td></td>
</tr>
</tbody>
</table>

- $\phi N_s$ = factored nominal tension strength
- $\phi V_s$ = factored nominal shear strength