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AS 5216:2021 Webinar Series

DESIGN OF CAST-IN ANCHOR CHANNELS IN ACCORDANCE WITH AS 5216:2021

MS Teams Webinar

Wed, 10 Aug 2022

12PM - 1PM

FREE

REGISTRATION

www.aefac.org.au/events.php

3 Critical Elements to Achieve Quality Assurance

AEFAC
Australian Engineered Fasteners and Anchors Council

01. **Pre-qualification**

Products independently tested and assessed to be “fit for purpose”

02. **Design**

Rigorous assessment to design for critical mode of failure

03. **Installation**

Informed and competent installer with appropriate supervision and experience

AEFAC - Introduction

AEFAC
Australian Engineered Fasteners and Anchors Council

AEFAC Founding Board Members

DEWALT ENGINEERED BY Powers

HILTI

HOBSON ENGINEERING

Leviat A CRH COMPANY

Ramset

SWINBURNE UNIVERSITY OF TECHNOLOGY

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AEFAC Supporting Members

ICCONS

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pryda

SIMPSON StrongTie

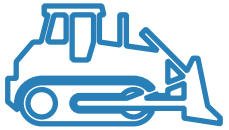
UNITED Fasteners

The role of AEFAC....

AEFAC
Australian Engineered
Fasteners and Anchors Council

For Designers

Guidelines for the specification and design of fasteners



For Contractors

Training and certification

For Field Engineers

Guidelines for field testing

For Manufacturers

Minimum performance and standard specifications

For fastener Industry

Research and development

AEFAC Installer Certification Program

AEFAC
Australian Engineered Fasteners and Anchors Council

"The best anchor product is only as good as its installation"

www.aefac.com/icp - Free online training

Standard Development

AEFAC
Australian Engineered Fasteners and Anchors Council

SA TS 101 - 2015

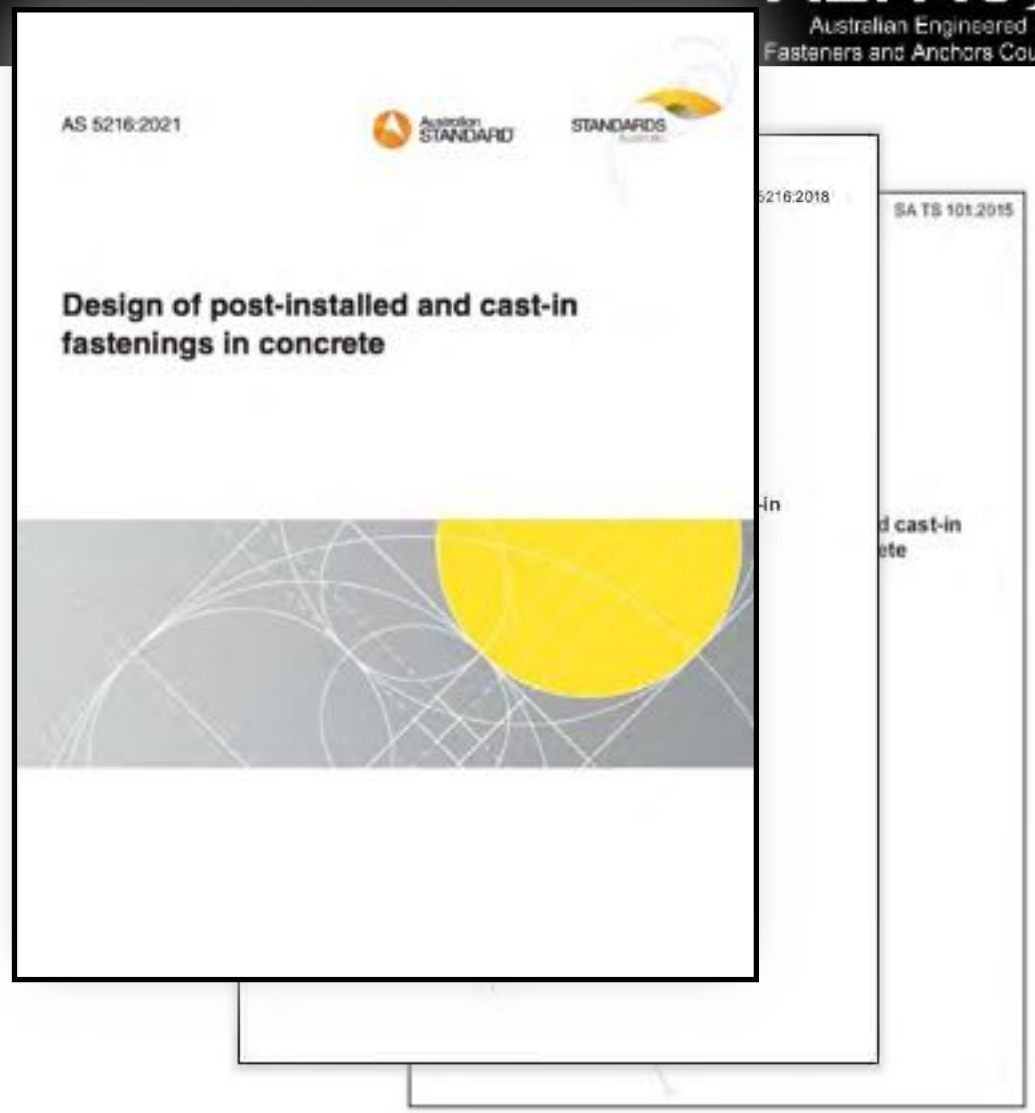
Design of post-installed and cast-in fastenings for use in concrete

AS 5216 - 2018

Design of post-installed and cast-in fastenings in concrete

AS 5216 - 2021

Design of post-installed and cast-in fastenings in concrete



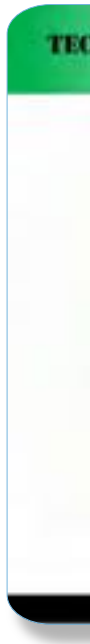
Scope of AS 5216

AEFAC
Australian Engineered Fasteners and Anchors Council

- Post-installed fasteners
- Cast-in fasteners

- Design for seismic actions
- Anchor channel with 3-D loading
- Post-installed rebar connections
- Redundant non-structural connections
- Design for fire and durability
- Design for fatigue

Technical Publications



All publications are available for free on **www.aefac.org.au**

Vol 1: General
Vol 2: Proof Test
Vol 3: Ultimate Test
Vol 4: Masonry

AEFAC Webinar Series on AS 5216:2021

SEMINAR #3
Cast-in Anchor Channels

Dr. Tilak Pokharel MIEAust CPEng NER APEC Engineer IntPE(Aus)

10 August 2022

What is covered?

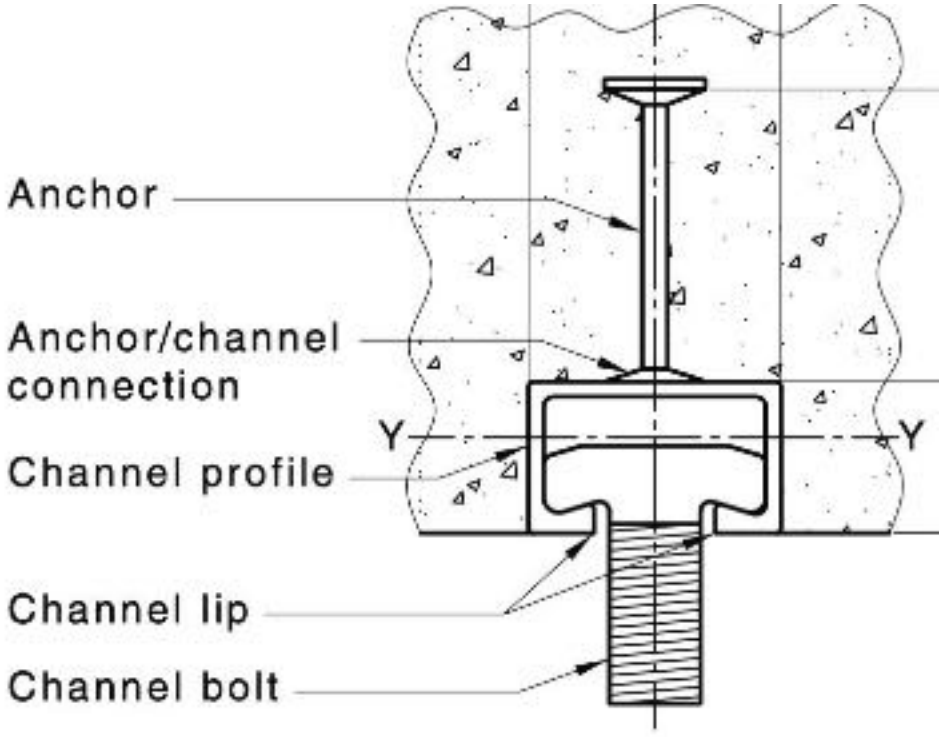
AEFAC
Australian Engineered Fasteners and Anchors Council

- What are Anchor Channels and their application
- What has been changed in AS 5216:2021
- Pre-qualification of Anchor Channels
- Design of Anchor Channels
- Installation of Anchor Channels
- Other international standards

AS 5216: 2021 vs AS 5216:2018

Standard Definitions

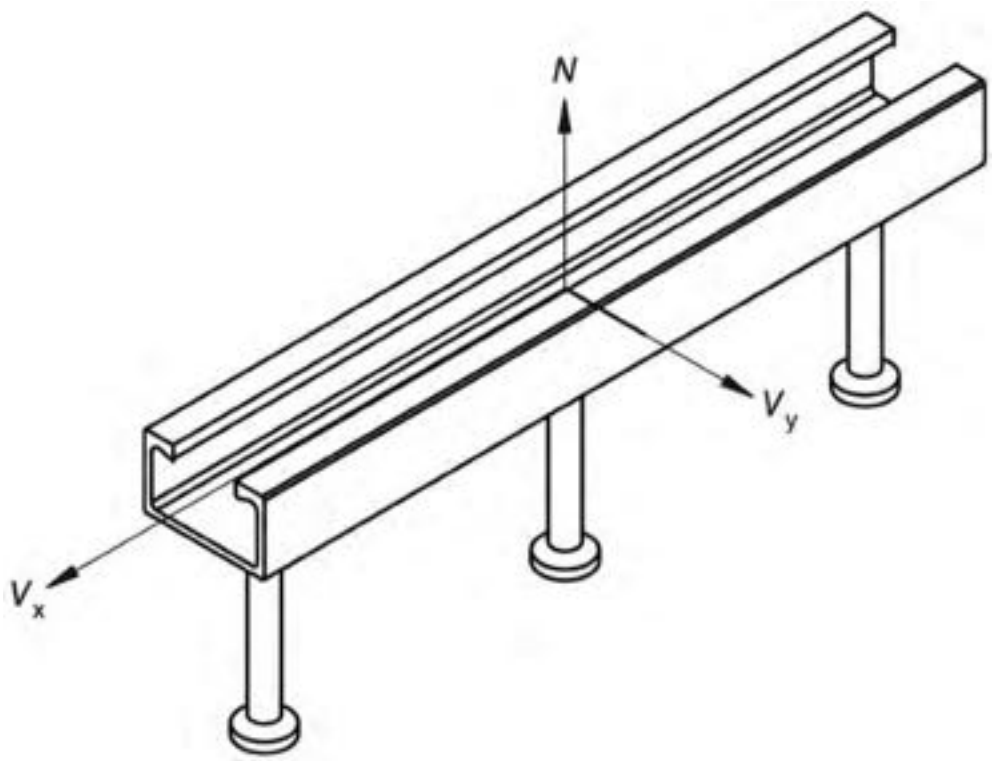
- Anchor channel
  - fastener made of profiled steel element with two or more rigidly connected anchors that are installed into position to the casting of concrete
- Anchor
  - Headed component of anchor channel
- T-Bolt / Channel bolt
  - Special bolt positioned in the steel profile of the anchor channel that is used to connect an element to the anchor channel



2018 2021

Standard Definitions

- X – direction
  - direction along the longitudinal axis of the channel
- Y– direction
  - direction perpendicular to the longitudinal axis of the channel



What is Anchor Channel?

- C-shaped profile with at least 2 anchors
- Load transferred through headed bolts
- Available as hot-rolled and cold formed profiles
- Available in different finishes (normally HDG or stainless steel)

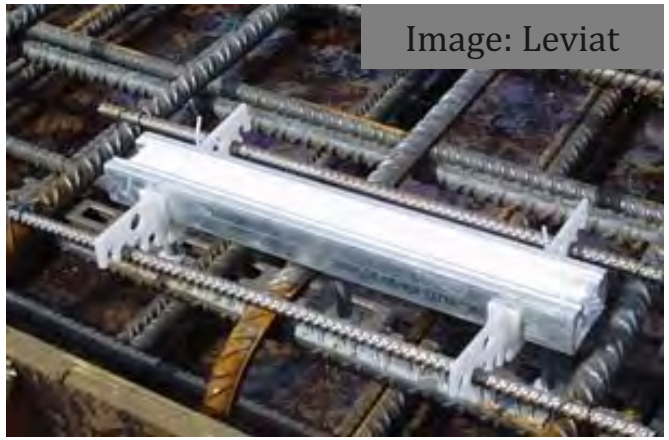
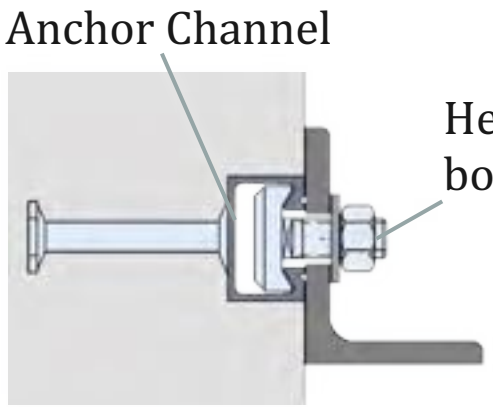
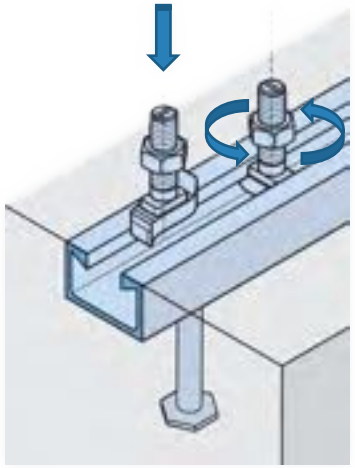


Image: Leviat


Image: Hilti





Applications of Anchor Channels

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Curtain Wall/ façade Connections

Courtesy: Leviat

Applications of Anchor Channels

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Fence/Handrail/Seat connections

Courtesy: Leviat

Applications of Anchor Channels

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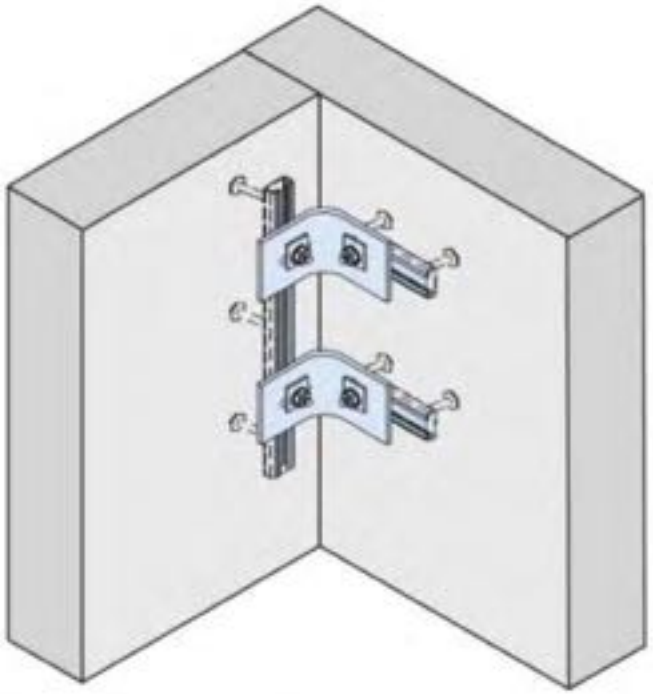
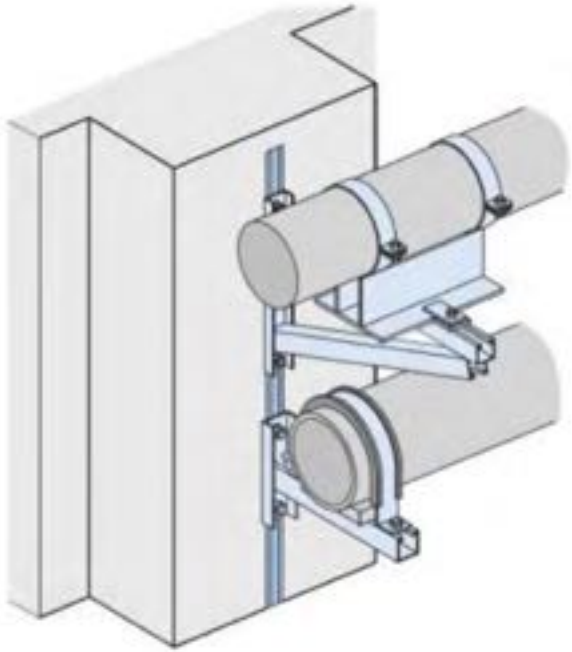
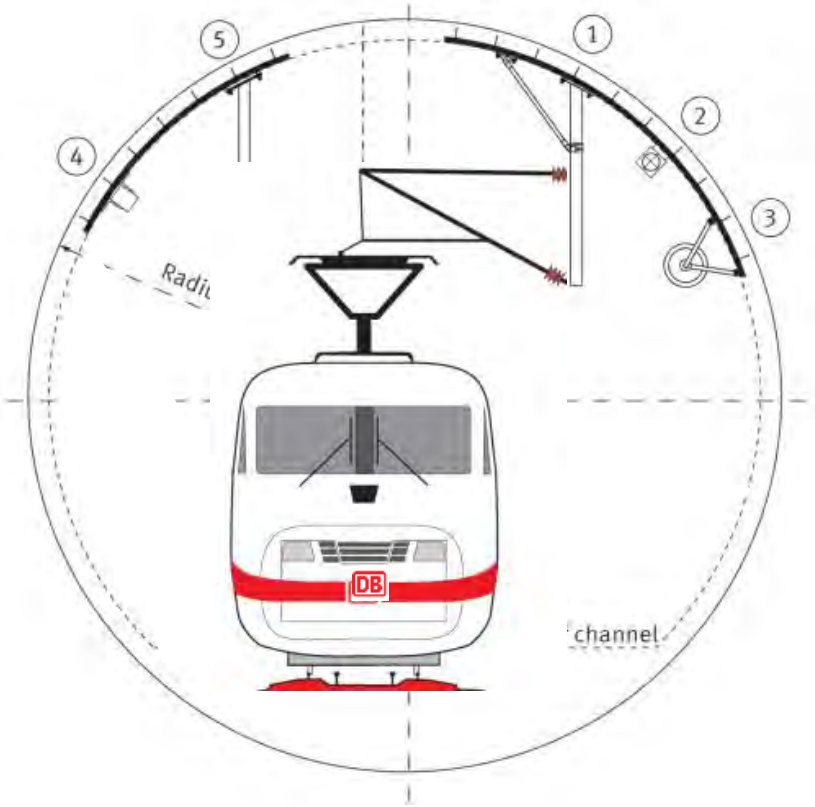
Other Structural/non-structural connections







Courtesy: Leviat

Why Anchor Channel?

- Cast-in Anchors
  - Generally better performance
- Congested reinforcements

Why Not?

- Less flexibility

Design Standard

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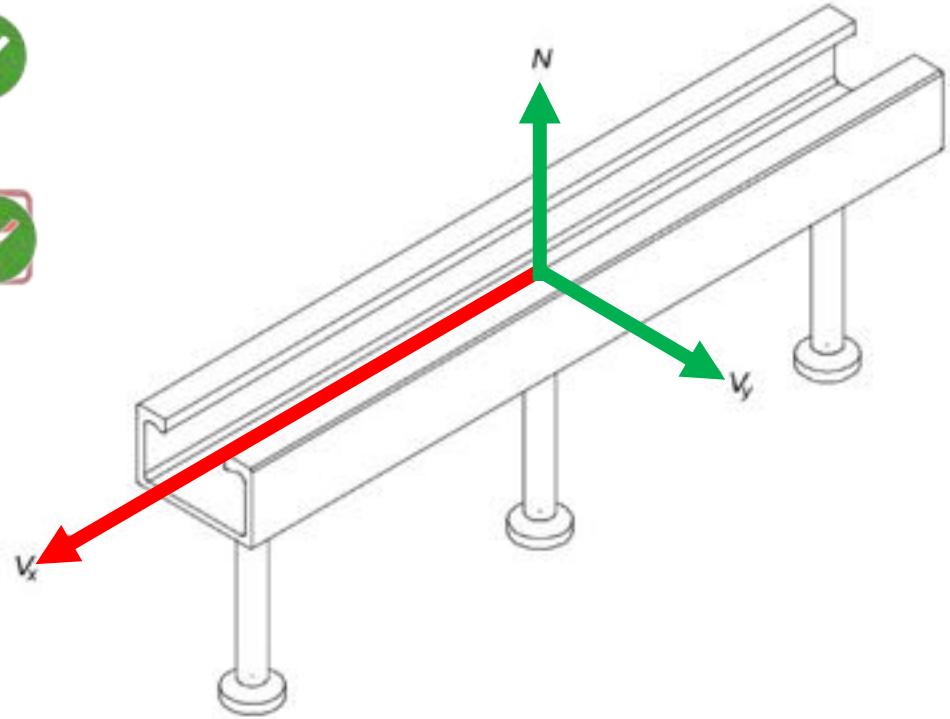
Scope of AS 5216:2018

- Post-installed fasteners
  - Mechanical fasteners
  - Chemical fasteners

- Cast-in fasteners
  - Anchor channel

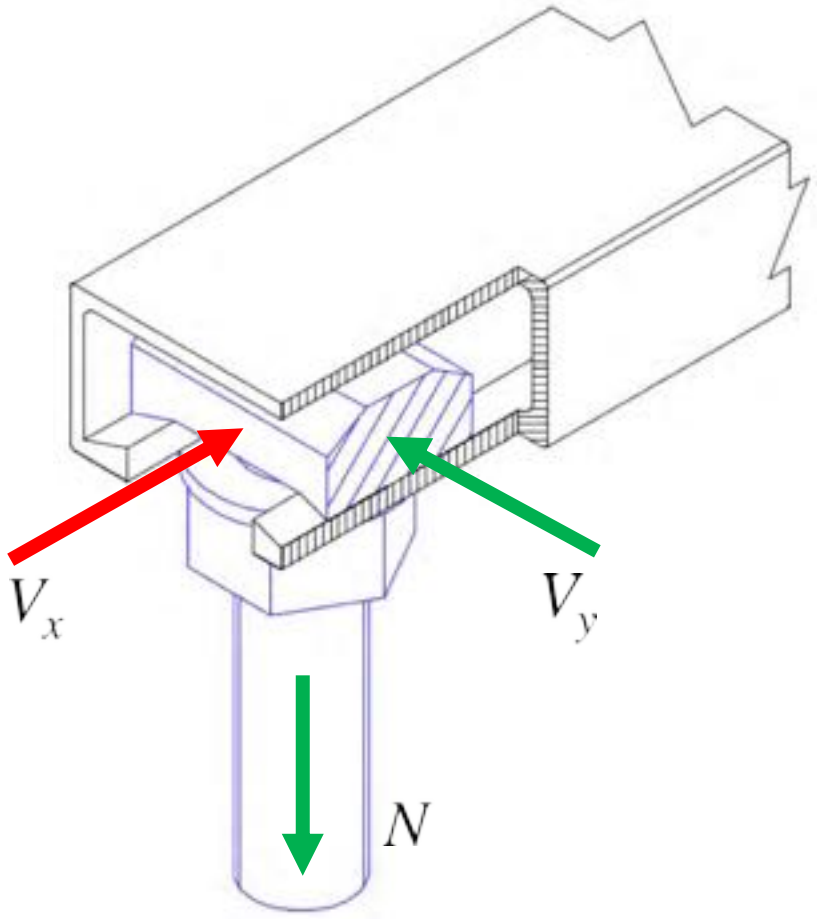
What has Changed in 2021?

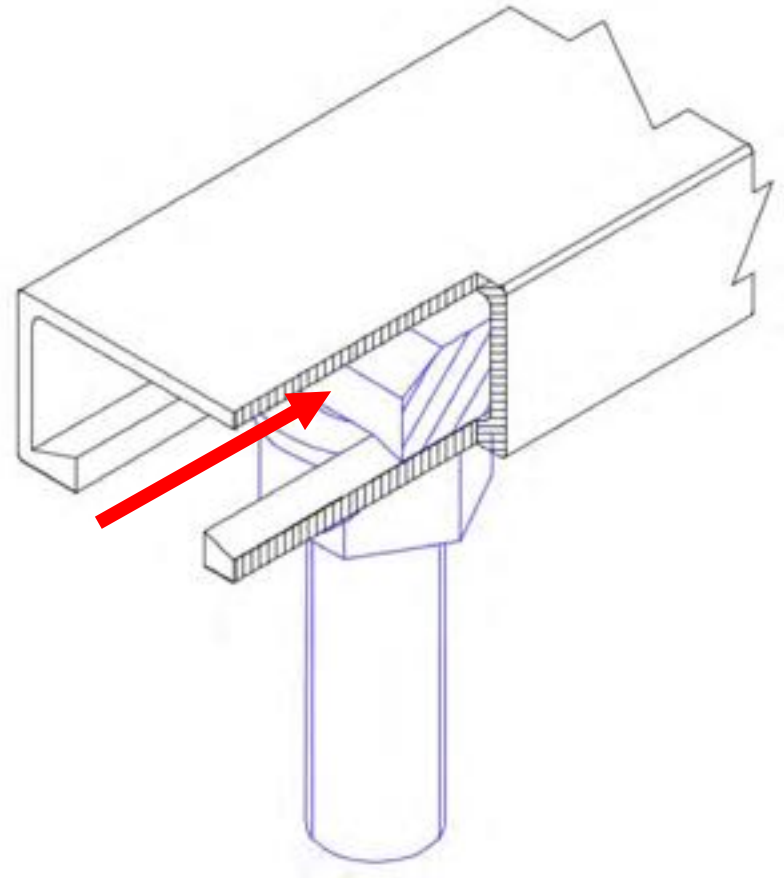
- **Anchor channel loaded in Tension (N)**
- **Anchor channel loaded in Shear in perpendicular to channel axis (Vy)**
- **Anchor channel loaded in Shear in parallel to the channel axis (Vx)**



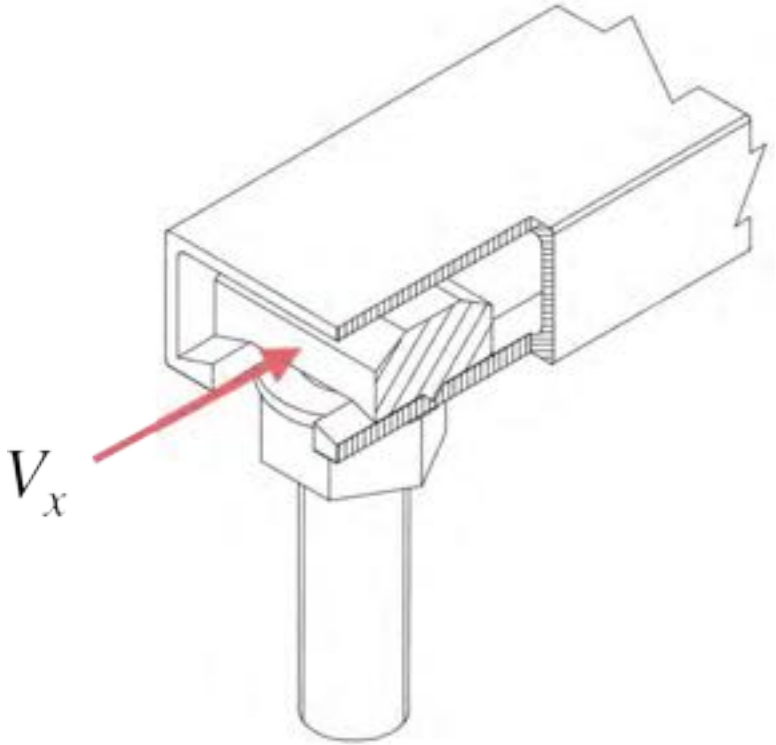
AS 5216:2018	AS 5216:2021
N, Vy	N, Vx, Vy

What is different in longitudinal direction

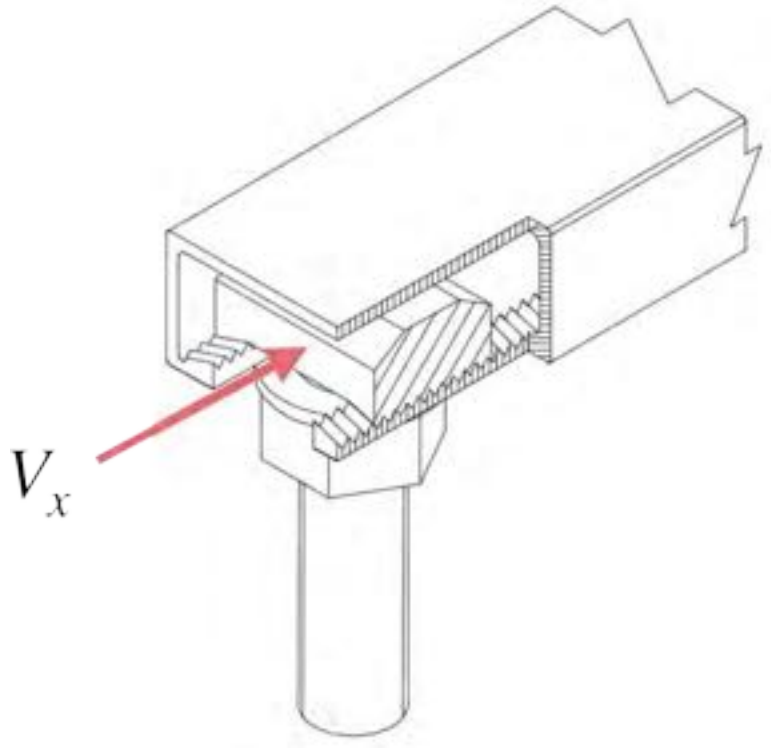




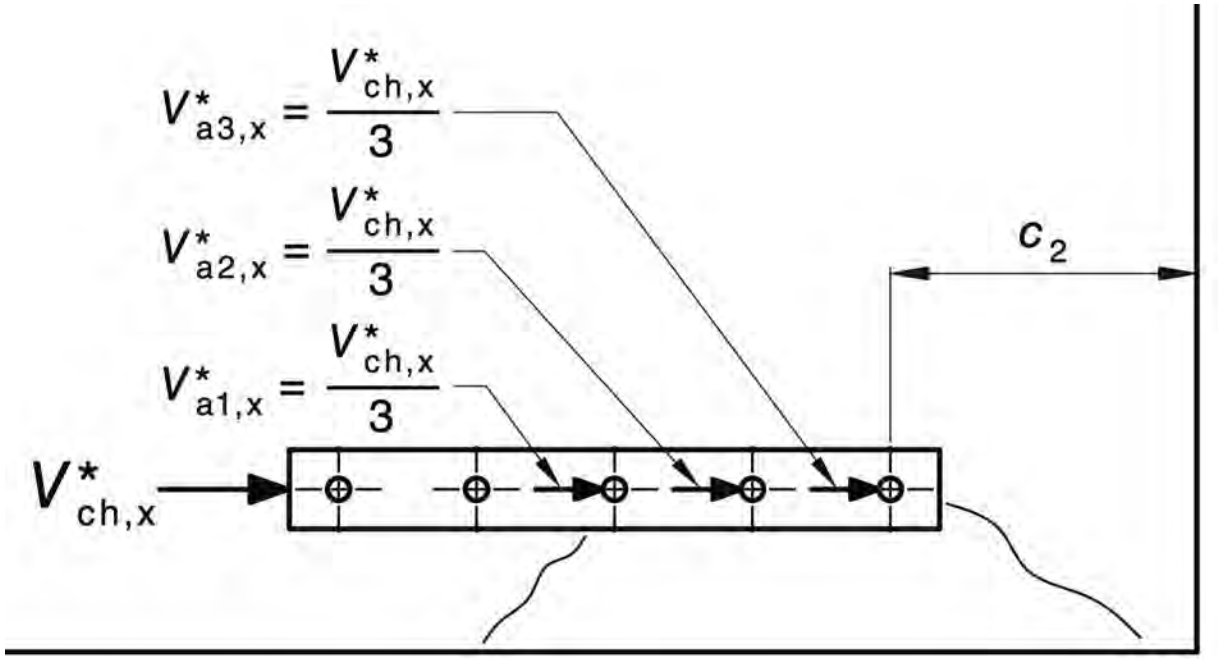
What do we need?



Notch



Serrations

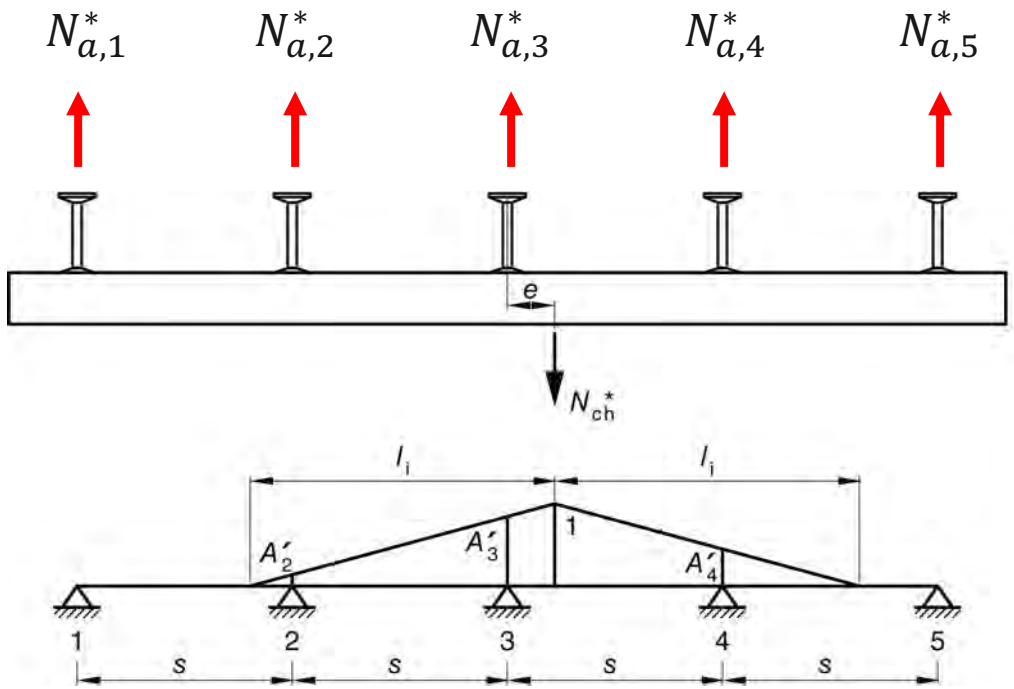


Determination of forces

Determination of forces - Tension

$N^*_{a,i}$ = Tension Load in anchor i

N^*_{ch} = Design Tension Load in Anchor channel



$$A'_2 = \frac{l_i - e - s}{l_i}$$

$$A'_3 = \frac{l_i - e}{l_i}$$

$$A'_4 = \frac{l_i + e - s}{l_i}$$

$$N^*_{a,2} = A'_2 \cdot k \cdot N^*_{ch}$$

$$N^*_{a,3} = A'_3 \cdot k \cdot N^*_{ch}$$

$$N^*_{a,4} = A'_4 \cdot k \cdot N^*_{ch}$$

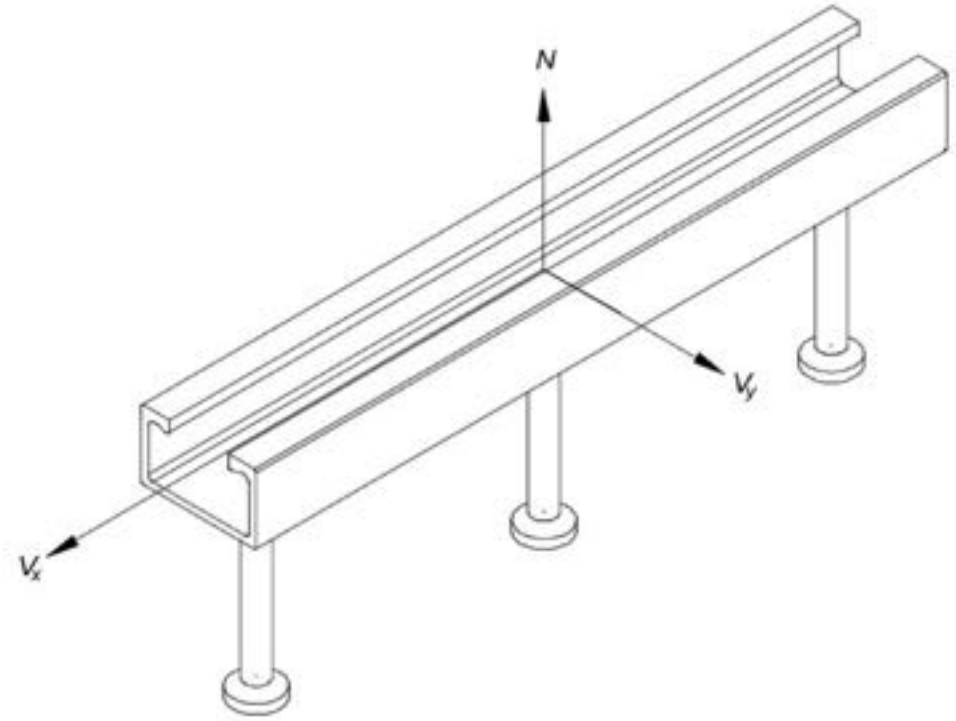
$$N^*_{a,1} = N^*_{a,5} = 0$$

$$k = \frac{1}{\sum_1^n A'_i}$$

AS 5216 2018 AS 5216 2021

Determination of forces

- Shear load PERPENDICULAR to longitudinal axis of the channel
  - Y axis
  - Same as tensile load



Determination of forces

- Shear load PARALLEL to longitudinal axis of the channel (X axis)

  - Anchor channel remote from the edge

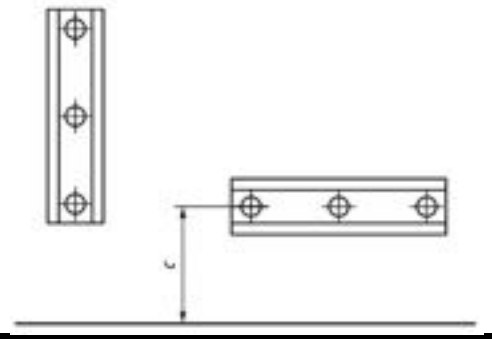
    edge distance $\geq \max(10h_{ef}\ or\ 60d_a)$

    - Installed parallel to the edge
    - Installed perpendicular to the edge

  - Anchor channel close to the edge

    edge distance $< \max(10h_{ef}\ or\ 60d_a)$

    - Installed parallel to the edge
    - Installed perpendicular to the edge

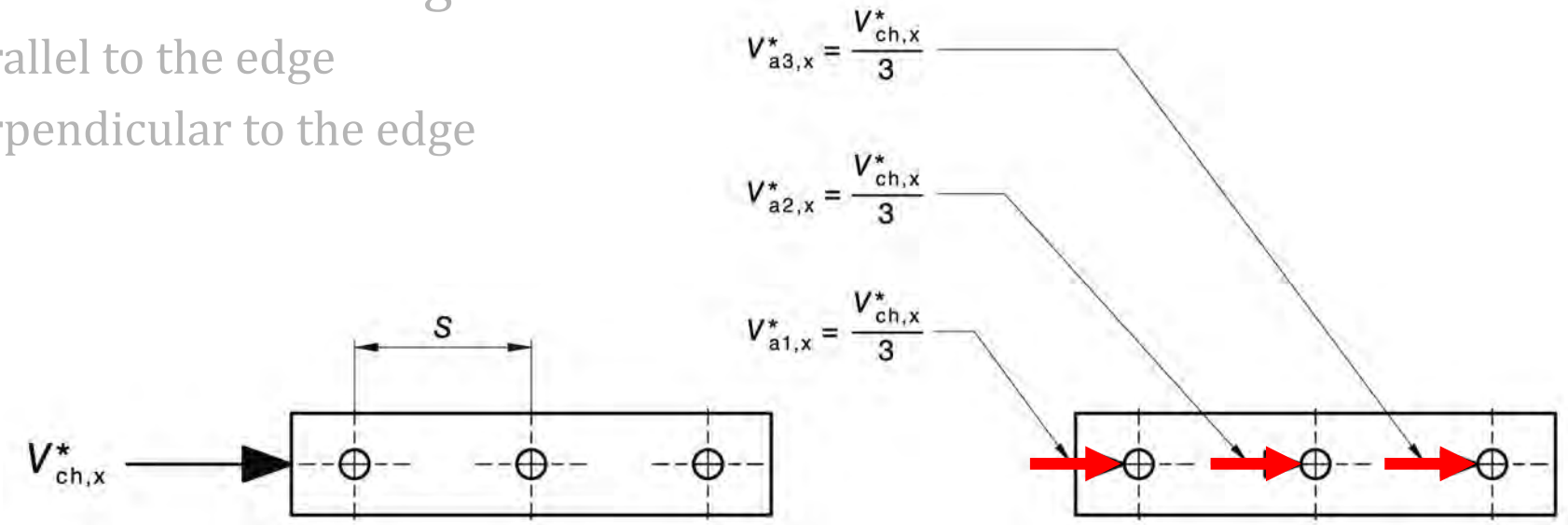


Determination of forces

- Shear load PARALLEL to longitudinal axis of the channel
  - Anchor channel remote from the edge
    - **Installed parallel to the edge**
      - **Failure of anchor/connection, pry-out failure, concrete edge failure**
    - Installed perpendicular to the edge
  - Anchor channel close to the edge
    - Installed parallel to the edge
    - Installed perpendicular to the edge

$$V^*_{a,x} = \frac{1}{n_a} \Sigma V^*_{ch,x}$$

$$n_a \leq 3$$



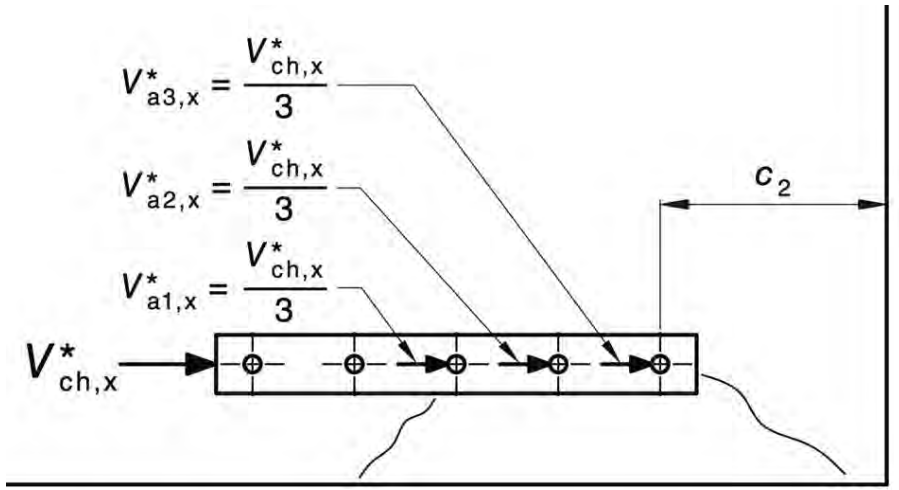
Determination of forces

- Shear load PARALLEL to longitudinal axis of the channel
  - Anchor channel remote from the edge
    - Installed parallel to the edge
      - Failure of anchor/connection, pry-out failure, concrete edge failure
    - **Installed perpendicular to the edge**
      - **Concrete edge failure**
  - Anchor channel close to the edge
    - Installed parallel to the edge
    - Installed perpendicular to the edge

Equally distributed to
a) All anchors (with no more than 3 anchors)
b) 3 adjacent anchors closest to the edge (with more than 3 anchors)

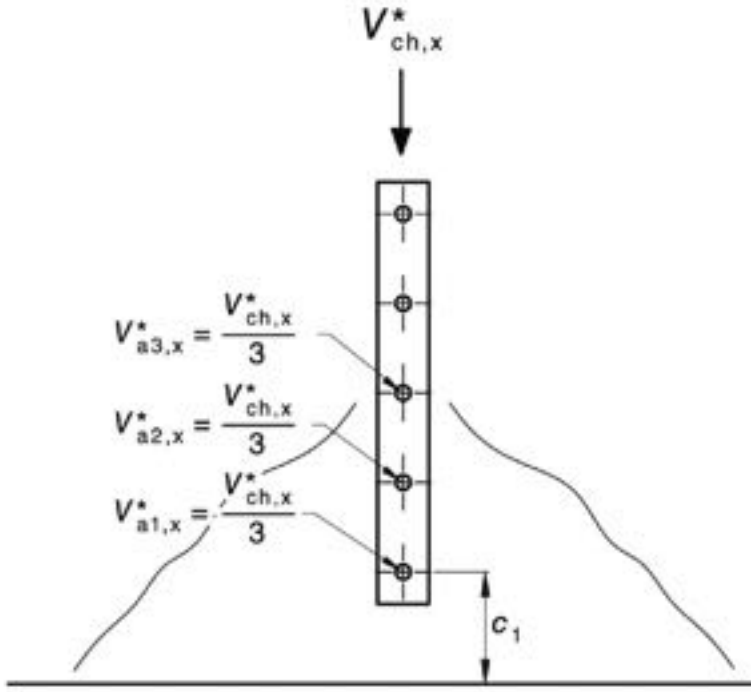
Determination of forces

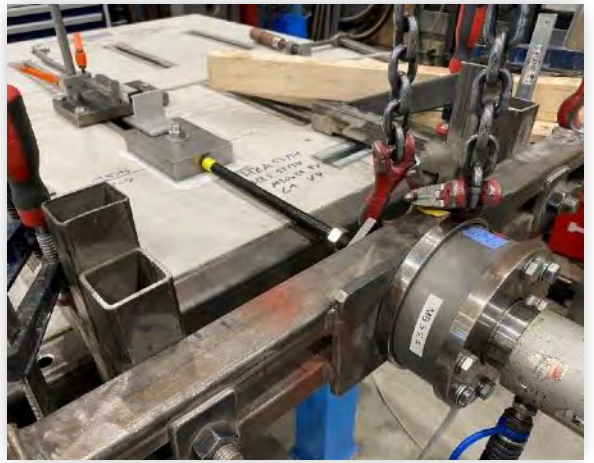
- Shear load PARALLEL to longitudinal axis of the channel
  - Anchor channel remote from the edge
    - Installed parallel to the edge
      - Failure of anchor/connection, pry-out failure, concrete edge failure
    - Installed perpendicular to the edge
      - Concrete edge failure
  - Anchor channel close to the edge
    - **Installed parallel to the edge**
      - **Concrete edge failure**
      - **Other failure modes**
    - Installed perpendicular to the edge



Determination of forces

- Shear load PARALLEL to longitudinal axis of the channel
  - Anchor channel remote from the edge
    - Installed parallel to the edge
      - Failure of anchor/connection, pry-out failure, concrete edge failure
    - Installed perpendicular to the edge
      - Concrete edge failure
  - Anchor channel close to the edge
    - Installed parallel to the edge
      - Concrete edge failure
      - Other failure modes
    - **Installed perpendicular to the edge**
      - **Concrete edge failure**
      - **Other failure modes**





Pre-qualification

Pre-qualification of Anchor Channel

- Products independently tested and assessed to be “fit for purpose”
- Appendix A of AS 5216:2021

Appendix A
(normative)

Testing and assessment of fasteners

A.1 Testing procedures and reporting

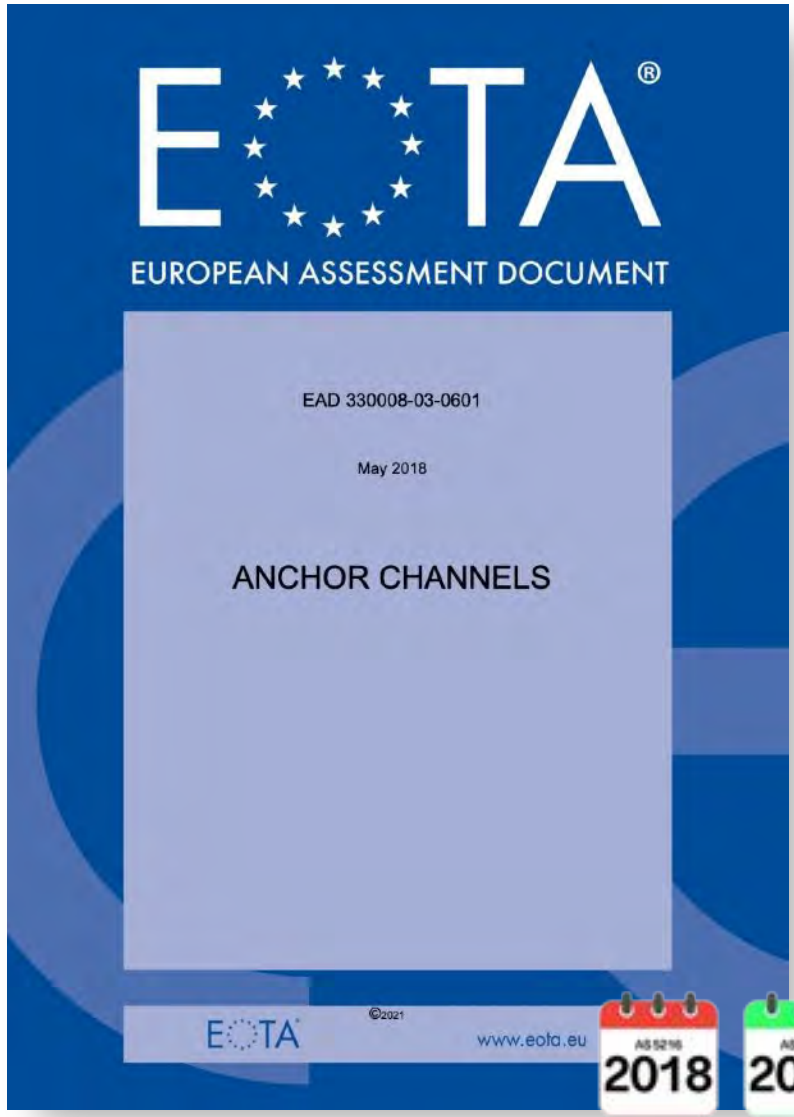
A.1.1 General

Testing of post-installed fasteners for suitability and admissible service conditions shall be performed in accordance with EAD 330232 and EAD 330499, as relevant. The nature and extent of testing shall be defined by an option number that is presented in EAD 330232 as shown in Table A.1.1.

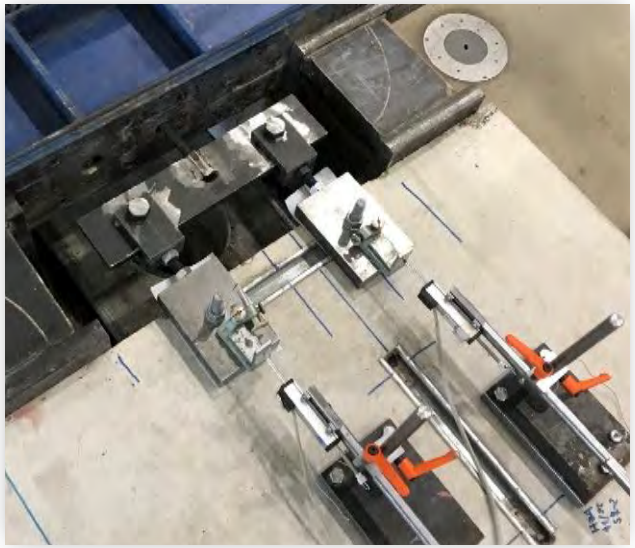
Testing of post-installed fasteners for seismic actions shall be performed in accordance with EOTA TR049.

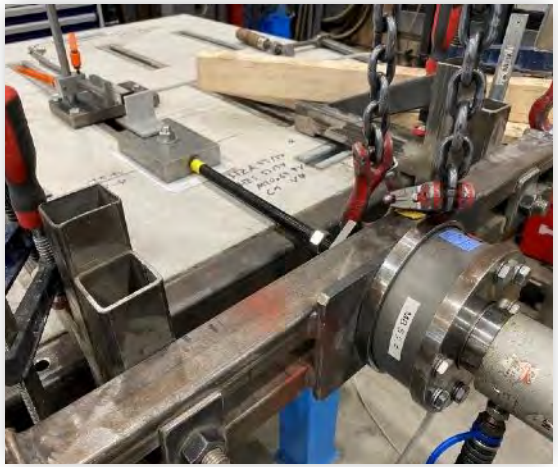
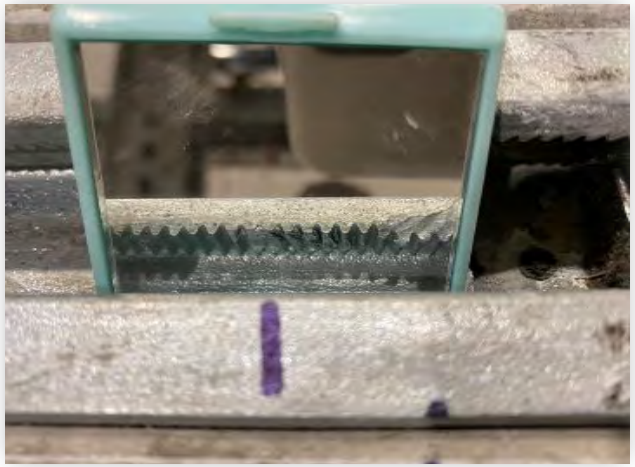
Testing of post-installed reinforcing bars and fasteners for redundant non-structural systems shall be performed in accordance with the requirements of the EAD 330087 and EAD 330747 respectively

Testing of cast-in anchor channel shall be performed in accordance with the requirements of the European Assessment Document EAD 330008.

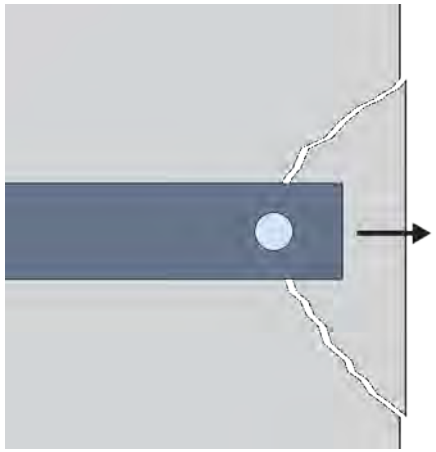


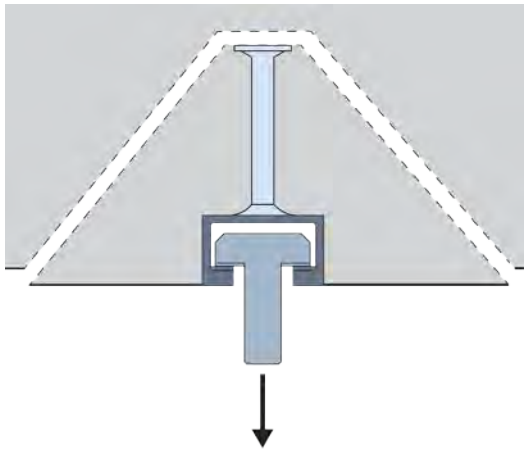
Pre-qualification tests

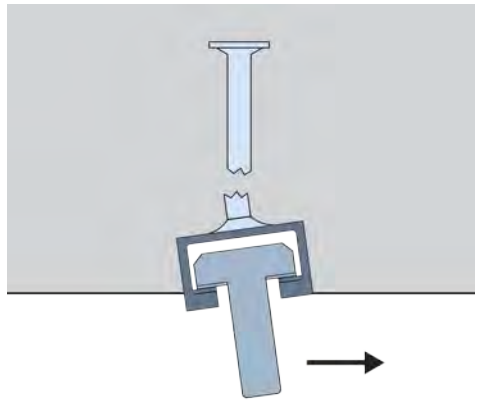




Courtesy: Leviat



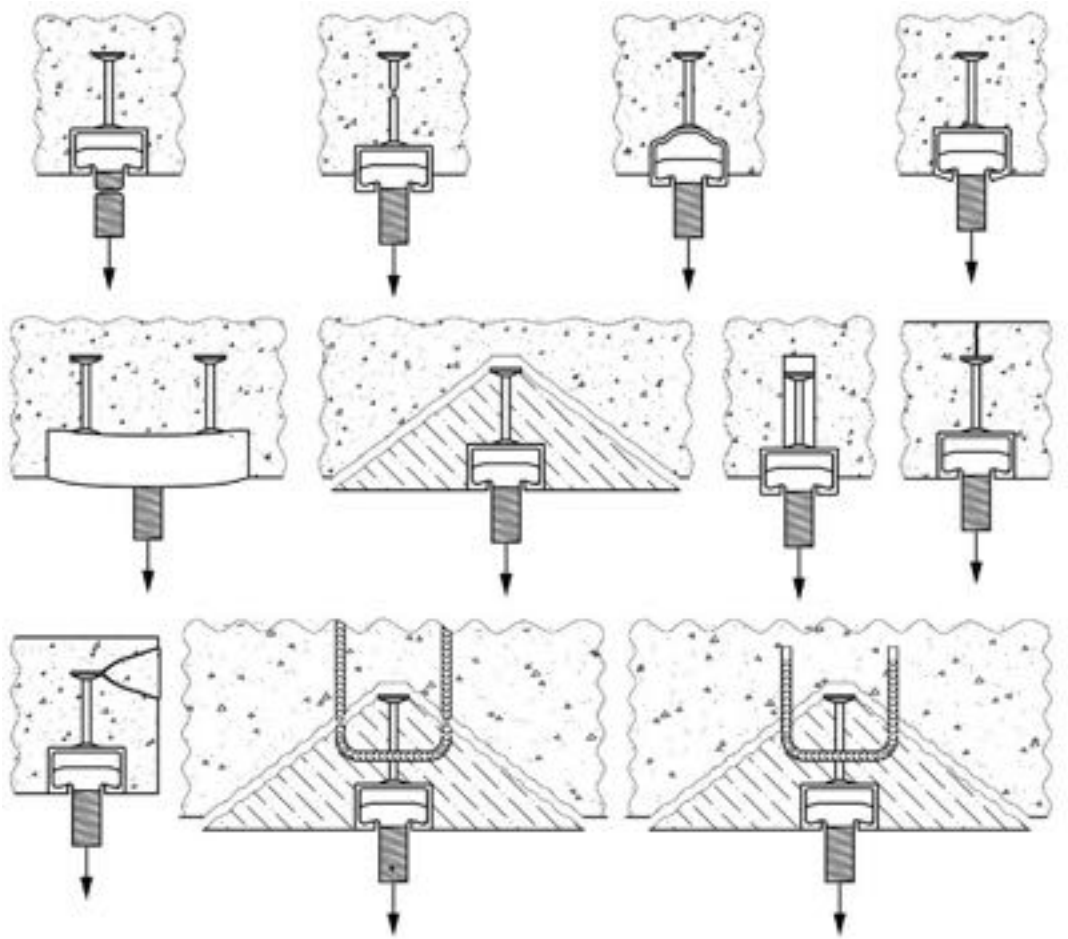




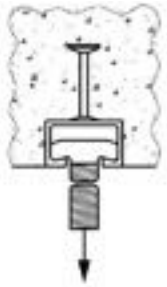
Design

Design for tensile loading

- Channel bolt fracture
- Anchor fracture
- Connection between anchor and channel
- Local flexure of channel lip
- Flexure of channel
- Concrete cone failure
- Pull-out failure
- Concrete splitting failure
- Concrete blow-out failure
- Supplementary reinforcement failure (steel and anchorage)



Design for tensile loading



Channel bolt fracture

$N^* \leq \phi_{Ms} \cdot N_{Rk,s}$

$\phi_{Ms} \leq 1/1.4$

Anchor fracture

$N_a^* \leq \phi_{Ms} \cdot N_{Rk,s,a}$

$\phi_{Ms} \leq 1/1.4$

Pullout failure

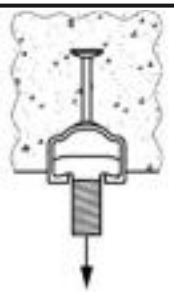
$N_a^* \leq \phi_{Mp} \cdot N_{Rk,p}$

$\phi_{Mp} = 1/1.5$

Local flexure failure of channel lip

$N^* \leq \phi_{Ms,l} \cdot N_{Rk,s,l}$

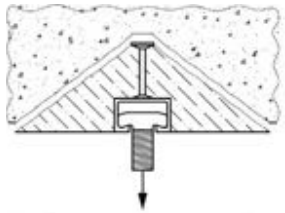
$\phi_{Ms,l} = 1/1.8$



Failure of connection anchor/channel

$N_a^* \leq \phi_{Ms,ca} \cdot N_{Rk,s,c}$

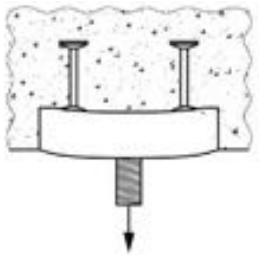
$\phi_{Ms,ca} = 1/1.8$



Concrete Cone Failure

$N_a^* \leq \phi_{Mc} \cdot N_{Rk,c}$

$\phi_{Mc} = 1/1.5$



Flexure failure of channel

$M^* \leq \phi_{Ms,flex} \cdot M_{Rk,s,flex}$

$\phi_{Ms,flex} = 1/1.15$

Concrete blow-out

$N_a^* \leq \phi_{Mc} \cdot N_{Rk,cb}$

$\phi_{Mc} = 1/1.5$

Concrete splitting

$N_a^* \leq \phi_{Msp} \cdot N_{Rk,sp}$

$\phi_{Msp} = 1/1.5$

$N^* =$ Tension Load on the channel bolt

$N_a^* =$ Tension Load on the anchor

AS 5216 2018 AS 5216 2021

Design for shear loading (Y-direction)

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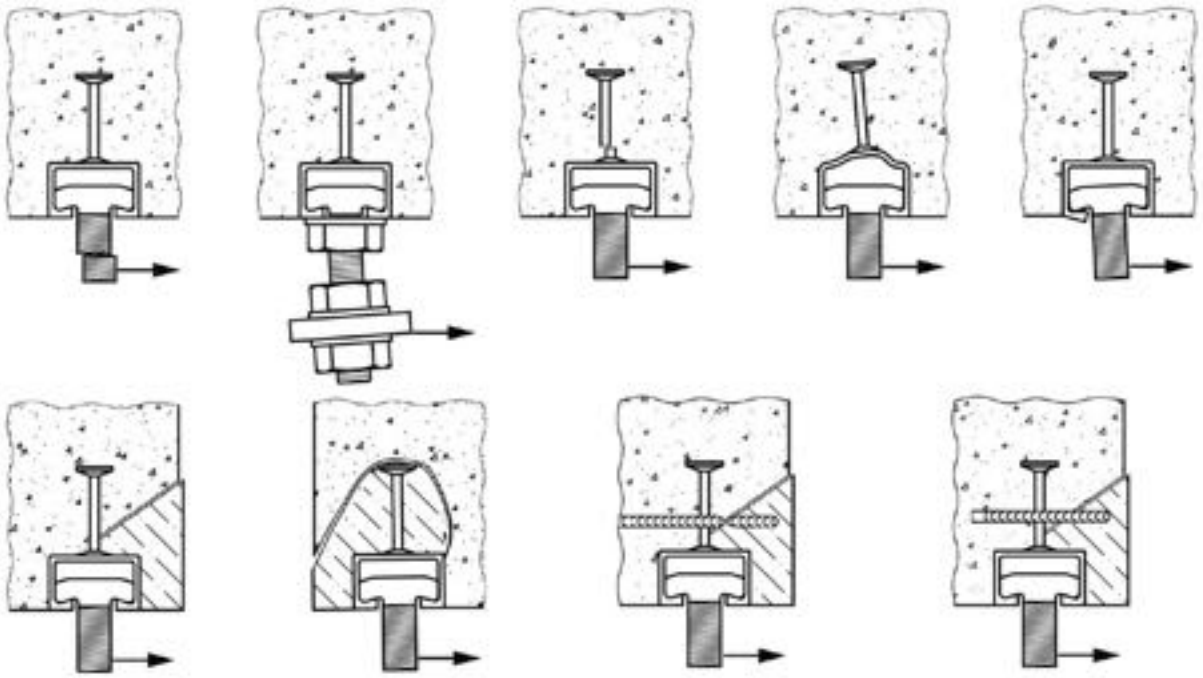
- Channel bolt (without lever arm)
- Channel both (with lever arm)
- Anchor
- Connection between anchor and channel
- Local flexure of channel lip
- Concrete edge failure
- Pry-out failure
- Supplementary reinforcement (steel and anchorage)

AS 5216 2018 AS 5216 2021

Design for shear loading (Y-direction)

AEFAC
Australian Engineered Fasteners and Anchors Council

Mode of failure	Channel	Most unfavourable anchor or channel bolt
Channel bolt without lever arm		$V^*_{cb,y} \le \phi_{Ms} V_{Rk,s}$
Channel bolt with lever arm		$V^*_{cb,y} \le \phi_{Ms} V_{Rk,s,M}$
Anchor		$V^*_{a,y} \le \phi_{Ms} V_{Rk,s,a,y}$
Connection between anchor and channel		$V^*_{a,y} \le \phi_{Ms} V_{Rk,s,c,y}$
Local flexure of channel lip[a]	$V^*_y \le \phi_{Ms,l,y} V_{Rk,s,l,y}$	
Concrete edge failure[b]		$V^*_{a,y} \le \phi_{Mc} V_{Rk,c,y}$
Pry-out failure[b]		$V^*_{a,y} \le \phi_{Mc} V_{Rk,cp,y}$
Steel failure of supplementary reinforcement[b]	Design according to AS 3600	
Anchorage failure of supplementary reinforcement[c]	Design according to AS 3600	



V^*_y = Perpendicular Shear Load on the channel bolt
$V^*_{a,y}$ = Perpendicular Shear Load on the anchor

2018 2021

Design for shear loading (X-direction)

AEFAC
Australian Engineered Fasteners and Anchors Council

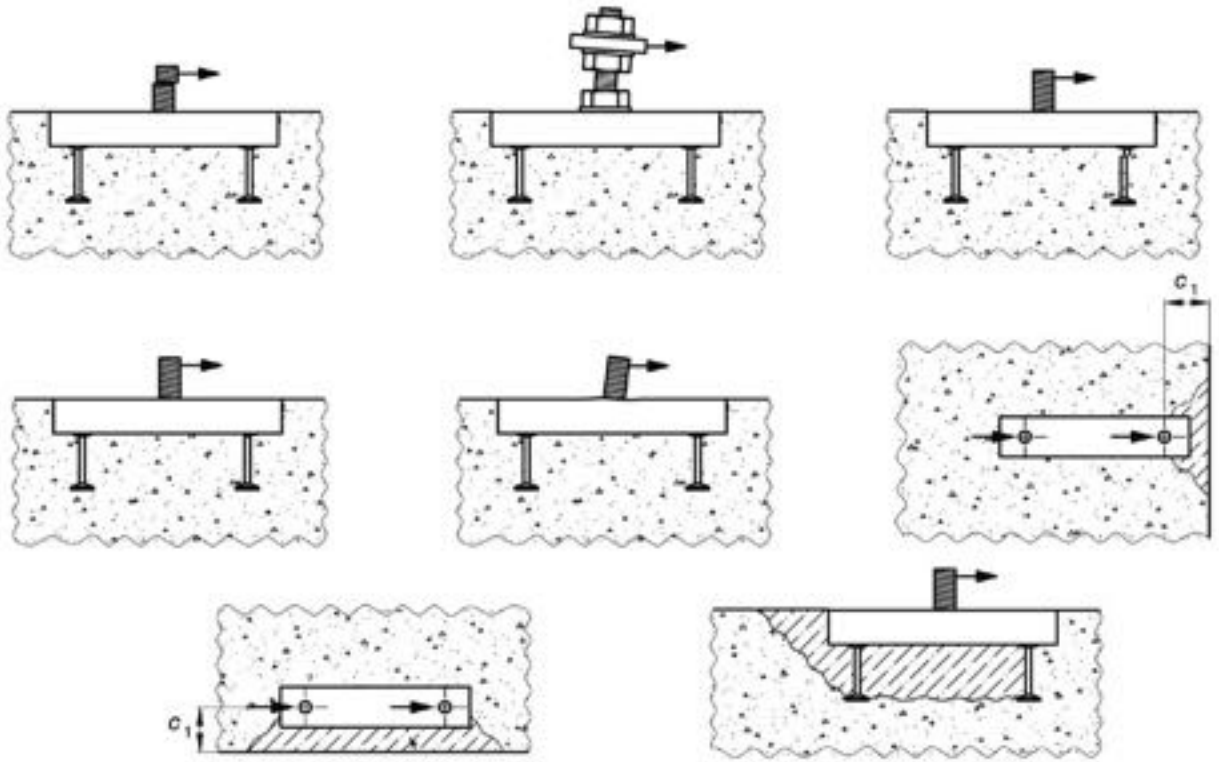
- Channel bolt (without lever arm)
- Channel both (with lever arm)
- Anchor
- Connection bet anchor and channel
- Connection between channel lip and channel bolt
- Concrete edge failure
- Pry-out failure
- Supplementary reinforcement (steel and anchorage)

AS 5216 2021

Design for shear loading (X-direction)

AEFAC Australian Engineered Fasteners and Anchors Council

Mode of failure	Channel	Most unfavourable anchor or channel bolt
Channel bolt without lever arm		$V^*_{cb,x} \le \phi_{Ms} V_{Rk,s}$
Channel bolt with lever arm		$V^*_{cb,x} \le \phi_{Ms} V_{Rk,s,M}$
Anchor		$V^*_{a,x} \le \phi_{Ms} V_{Rk,s,a,x}$
Connection between anchor and channel		$V^*_{a,x} \le \phi_{Ms,ca} V_{Rk,s,c,x}$
Connection between channel lips and channel bolt[a]	$V^*_{cb,x} \le \phi_{Ms,l,x} V_{Rk,s,l,x}$	
Concrete edge failure[b]		$V^*_{a,x} \le \phi_{Mc} V_{Rk,c,x}$
Pry-out failure[b]		$V^*_{a,x} \le \phi_{Mc} V_{Rk,cp,x}$
Steel failure of supplementary reinforcement[c]	Design according to AS 3600	
Anchorage failure of supplementary reinforcement[c]	Design according to AS 3600	



$V^*_{cb,x}$ = Longitudinal Shear Load on the channel bolt

$V^*_{a,x}$ = Longitudinal Shear Load on the anchor

AS 5216 2021

Combined loading

- Steel failure

$$\max\left[\left(\frac{N^*_{cb}}{\phi_{s,l}N_{Rk,s,l}}\right),\left(\frac{M^*_{ch}}{\phi_{Ms,flex}M_{Rk,s,flex}}\right)\right]^{k_{13}}+\left(\frac{V^*_{cb,y}}{\phi_{s,l}V_{Rk,s,l,y}}\right)^{k_{13}}\leq 1-\left(\frac{V^*_{cb,x}}{\phi_{s,l}V_{Rk,s,l,x}}\right)^2$$

- Anchor and anchor channel connection failure

$$\max\left(\frac{N^*_a}{\phi_{s,l}N_{Rk,s,a}},\frac{N^*_a}{\phi_{s,l}N_{Rk,s,c}}\right)^{k_{14}}+\max\left(\frac{V^*_{a,y}}{\phi_{s,l}V_{Rk,s,a,y}},\frac{V^*_{a,y}}{\phi_{s,l}V_{Rk,s,c,y}}\right)^{k_{14}}\leq 1-\max\left(\frac{V^*_{a,x}}{\phi_{s,l}V_{Rk,s,a,x}},\frac{V^*_{a,x}}{\phi_{s,l}V_{Rk,s,c,x}}\right)^2$$

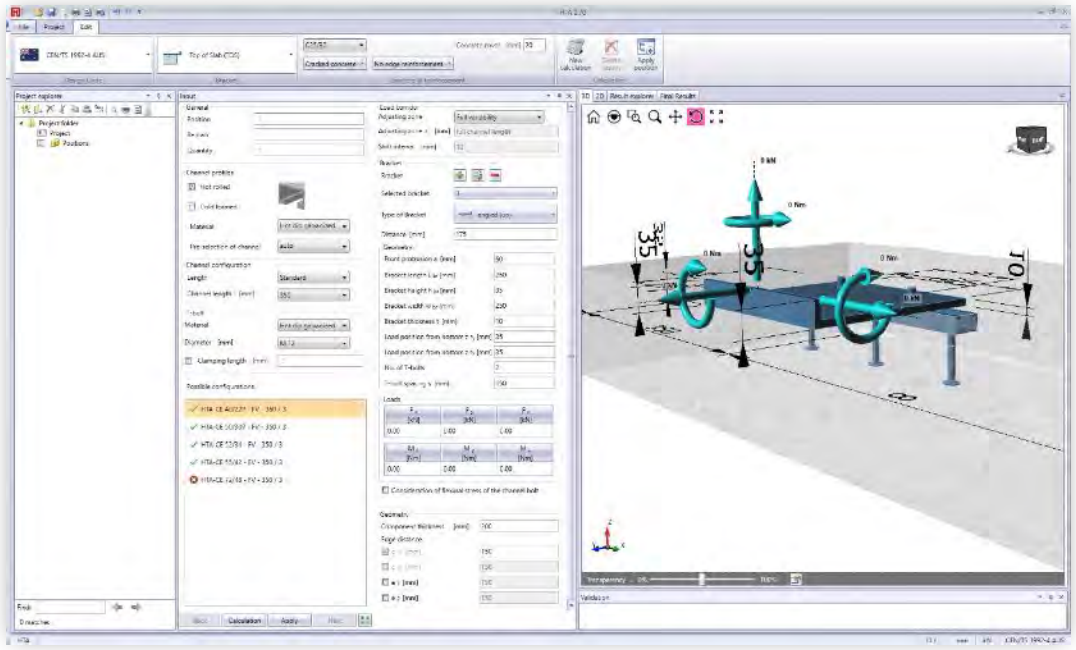
Combined loading

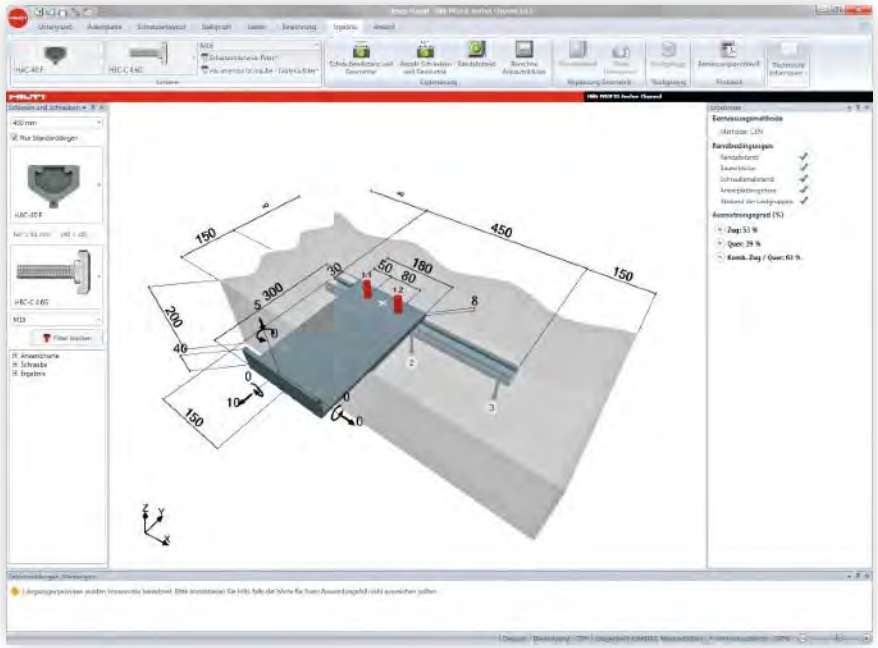
- Concrete related failure modes

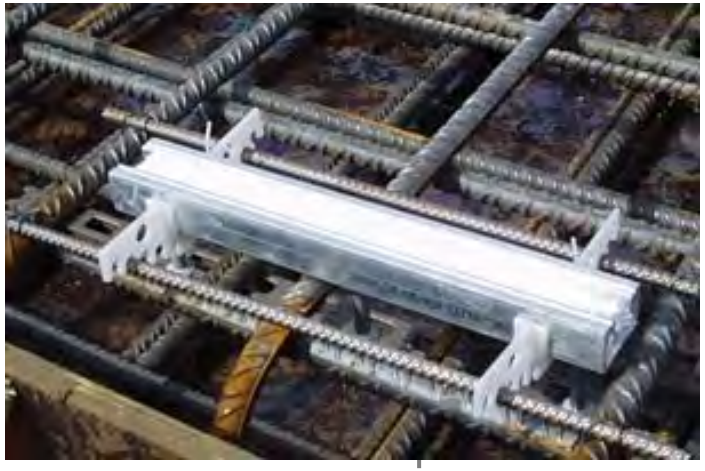
$$\left(\frac{N_a^*}{\phi_i N_{Rk,i}}\right)^{1.5} + \left(\frac{V_{a,x}^*}{\phi_i V_{Rk,i,x}}\right)^{1.5} + \left(\frac{V_{a,y}^*}{\phi_i V_{Rk,i,y}}\right)^{1.5} \leq 1$$

Software

- Suppliers offer software to provide design capacities
- Software needs to be product specific
- Software based on approval documents (e.g., ETAs)







Installation

Installation Videos

https://www.youtube.com/watch?v=nnJ2-4M4kqs

https://www.youtube.com/watch?v=xC0HGzCLqlk

Search AEFAC on YouTube

Other international Standards

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Assessment	EAD 330008	AS 5216 Appendix A / EAD 330008	ICC – AC 232
Design	EN 1992-4 / CEN/TR 17080	AS 5216	ICC – AC 232
Approval	European Technical Assessment (ETA)	Pre-qualification Report / European Technical Assessment (ETA)	ICC-ESR

AS 5215 Vs. EN 1992-4 Vs ICC – AC 232

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Loading	Configurations / Restrictions			
N, Vy	Number of anchors	Not limited	Not limited	Not limited
	effective	all	all	all
Vx	Total number of anchors	≤ 3	Not limited	Not limited
	effective (steel and other)	all	all	all
	effective (concrete edge, perpendicular)	1 (nearest edge)	≤ 3	≤ 3
	effective (concrete edge, pry-out, parallel)	all	≤ 3	≤ 3

3 Critical Elements to Achieve Quality Assurance

AEFAC
Australian Engineered Fasteners and Anchors Council

01. **Pre-qualification**

Products independently tested and assessed to be “fit for purpose”

EAD 330008

02. **Design**

Rigorous assessment to design for critical mode of failure

AS 5216:2021

03. **Installation**

Informed and competent installer with appropriate supervision and experience

Qualified

Thank You!

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