



FIELD FIXES

**For installation errors with HAC(-T)
and HAC-C(-P) cast-in anchor
channels using HBC channel bolts**

March 2020



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1. INTRODUCTION

The field remediations provided in this brochure are valid for Hilti HAC & HAC-C anchor channels incl. the corresponding T-bolts. For more details please refer to the tables on pages 5 and 6. The scope of this brochure covers the anchor channel systems given in ETA-11/0006, ESR-3520 and ETA-17/0336.

In chapter 3, this document provides guidance on how to correctly install anchor channel systems which help to avoid any misplacement of the anchor channels in concrete and improper installation of the channel bolts. It is mandatory to follow the instructions for use (IFU), so that the technical data given in ETA-11/0006, ETA-17/0336 and ESR-3520 is applicable to avoid damaging the anchor channel system during installation.

In chapter 4 Hilti has framed different scenarios for incorrectly installed anchor channels to provide recommendations for solving the specific installation problem. If the local situation is different than the one discussed, Hilti recommends contacting the local Hilti representative for further assistance and guidance.

Chapter 5 describes how to utilize post-installed anchors in situations where the cast-in anchor channel is no longer viable.

2. PRODUCT RANGE COVERED

HAC - cast-in anchor channels with plain channel profiles			
HAC-40	HAC-50	HAC-60	HAC-70
HBC-C and HBC-C-N			

HAC-T - cast-in anchor channels with serrated channel profiles		
HAC-30	HAC-T 50	HAC-T 70
HBC-B	HBC-T	

HAC-C-(P) hot-rolled cast-in anchor channels

HAC-C 40/22	HAC-C-P 40/22	HAC-C 50/30	HAC-C-P 50/30	HAC-C 52/34
HBC				

HAC-C cold-formed cast-in anchor channels

HAC-C 28/15	HAC-C-P 38/17	HAC-C 40/25	HAC-C-P 49/30	HAC-C 54/33
HBC				

3. CORRECT INSTALLATION OF HAC AND HAC-C CHANNELS WITH HBC BOLTS

3.1. Installation of HAC and HAC-C anchor channel systems

HAC and HAC-T anchor channel systems are covered in the European Technical Assessment ETA-11/0006 and in the ICC Evaluation Service Report ESR-3520. HAC-C and HAC-C-P anchor channel systems are covered in ETA-17/0336.

There are two types of installations that are allowed (see Figure 1).

1) The channel can be installed with full contact of the fixture between concrete surface and channel profile. This installation is named “General installation” in the European framework and “Installation type A” in the US framework. In

this case the pre-tension force applied is transferred to the entire anchor channel system.

2) The channel can be also installed with contact between the fixture and channel profile only. This installation is named “Steel-to-steel contact” in the European framework and “Installation type B” in the US framework. In this case, the pre-tension force applied, only results in stresses in the channel bolt and no resulting forces are introduced in the anchor channel since the fixture is only clamped against the channel profile.

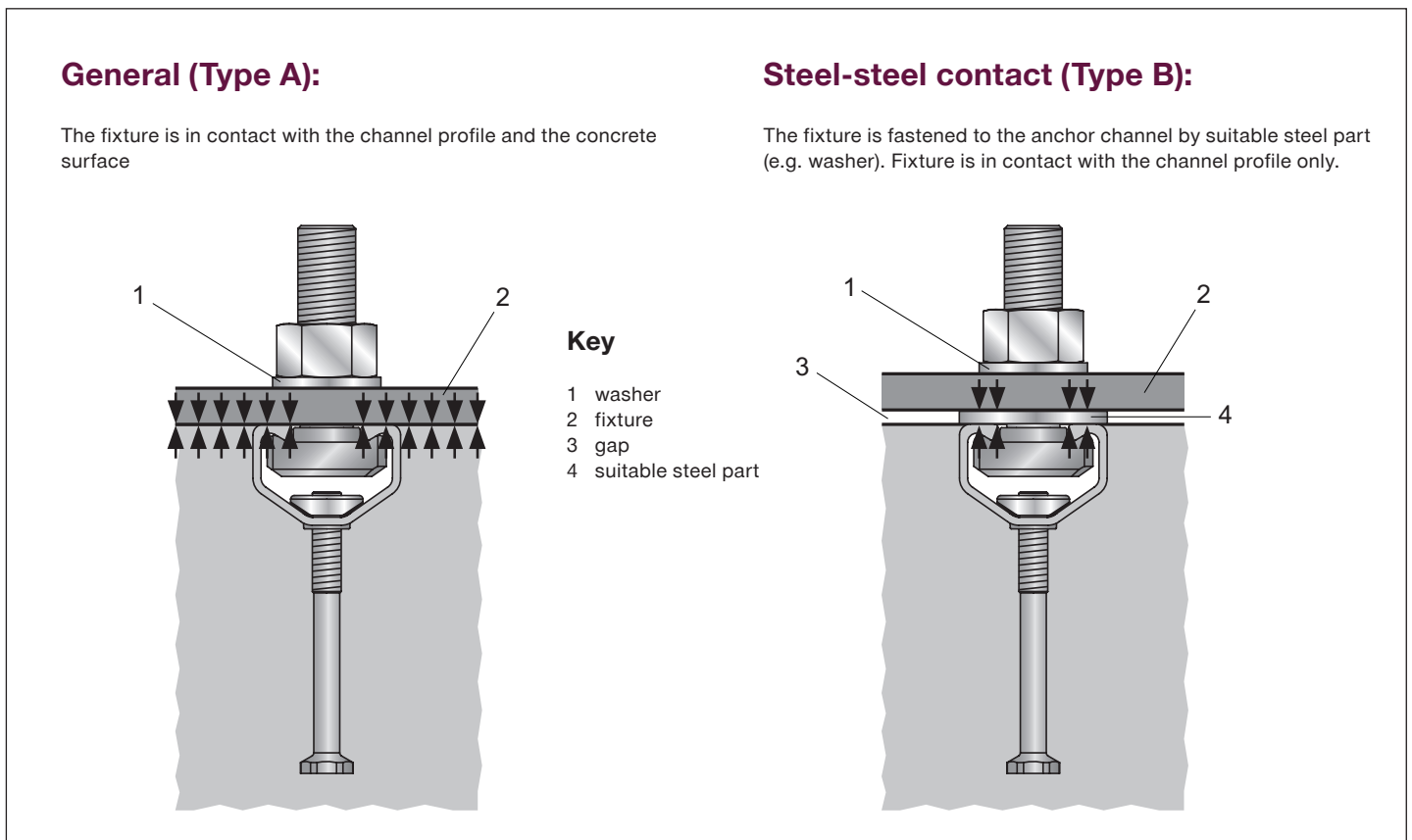


Figure 1: Installation conditions

Different installation torques T_{inst} are given for installation type A (General) and installation type B (Steel-steel contact). The specified T_{inst} values are the maximum installation torques which are assessed on a characteristic level in order to avoid damage of the anchor channel system during installation.

There is no difference in the technical data provided for installation type A (General) and installation type B (Steel-to-steel contact).

It is allowed to utilize the installation torques T_{inst} from installation Type A (General) for installation Type B (Steel-to-steel contact) but not the opposite.

The following installation instructions are part of every jobsite delivery and are given in the relevant technical documents (ETA-11/0006, ETA 17/0336 and ESR-3520). **Please note: Not following the instructions will no longer meet the requirements of the ETA and ESR, as well as it can lead to potential reduction in the capacity of the anchor channel system.**

3.1.1. Installation instructions for anchor channels HAC and HAC-T

1) Correct selection of anchor channel in accordance with the design specification.

2) If cutting the anchor channel is necessary, cut the channel with an end spacing as shown.

$x = 25\text{mm}$ or 0.98 inch

3) Position the anchor channel such that the channel lips will be flush with the surface of the concrete. Secure anchor channels to formwork (3a) or adjoining reinforcing steel (3b) with nails, staples, rivets, or wire ties as appropriate. Supports and attachments shall be adequate to ensure that anchor channels remain in position during concrete placement. Anchor channels shall not be pushed into fresh concrete (3c). Anchors shall not be bent, cut or otherwise modified (3d).

4) Anchor channels shall be protected from intrusion of concrete and slurry into the channel during concrete placement. Place and consolidate concrete around anchor channels to mitigate voids.

Make sure that channels are leveled.

5) Installed anchor channels must be flush with the concrete surface.

6) and 7) Remove the foam filler after hardening of concrete and striking the formwork.

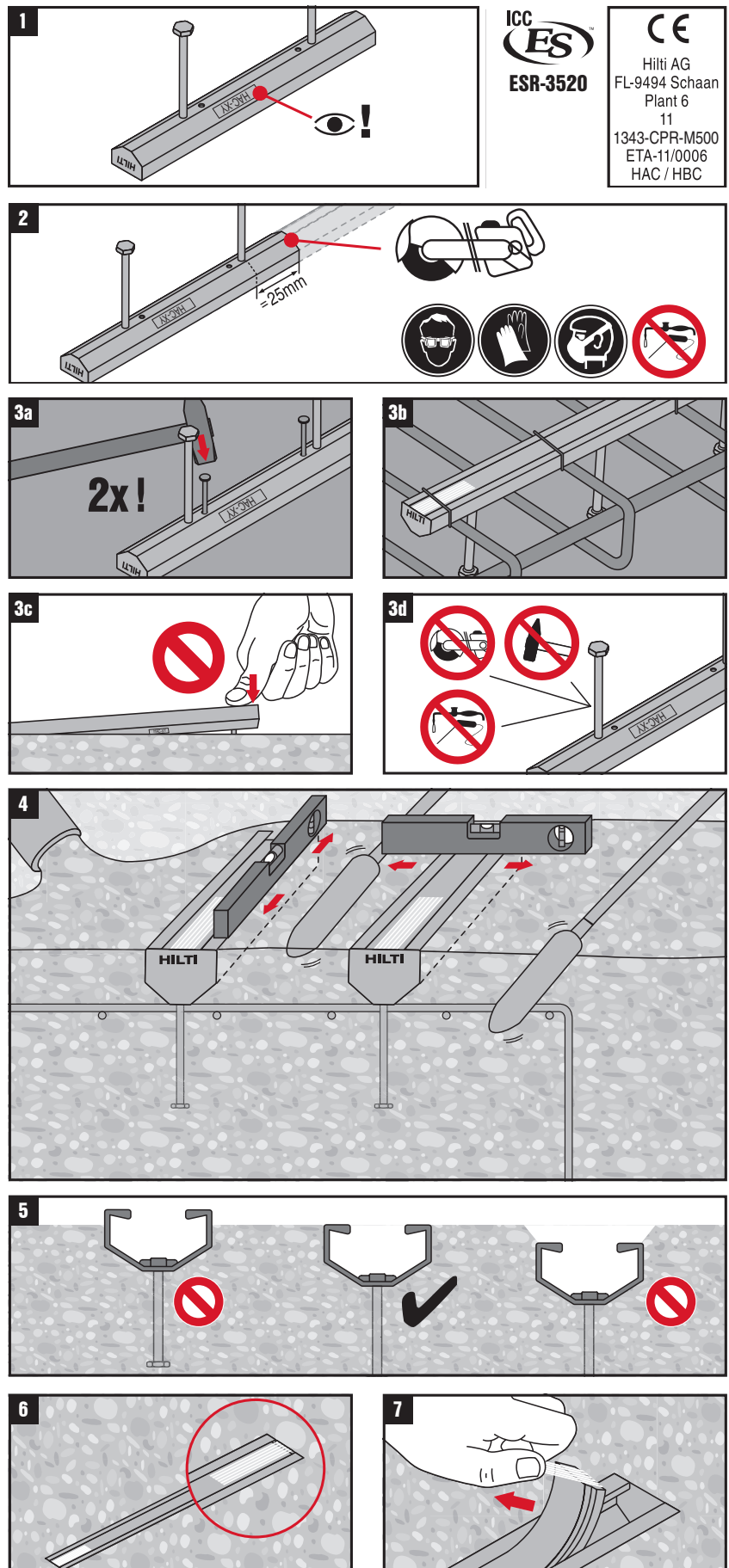


Figure 2: Hilti Instructions for Use (IFU) for HAC and HAC-T anchor channels

3.1.2. Installation instructions for HAC-C(-P) anchor channels

1) Correct selection of anchor channel in accordance with the design specification.

2) If cutting of the anchor channel is necessary, cut the channel with an end spacing

x = 25 or 35 mm for round or welded anchors with profile:
40/22
50/30

Minimum two anchors per channel!

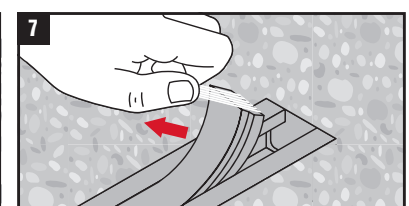
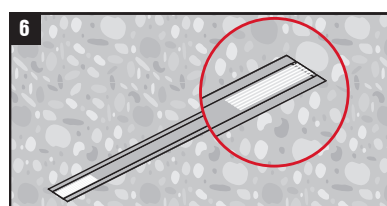
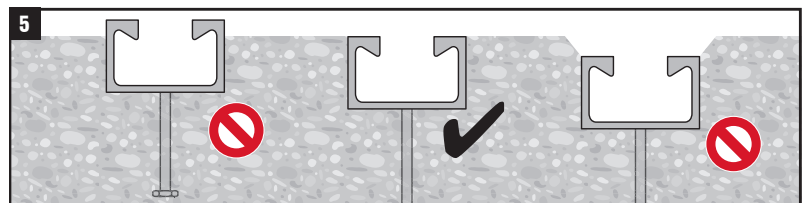
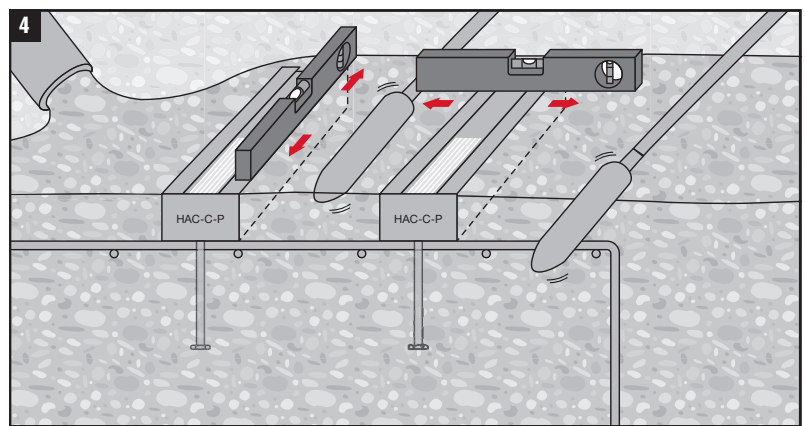
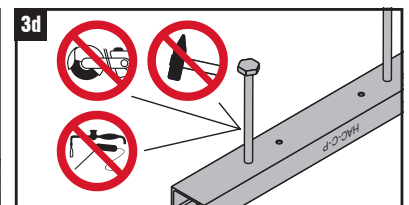
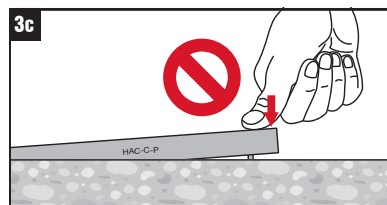
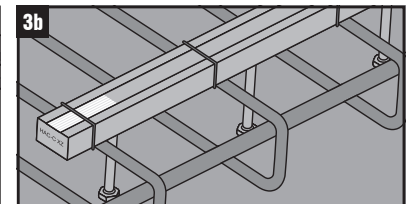
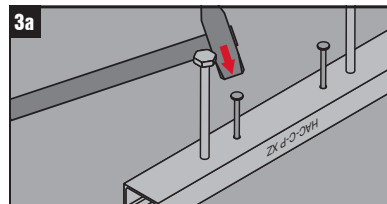
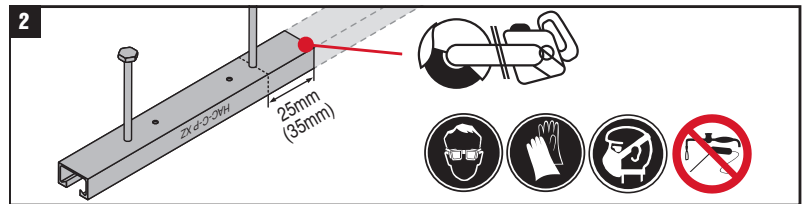
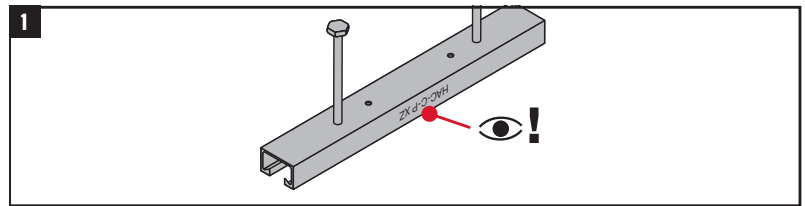
3) Position the anchor channel such that the channel lips will be flush with the surface of the concrete. Secure anchor channels to formwork (3a) or adjoining reinforcing steel (3b) with nails, staples, rivets, or wire ties as appropriate. Supports and attachments shall be adequate to ensure that anchor channels remain in position during concrete placement. Anchor channels shall not be pushed into fresh concrete (3c). Anchors shall not be bent, cut or otherwise modified (3d).

4) Anchor channels shall be protected from intrusion of concrete and slurry into the channel during concrete placement. Place and consolidate concrete around anchor channels to mitigate voids.

Make sure that channels are leveled.

5) Installed anchor channels must be flush with the concrete surface.

6) and 7) Remove the foam filler after hardening of concrete and striking the formwork.



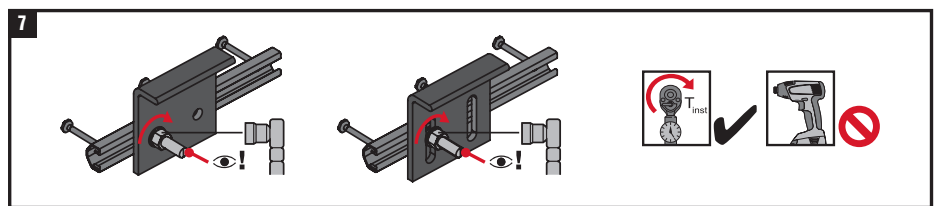
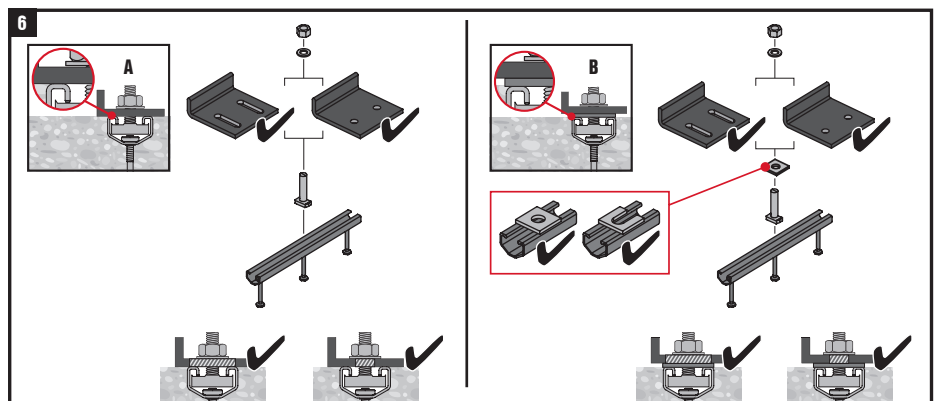
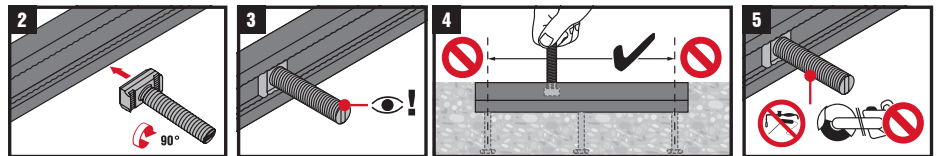
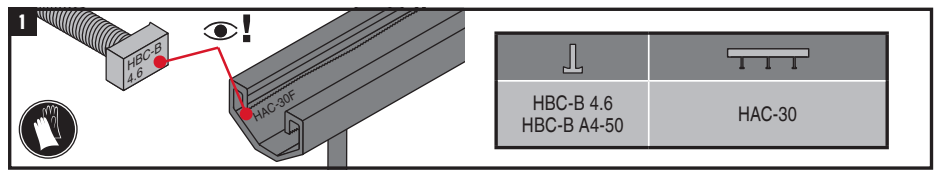
3.1.3. Installation instructions for HBC-B channel bolts

- 1) Select Hilti channel bolt type HBC-B in accordance with the design specification.
- 2) Place the channel bolt in the channel and lock the channel bolt in the channel by turning it 90 degrees.
- 3) Verify alignment of the bolt with the groove. Groove of bolt must be perpendicular to the longitudinal axis of the channel.
- 4) Verify that the channel bolt is not located outside the part of the channel bounded by the outermost anchors.
- 5) Do not cut channel bolts.
- 6) Install the fixture distinguishing between installation type A and installation type B.

- For installation type A, the fixture is in contact with the concrete surface and the channel profile.
- For installation type B, a suitable steel element e.g. square plate washer is used to avoid introducing forces into the concrete during application of the installation torque T_{inst} . The steel element shall have a sufficient stiffness to avoid deformation of the channel lips.

- 7) Apply the installation torque T_{inst} to the channel bolt with a calibrated torque wrench. Do not exceed the value T_{inst} distinguishing between installation type A and installation type B.

Select the correct installation torque T_{inst} according to material, channel type, channel bolt diameter, and installation type A or B.



		T_{inst}	
		 HAC-30	 HAC-30
M10	4.6, A4-50	15 Nm / 11 ft-lb	15 Nm / 11 ft-lb
M12	4.6, A4-50	25 Nm / 19 ft-lb	25 Nm / 19 ft-lb

Figure 3: Hilti Instructions for Use (IFU) for HBC-B channel bolts

3.1.4. Installation instructions for HBC-C channel bolts

1) Select Hilti channel bolt type HBC-C in accordance with the design specification.

2) Place the channel bolt in the channel and lock the channel bolt in the channel by turning it 90 degrees.

3) Verify alignment of the bolt with the groove. Groove of bolt must be perpendicular to the longitudinal axis of the channel.

4) Verify that the channel bolt is not located outside the part of the channel bounded by the outermost anchors.

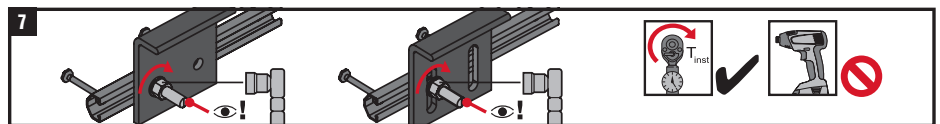
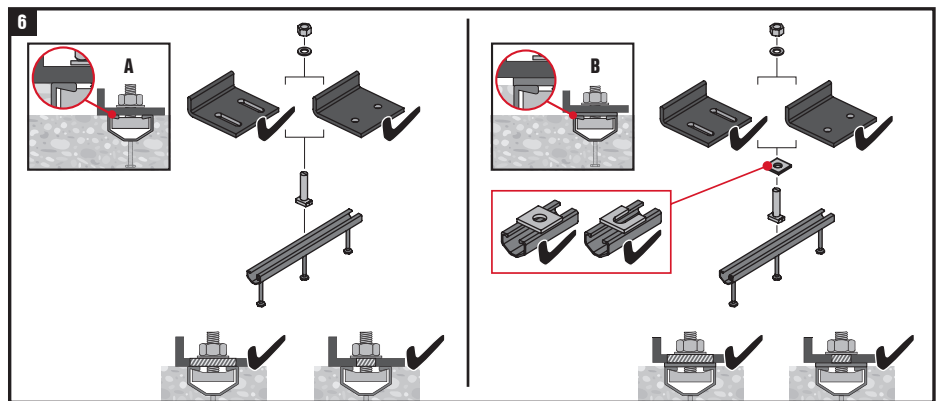
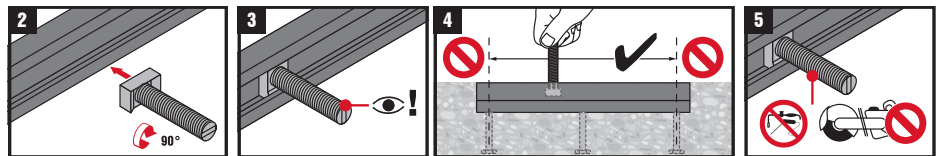
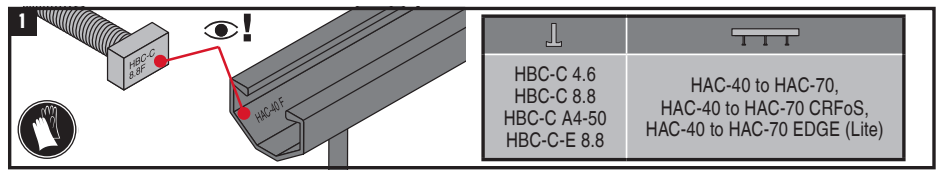
5) Do not cut channel bolts.

6) Install the fixture distinguishing between installation type A and installation type B.

- For installation type A, the fixture is in contact with the concrete surface and the channel profile.
- For installation type B, a suitable steel element e.g. square plate washer is used to avoid introducing forces into the concrete during application of the installation torque T_{inst} . The steel element shall have a sufficient stiffness to avoid deformation of the channel lips.

7) Apply the installation torque T_{inst} to the channel bolt with a calibrated torque wrench. Do not exceed the value T_{inst} distinguishing between installation type A and installation type B.

Select the correct installation torque T_{inst} according to material, channel type, channel bolt diameter, and installation type A or B.



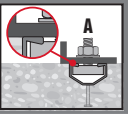
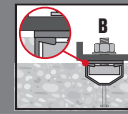
		T_{inst}							
									
		HAC-40	HAC-50	HAC-60	HAC-70	HAC-40	HAC-50	HAC-60	HAC-70
M10	4.6, A4-50		15 Nm / 11 ft-lb				15 Nm / 11 ft-lb		
	8.8		15 Nm / 11 ft-lb				48 Nm / 35 ft-lb		
M12	4.6, A4-50		25 Nm / 19 ft-lb				25 Nm / 19 ft-lb		
	8.8		25 Nm / 19 ft-lb				75 Nm / 55 ft-lb		
M16	4.6, A4-50		60 Nm / 44 ft-lb				60 Nm / 44 ft-lb		
	8.8		60 Nm / 44 ft-lb				185 Nm / 136 ft-lb		
M20	4.6, A4-50	70 Nm / 52 ft-lb	105 Nm / 78 ft-lb	120 Nm / 89 ft-lb		120 Nm / 89 ft-lb	120 Nm / 89 ft-lb		
	8.8	70 Nm / 52 ft-lb	105 Nm / 78 ft-lb	120 Nm / 89 ft-lb		320 Nm / 236 ft-lb			

Figure 4: Hilti Instructions for Use (IFU) for HBC-C channel bolts

3.1.5. Installation instructions for HBC-T channel bolts

1) Select Hilti serrated channel bolt in accordance with the design specification.

2) Place the channel bolt in the channel and lock the channel bolt in the channel by turning it 90 degrees.

3) Verify alignment of the bolt with the groove. Groove of bolt must be perpendicular to the longitudinal axis of the channel.

4) Verify that the channel bolt is not located outside the part of the channel bounded by the outermost anchors.

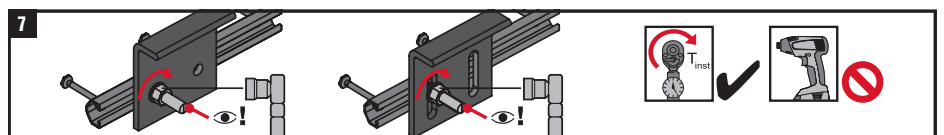
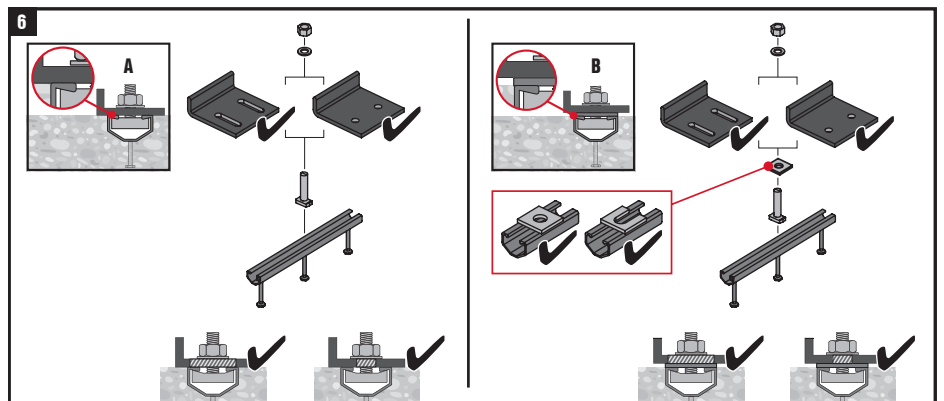
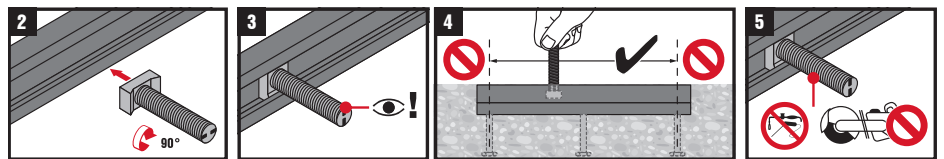
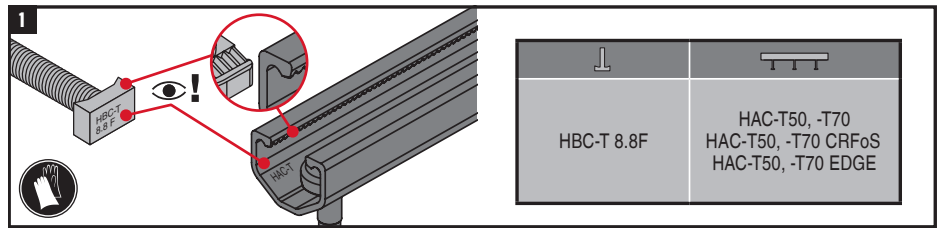
5) Do not cut channel bolts.

6) Install the fixture distinguishing between installation type A and installation type B.

- For installation type A, the fixture is in contact with the concrete surface and the channel profile.
- For installation type B, a suitable steel element e.g. square plate washer is used to avoid introducing forces into the concrete during application of the installation torque T_{inst} . The steel element shall have a sufficient stiffness to avoid deformation of the channel lips.

7) Apply the installation torque T_{inst} to the channel bolt with a calibrated torque wrench. Do not exceed the value T_{inst} distinguishing between installation type A and installation type B. Complete removal and reinstallation of the channel bolt HBC-T is not allowed.

Select the correct installation torque T_{inst} according to material, channel type, channel bolt diameter, and installation type A or B.



		A		B	
		T_{inst}		T_{inst}	
		HAC-T50	HAC-T70	HAC-T50	HAC-T70
M12	8.8	75 Nm / 55 ft-lb		75 Nm / 55 ft-lb	
M16	8.8	100 Nm / 74 ft-lb		185 Nm / 136 ft-lb	
M20	8.8	120 Nm / 89 ft-lb		320 Nm / 236 ft-lb	

Figure 5: Hilti Instructions for Use (IFU) for HBC-T channel bolts

3.1.6. Installation instructions for HBC-C-N channel bolts

1) Select Hilti channel bolt in accordance with the design specification.

2) Place the channel bolt in the channel and lock the channel bolt in the channel by turning it 90 degrees.

3) Verify alignment of the bolt with the groove. Groove of bolt must be perpendicular to the longitudinal axis of the channel.

4) Verify that the channel bolt is not located outside the part of the channel bounded by the outermost anchors.

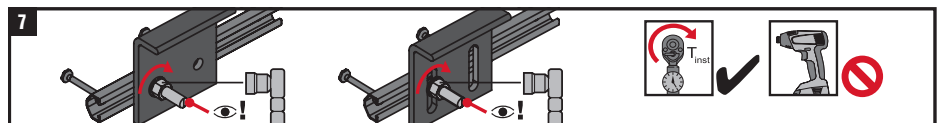
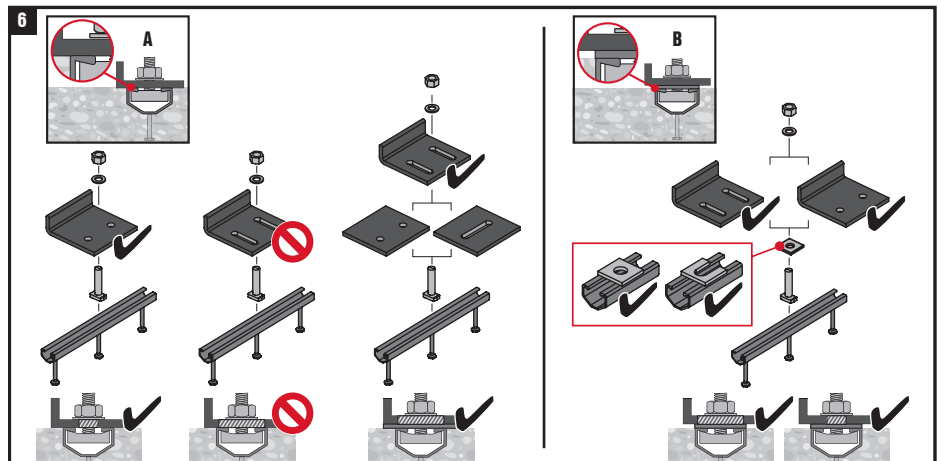
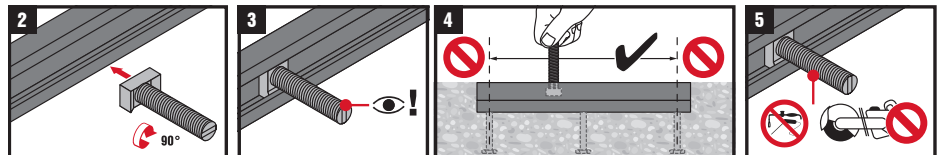
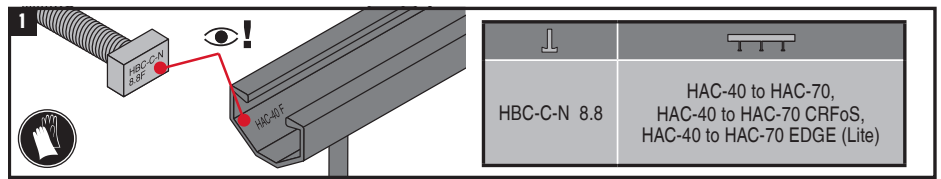
5) Do not cut channel bolts.

6) Install the fixture distinguishing between installation type A and installation type B.

- For installation type A, the fixture is in contact with the concrete surface and the channel profile.
- For installation type B, a suitable steel element e.g. square plate washer is used to avoid introducing forces into the concrete during application of the installation torque T_{inst} . The steel element shall have a sufficient stiffness to avoid deformation of the channel lips.

7) Apply the installation torque T_{inst} to the channel bolt with a calibrated torque wrench. Do not exceed the value T_{inst} distinguishing between installation type A and installation type B. As per approval, complete removal and reinstallation of the channel bolt HBC-C-N is not allowed.

Select the correct installation torque T_{inst} according to material, channel type, channel bolt diameter, and installation type A or B.



		T_{inst}							
		A				B			
		HAC-40	HAC-50	HAC-60	HAC-70	HAC-40	HAC-50	HAC-60	HAC-70
M12	8.8		75 Nm / 55 ft-lb				75 Nm / 55 ft-lb		
M16	8.8		185 Nm / 136 ft-lb				185 Nm / 136 ft-lb		
M20	8.8	-	320 Nm / 236 ft-lb			-	320 Nm / 236 ft-lb		

Figure 6: Hilti Instructions for Use (IFU) for HBC-C-N channel bolts

3.1.7. Installation instructions for HBC channel bolts

1) Select Hilti channel bolt type HBC in accordance with the design specification.

2) Place the channel bolt in the channel and lock the channel bolt in the channel by turning it 90 degrees.

3) Verify alignment of the bolt with the groove.

4) Verify that the channel bolt is not located outside of that part of the channel bounded by the outermost anchors.

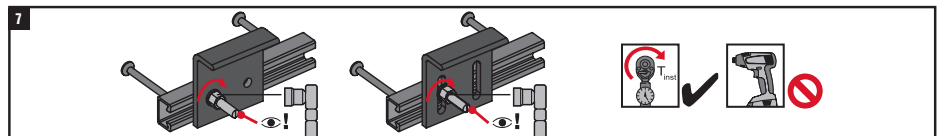
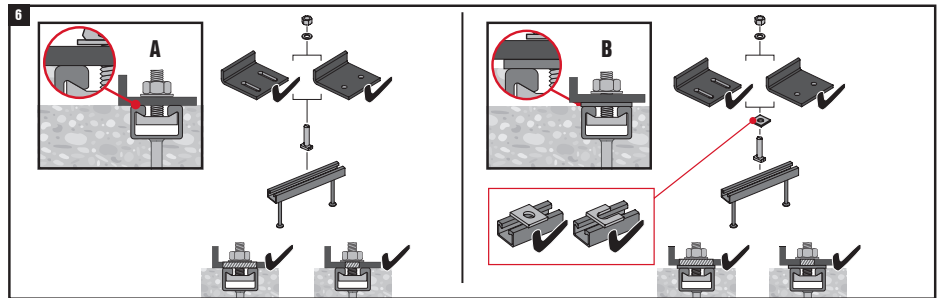
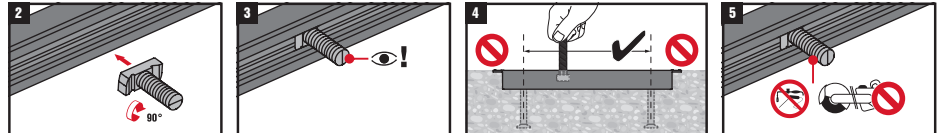
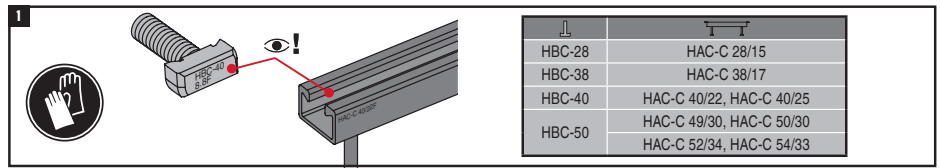
5) Do not cut channel bolts.

6) Install the fixture distinguishing between installation type A and installation type B.

- For installation type A the fixture is in contact with the concrete surface and the channel profile.
- For installation type B suitable steel element e.g. square plate washer is used to avoid introducing forces into the concrete during application of the installation torque T_{inst} . The steel element shall have sufficient stiffness to avoid deformation of the channel lips

7) Apply the installation torque T_{inst} to the channel bolt with a calibrated torque wrench. Do not exceed the value T_{inst} distinguishing between installation type A and installation type B.

Select the correct installation torque T_{inst} according to material, channel type, channel bolt diameter, and installation type.



Channel bolt		$T_{inst}^{1)} [Nm]$			
		General		Steel - steel contact	
		4.6, 8.8, A4-70	4.6	8.8	A4-70
HBC 40/22	M10	15	-	-	40
	M12	25		70	70
	M16	30		120	70
HBC 50/30	M12	25	-	70	70
	M16	60		120	180
	M20	75		360	360

Hilti Instructions for Use (IFU) for Hilti HBC channel bolts

Remark for fixtures with slotted holes

Generally, in many applications such as curtain wall fastenings, fixtures with slotted holes are used (Figure 7). These provide orthogonal tolerances to the channel axis and facilitate the installation. Without proper support of the channel lips, as specified in the instructions for use (IFU), the HBC-C-N or HBC-N notching T-bolts can cause damage to the channel lip. Schematic representation of this is given in Figure 8 and 9.



Figure 7: Fixture with slotted hole

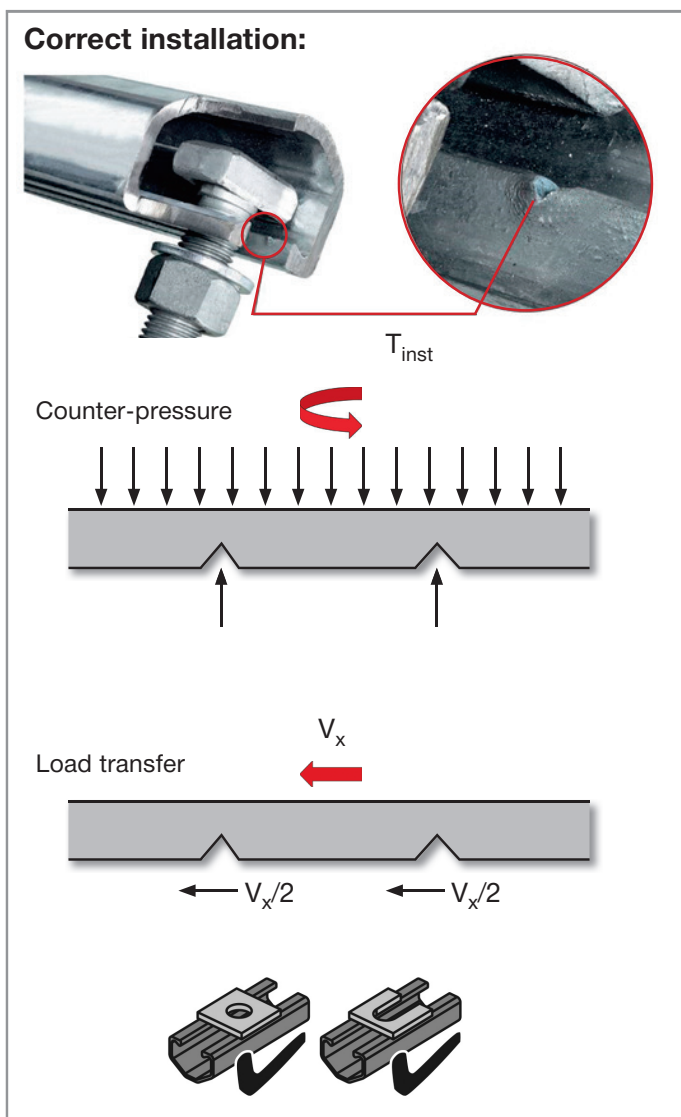


Figure 8: Installation with shim - correct installation

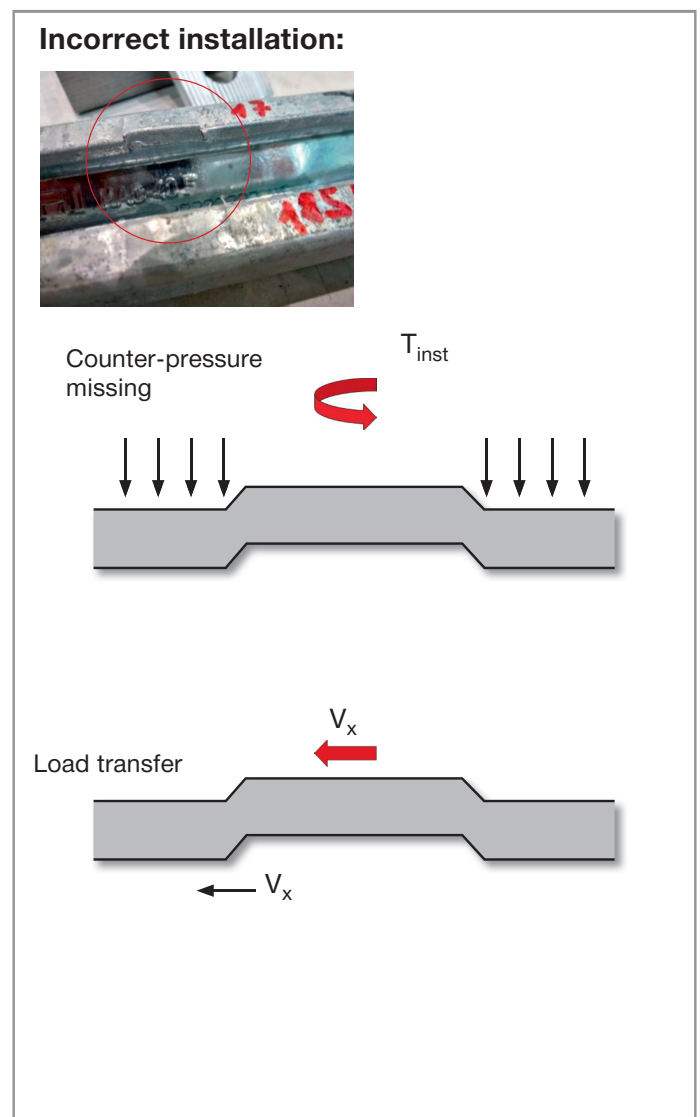


Figure 9: Installation without shims (not allowed in case of high installation torque in combination with slotted holes) - can cause local damage to channel lips

4. RECOMMENDATIONS FOR INCORRECTLY INSTALLED ANCHOR CHANNEL SYSTEMS

4.1. Potential cases of incorrectly installed anchor channel systems

In the following sections, several potential installation defects of anchor channel systems are described and Hilti recommendations are given based on testing and sound engineering judgement. The load directions considered in this document are shown in Figure 10.

Tension load (N)

z-direction (in direction of channel bolt)

Shear load (V_y)

y-direction (perpendicular to longitudinal axis of the channel)

Longitudinal shear load (V_x)

x-direction (in direction of longitudinal axis of the channel)

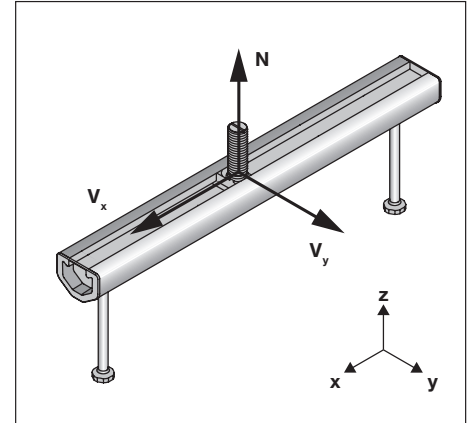


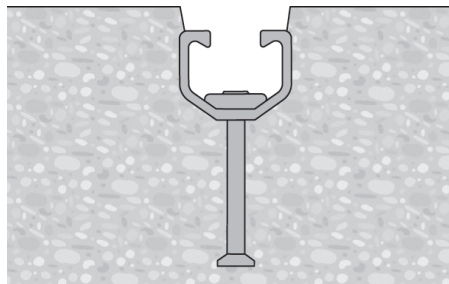
Figure 10: Definition of load directions covered in this document

An incorrectly installed anchor channel system can lead to potential consequences:

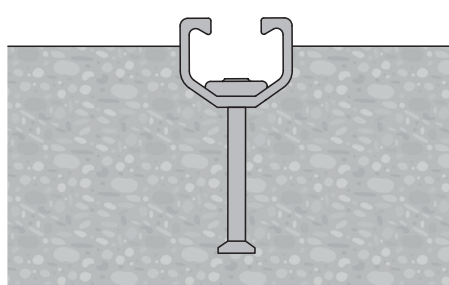
- Reduction in capacity
- Insufficient installation quality (stiffness, wobbling etc.) resulting in reduced serviceability

Potential installation defects are shown in Figure 11 a-e.

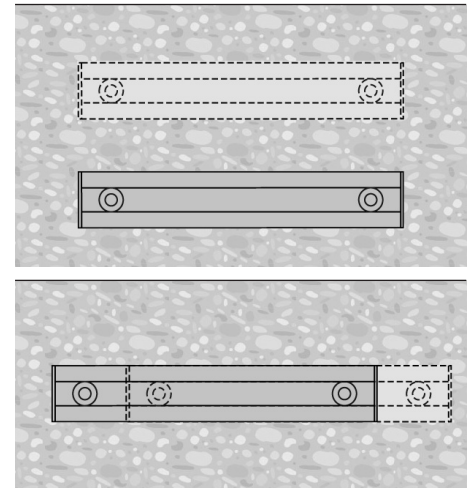
a) Anchor channel installed too deep



b) Anchor channel installed too high

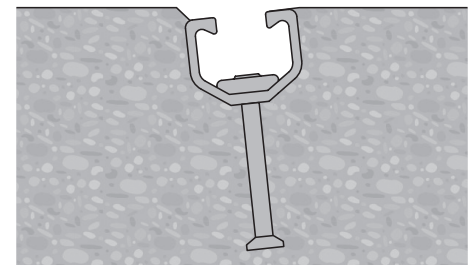


c) Anchor channel installed with wrong edge/corner distance

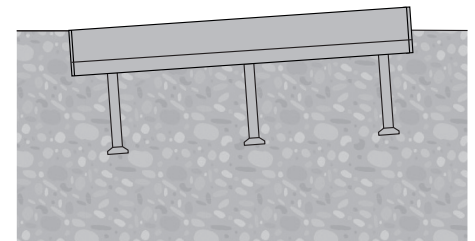


d) Anchor channel installed inclined

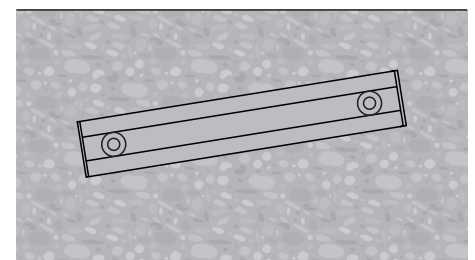
Rotation around x-axis



Rotation around y-axis



Rotation around z-axis



e) Channel bolt not installed correctly

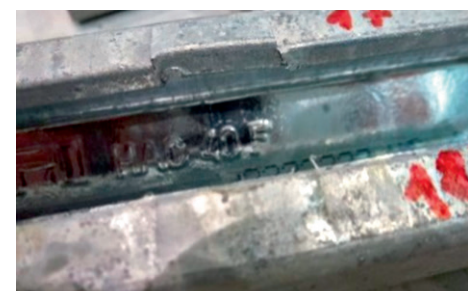


Figure 11: Potential installation errors a) – e)

4.2. Anchor channel not installed correctly

4.2.1. Anchor channel installed too deep

Description of the problem

When anchor channels are cast too deep into the concrete, the channel lips are not flush with the concrete surface (Figure 12). This type of installation error may result from incorrect anchor channel placement in the formwork.

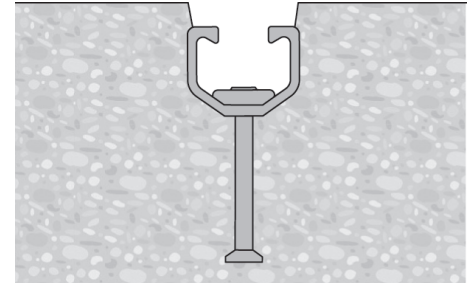


Figure 12: Anchor channel installed too deep

Possible consequences

Channel too deep	During bolt installation	During loading			Other effects
		Tension	Perpendicular shear	Longitudinal shear	
≤ 3 mm	Possible consequence considered in qualification tests				-
> 3 mm ≤ 15 mm	Damage of channel lips, anchors, connection between anchor and channel or pullout due to high pre-stressing forces	No consequences	Additional bending of the channel bolt and channel lips, reduced stiffness of the system		The channel bolt length according to specification might be too short
> 15 mm)			Same as above, additionally concrete edge breakout strength is reduced		

Recommendations

Channel too deep	Recommendations
≤ 3 mm	No actions needed
> 3 mm ≤ 15 mm	<p>Required actions on site:</p> <ul style="list-style-type: none"> The gap between fixture and anchor channel must be filled. This can be achieved by using appropriate shims or metal washers as shown in Figure 13. The width of the shims should be equal to the width of the channel profile. In case the T-bolt is too short, select a channel bolt with suitable channel bolt length. <p>Design verification: A stand-off condition must be verified.</p>
> 15 mm	A general assessment is not possible. Contact your local Hilti representative for further guidance.

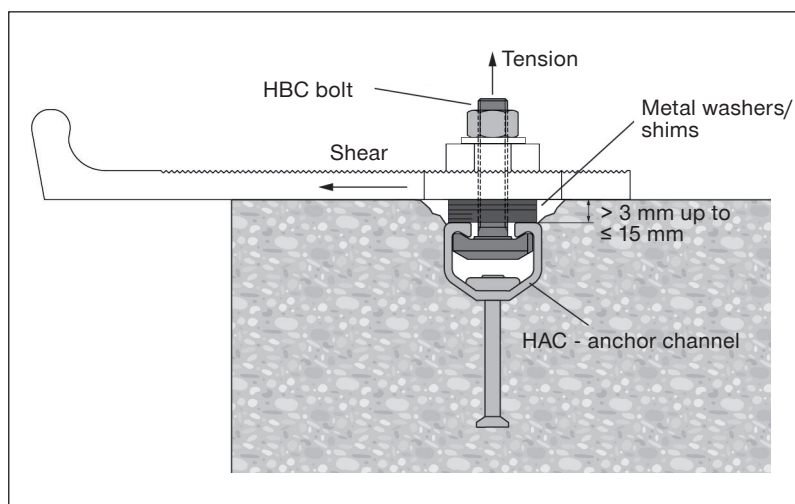


Figure 13: HAC anchor channel embedded in concrete > 3 mm up to ≤ 15 mm too deep

4.2.2. Anchor channel installed too high

Description of the problem

When anchor channels are cast too high into the concrete, the channel lips are not flush with the concrete surface and the anchor channel system protrudes from the concrete (Figure 14). This type of installation error may result from incorrect anchor channel placement in the formwork.

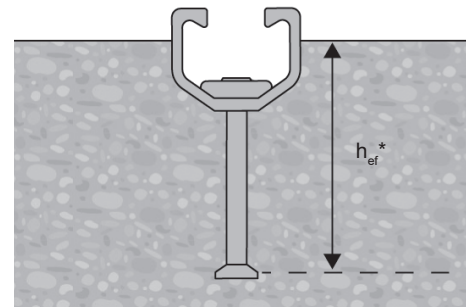


Figure 14: Anchor channel installed too high

Possible consequences

Channel too high	During bolt installation	During loading			Other effects
		Tension	Perpendicular shear	Longitudinal shear	
≤ 3 mm			-		
> 3 mm up to 2/3 h _{ch}	No consequences	Reduction of concrete capacity due to reduced embedment depth	Reduced concrete capacity (concrete edge breakout and pry-out), reduced steel capacity due to unsupported channel lips (channel lip, anchor and connection between anchor and channel)	Reduction of concrete capacity due to reduced embedment depth	Different support conditions of the fixture (no contact between the fixture and the concrete surface) results in higher acting loads on the anchor channel system
> 2/3 h _{ch}			Same as above with higher reduction in concrete and steel capacity		

Recommendations

Channel too high	Recommendations
≤ 3 mm	<p>Required actions on site: No actions required, however leveling of the concrete surface is recommended to provide full support of the fixture (Figure 15, 16) and to avoid rocking of the fixture and/or avoid inducing additional prying forces.</p>
>3 mm up to 2/3 h _{ch}	<p>Required actions on site: Grout a pad around the anchor channel to entirely fill the gap between concrete surface and channel lips to embed the anchor channel flush with the mortar surface (Figure 15). The minimum dimensions of the grout pad shall be chosen according to Figure 16.</p> <p>Following requirements need to be fulfilled:</p> <ul style="list-style-type: none"> The concrete surface needs to be roughened in order to guarantee interlock between grout pad and concrete structure. Note: While roughening the concrete surface, the anchor channel shall be protected to avoid damaging the fastening system. The strength of the mortar shall be the minimum of 30 MPa and the in-situ concrete compressive strength. The use of non-shrink grout is recommended. <p>Design verification: Revise design calculation with reduced embedment depth h_{ef}*.</p>
> 2/3 h _{ch}	A general assessment is not possible. Contact your local Hilti representative.

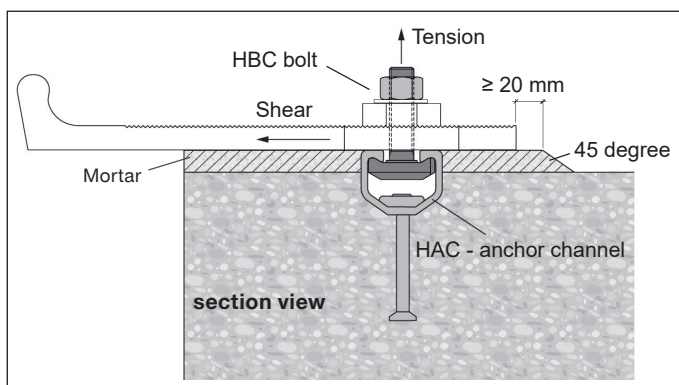


Figure 15: Placement of mortar under the fixture

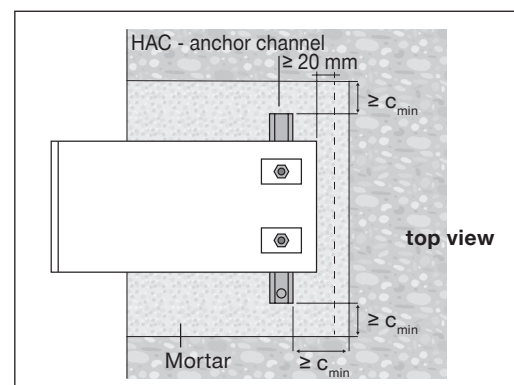


Figure 16: Minimum required dimensions of the grout pad

4.2.3. Edge and/or corner distances not according to design

Description of the problem

The anchor channel is properly embedded in the concrete member but the edge and/or corner distances are not according to the design specifications (Figure 17). Both edge and/or corner distance can be larger or smaller than the specified distance.

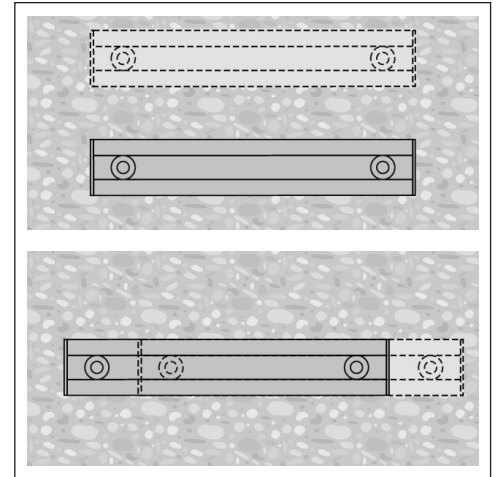


Figure 17: Edge and/or corner distance not according to design

Possible consequences

Edge and/or corner distance not according to design	During bolt installation	During loading			Other effects
		Tension	Perpendicular shear	Longitudinal shear	
Actual distance larger than specified distance	No consequences	No reduction of the anchor channel capacity			Fixture might need to be modified and could lead to higher forces on the anchor channel system.
Actual distance smaller than specified distance	If the distance is smaller than c_{min} given in the relevant ETA or ESR, a splitting crack can develop during installation	Reduction of concrete capacity due to reduced distance to edges of the concrete member			

Recommendations

Edge distance not according to design	Recommendations
Actual distance larger than specified distance	The fixture might need to be changed to connect the anchor channel (Figure 18). Alternatively, post-installed anchor can be installed at the planned location of the anchor channel if the fixture cannot be adjusted (see recommendations given in Section 5). This condition then need to be re-analyzed and verified by the engineer of record.
Actual distance smaller than specified distance	The design calculations must be revised with the actual edge and/or corner distance. The actual edge and/or corner distance must not be less than c_{min} given in the ETA/ESR (Figure 19). Alternatively, post-installed anchor can be installed at the planned location of the anchor channel and the anchor channel need to be properly filled (see recommendations given in Section 5).

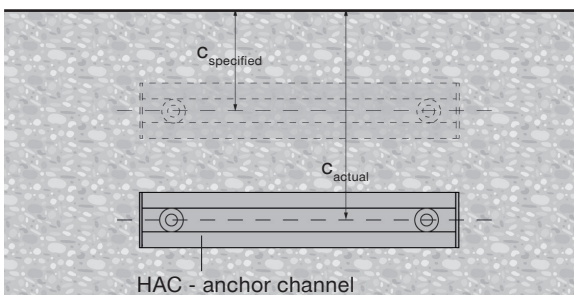


Figure 18: Actual edge distance more than design edge distance

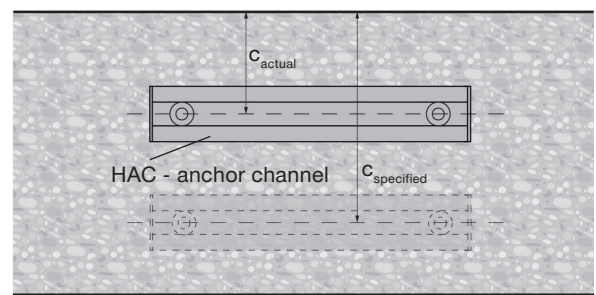


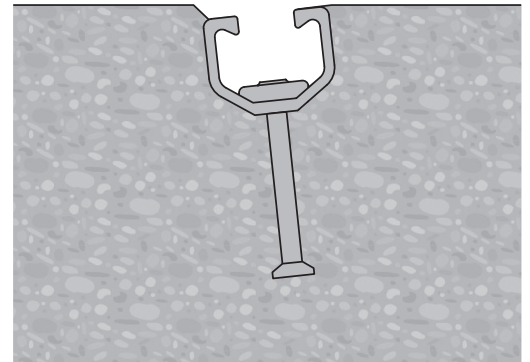
Figure 19: Actual edge distance less than design edge distance

4.2.4. Channel inclined (rotation around x-, y- and z-direction)

Description of the problem

If anchor channels are not properly fastened in the formwork, rotation of the anchor channel around the x-, y- or z-axis may result. This can also happen through bumps with the vibrator during the concrete pour or movement of the channel (e.g. workers walking on the reinforcement before filling in the concrete).

This type of installation error results either in channel lips that are not flush with the concrete surface along the entire length of the anchor channel (Figure 20a and b) and/or incorrect edge/corner distance (Figure 20c).



The following cases are considered:

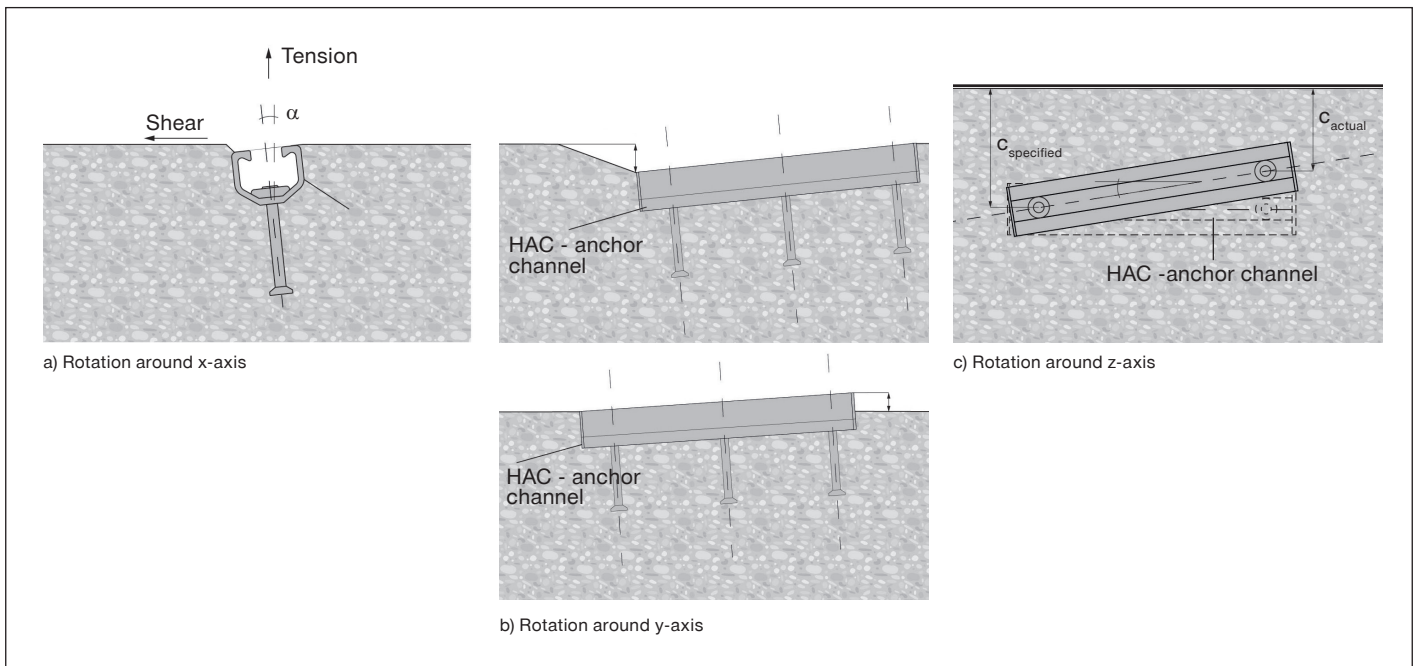


Figure 20: Anchor channel rotated around different axis a) - c)

Possible consequences

Channel inclined	During bolt installation	During loading		
		Tension	Perpendicular shear	Longitudinal shear
Rotation around x-axis	Damage of channel lips, anchors, connection between anchor and channel or pullout due to high pre-stressing forces	Channel bolt head is not in full contact with the channel lips. This can result in a reduction of the steel capacity due to eccentric loading of the channel lips.		
Rotation around y-axis		Same as above. Additionally, the concrete capacity can be negatively influenced (see section 4.2.1 (anchor channel installed too deep) and section 4.2.2 (anchor channel installed too high)).		
Rotation around z-axis	-	Reduction in concrete capacity due to reduced edge and/or corner distance.	Reduced concrete edge breakout strength and pryout capacity due to reduced edge and/or corner distance. An additional shear force in long. direction is generated.	

Recommendations

Channel inclined (α)	Recommendations	
Rotation around x-axis	$\leq 3^\circ$	No actions needed
	$> 3^\circ$ $\leq 6^\circ$	Required actions on site: The channel bolt needs to be installed inclined (channel bolt head in full contact with the channel lips). This can be achieved by using a wedge washer to avoid bending the channel lips during installation and a spherical washer underneath the nut (see Figure 21).
	$> 6^\circ$	A general assessment is not possible. Contact your local Hilti representative for further guidance
Rotation around y-axis	$\leq 3^\circ$	If the anchor channel is installed too deep into the concrete refer to section 4.2.1. If the anchor channel is installed too high into the concrete refer to section 4.2.2.
	$> 3^\circ$	A general assessment is not possible. Contact your local Hilti representative for further guidance.
Rotation around z-axis	$\leq 3^\circ$	Design verification: The design calculations must be revised with the smaller edge and/or corner distance. The smaller edge and/or corner distance must not be less than c_{min} given in the ETA/ESR (Figure 20).
	$> 3^\circ$	Design verification: The design calculations must be revised with the smaller edge and/or corner distance. The smaller edge and/or corner distance must not be less than c_{min} given in the ETA/ESR (Figure 20). Additionally, due to the rotation of the anchor channel an acting load in the longitudinal direction is generated. The design verifications need to be revised considering the additional shear load in longitudinal direction. In case of an HAC standard channel in combination with a channel bolt HBC-C, a channel bolt HBC-C-N needs to be used. In case of an HAC-C standard channel in combination with a channel bolt HBC, a channel bolt HBC-N needs to be used.
Rotation around more than one axis	If an anchor channel is rotated around more than one axis a general assessment is not possible. Please contact your local Hilti representative.	

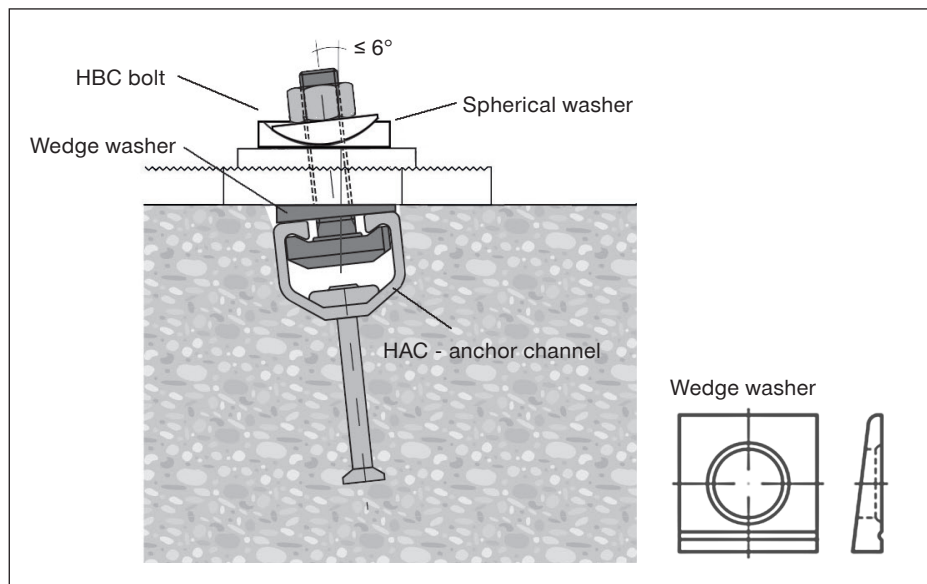


Figure 21: Recommendation for anchor channel rotated around x-axis. Use a wedge washer and a spherical washer to avoid bending of channel during installation.

4.3. Channel bolt not installed correctly

4.3.1. Wrong installation torque applied

Description of the problem:

The installation torque applied to the channel bolts is not in accordance with the instructions for use (IFU). Either the installation torque is too high or too low.



Wrong installation torque

Possible consequences: HBC-B

Channel bolt not installed correctly	During bolt installation	During loading		
		Tension	Perpendicular shear	Longitudinal shear
T_{inst} less than specified acc. to Section 3.1.2	-	-	Possible reduction in channel lip capacity, less stiffness of the fastening	Reduced capacity of the connection between channel bolt and channel lips
T_{inst} more than specified acc. to Section 3.1.2	<p>General condition (installation type A): Damage of channel lips, anchors, connection between anchor and channel or pullout and damage of the channel bolt</p> <p>Steel-steel contact (installation type B): Damage of the channel bolt</p>	<p>General condition (installation type A): Possible reduction in steel capacity of the anchor channel due to damage of the anchor channel system during installation</p> <p>Steel-steel contact (installation type B): Possible reduction in steel capacity of channel bolt due to damage of the channel bolt during installation</p>		

Recommendations: HBC-B

Channel bolt not installed correctly	Recommendations
T_{inst} less than specified acc. to Section 3.1.2	Torque channel bolts up to the required value according to the instructions for use (IFU).
T_{inst} more than specified acc. to Section 3.1.2	Possible reduction of steel capacity depends on T_{inst} value applied to the channel bolt. No general assessment is possible. Contact your local Hilti representative for further guidance.

Possible consequences: HBC-C and HBC

Channel bolt not installed correctly	During bolt installation	During loading		
		Tension	Perpendicular shear	Longitudinal shear
T_{inst} less than specified acc. to Section 3.1.3 or 3.1.x	-	-	Possible reduction in channel lip capacity, less stiffness of the fastening	
T_{inst} more than specified for general condition (installation type A) and less than steel-steel contact (installation type B) acc. to Section 3.1.3 or 3.1.x	<p>General condition (installation type A): Damage of channel lips, anchors, connection between anchor and channel or pullout</p>	<p>General condition (installation type A): Possible reduction in steel capacity of the anchor channel due to damage of the anchor channel system during installation</p> <p>Steel-steel contact (installation type B): No consequences</p>		Not covered with HBC-C and HBC
T_{inst} more than specified for steel-steel contact (installation type B) acc. to Section 3.1.3 or 3.1.x	<p>General condition (installation type A): Damage of channel lips, anchors, connection between anchor and channel or pullout and damage of the channel bolt</p> <p>Steel-steel contact (installation type B): Damage of the channel bolt</p>	<p>General condition (installation type A): Possible reduction in steel capacity of the anchor channel due to damage of the anchor channel system during installation</p> <p>Steel-steel contact (installation type B): Possible reduction in steel capacity of channel bolt due to damage of the channel bolt during installation</p>		

Recommendations: HBC-C and HBC

Channel bolt not installed correctly	Recommendations
T_{inst} less than specified acc. to Section 3.1.4 or 3.1.7	Torque channel bolts up to the required value according to the instructions for use (IFU).
T_{inst} more than specified for general condition (installation type A) and less than steel-steel contact (installation type B) acc. to Section 3.1.4 or 3.1.7	<p>General condition (installation type A): Possible reduction of steel capacity depends on T_{inst} value applied to the channel bolt. No general assessment is possible. Contact your local Hilti representative for further guidance.</p> <p>Steel-steel contact (installation type B): No action needed</p>
T_{inst} more than specified for steel-steel contact (installation type B) acc. to Section 3.1.4 or 3.1.7	Possible reduction of steel capacity depends on T_{inst} value applied to the channel bolt. No general assessment is possible. Contact your local Hilti representative for further guidance.

Possible consequences: HBC-T

Channel bolt not installed correctly	During bolt installation	During loading		
		Tension	Perpendicular shear	Longitudinal shear
T_{inst} less than specified acc. to Section 3.1.5	-	-	Possible reduction in channel lip capacity, less stiffness of the fastening	Reduced capacity of the connection between channel bolt and channel lips
T_{inst} more than specified for general condition (installation type A) and less than steel-steel contact (installation type B) acc. to Section 3.1.5	<p>General condition (installation type A): Damage of channel lips, anchors, connection between anchor and channel or pullout</p> <p>Steel-steel contact (installation type B): No consequences</p>		<p>General condition (installation type A): Possible reduction in steel capacity of the anchor channel due to damage of the anchor channel system during installation in case of slotted holes in the fixture</p> <p>Steel-steel contact (installation type B): No consequences</p>	
T_{inst} more than specified for steel-steel contact (installation type B) acc. to Section 3.1.5	<p>General condition (installation type A): Damage of channel lips, anchors, connection between anchor and channel or pullout and damage of the channel bolt</p> <p>Steel-steel contact (installation type B): Damage of the channel bolt</p>		<p>General condition (installation type A): Possible reduction in steel capacity of the anchor channel due to damage of the anchor channel system during installation in case of slotted holes in the fixture</p> <p>Steel-steel contact (installation type B): Possible reduction in steel capacity of channel bolt due to damage of the channel bolt during installation</p>	

Recommendations: HBC-T

Channel bolt not installed correctly	Recommendations
T_{inst} less than specified acc. to Section 3.1.5	Torque channel bolts up to the required value according to the instructions for use (IFU).
T_{inst} more than specified for general condition (installation type A) and less than steel-steel contact (installation type B) acc. to Section 3.1.5	<p>General condition (installation type A): Possible reduction of steel capacity depends on T_{inst} value applied to the channel bolt. No general assessment is possible. Contact your local Hilti representative for further guidance.</p> <p>Steel-steel contact (installation type B): No action needed</p>
T_{inst} more than specified for steel-steel contact (installation type B) acc. to Section 3.1.5	Possible reduction of steel capacity depends on T_{inst} value applied to the channel bolt. No general assessment is possible. Contact your local Hilti representative for further guidance.

Possible consequences: HBC-C-N

Channel bolt not installed correctly	During bolt installation	During loading		
		Tension	Perpendicular shear	Longitudinal shear
T_{inst} less than specified acc. to Section 3.1.6	-	-	Possible reduction in channel lip capacity, less stiffness of the fastening	Reduced capacity of the connection between channel bolt and channel lips
T_{inst} more than specified for steel-steel contact (installation type B) acc. to Section 3.1.6	<p>General condition (installation type A): Damage of channel lips, anchors, connection between anchor and channel or pullout and damage of the channel bolt</p> <p>Steel-steel contact (installation type B): Damage of the channel bolt</p>	<p>General condition (installation type A): Possible reduction in steel capacity of the anchor channel due to damage of the anchor channel system during installation.</p> <p>Steel-steel contact (installation type B): Possible reduction in steel capacity of channel bolt due to damage of the channel bolt during installation</p>		

Recommendations: HBC-C-N

Channel bolt not installed correctly	Recommendations
T_{inst} less than specified acc. to Section 3.1.6	Torque channel bolts up to the required value according to the instructions for use (IFU).
T_{inst} more than specified for steel-steel contact (installation type B) acc. to Section 3.1.6	Possible reduction of steel capacity depends on T_{inst} value applied to the channel bolt. No general assessment is possible. Contact your local Hilti representative for further guidance.

4.3.2. Installation of channel bolts more than once

Description of the problem

In some applications, Hilti channel bolts may be installed multiple times. This can happen during maintenance operations or in case the fixture needs to be replaced or moved.

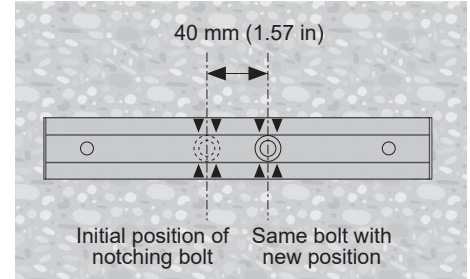


Figure 22: Multiple use of notching channel bolts (HBC-C-N)

Possible consequences

Product type	During bolt installation	During loading		
		Tension	Perpendicular shear	Longitudinal shear
HBC-C, HBC, HBC-T and HBC-B	-	-	-	-
HBC-C-N and HBC-N	The working principle of a notching channel bolt is that it creates indentations in the channel lips to transfer a shear load in the direction of the channel profile. The effect of this intended damage on other failure modes (e.g. bending failure in tension) is taken into account in the qualification of this product. Multiple use of notching channel bolts leads to multiple indentations in the channel lips during installation of the channel bolt.	In case the channel bolt is re-installed max. 5 times at new locations close to each other, no reduction in tension, bending and shear is observed.		In case the channel bolt is re-installed in a new position close to the original one in a distance smaller than 40mm (1.57 in), the longitudinal shear capacity of the connection between the channel bolt and channel lip $V_{Rk,s,l,x}$ is reduced.

Recommendations

Product type	Recommendations
HBC-C, HBC, HBC-T and HBC-B	-
HBC-C-N and HBC-N	<p>Required actions on site: In case of multiple use of notching channel bolts, a new channel bolt must be used in order to guarantee the full pre-tension in the system.</p> <p>Design verification: In case of longitudinal shear, the capacity of the connection between channel bolt and channel lips in longitudinal direction should be reduced by 30% in case the channel bolt is re-installed in a new position close the original one in a distance smaller than 40mm (1.57 in).</p>

5. USE OF POST-INSTALLED ANCHORS

Description of problem

A field fix according to Section 4 is not possible. Anchor channel cannot be used anymore due to wrong position or damage of the anchor, so the fastening needs to be made by other means (see Figure 23). This situation can happen due to several reasons:

- Wrong planning of location or wrong location of anchor channel realized on site (e.g. Section 4.2.3)
- Movement of the channel during casting concrete (e.g. Section 4.2.4)
- Damage of the anchor channel during installation in the formwork and/or casting the concrete (e.g. cutting or bending of anchors)
- Damage of the anchor channel system during installation of the channel bolt (e.g. Section 3.1.5 fixture with slotted holes used in combination with HBC-C-N or HBC-N)



Figure 23: Use of post-installed anchors due to wrong positioning of the anchor channel

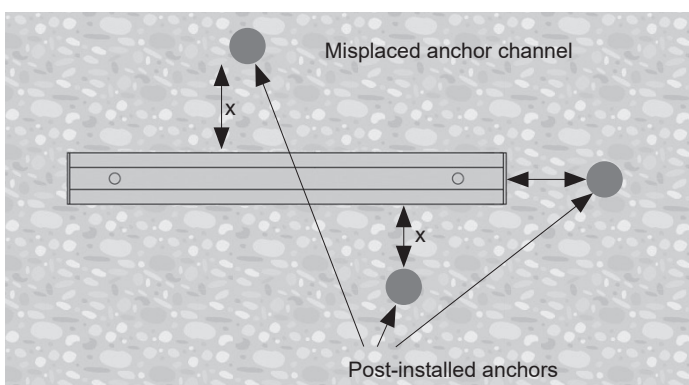
Recommendations

In case the anchor channel cannot be used anymore, Hilti recommends to use post-installed anchors and design the new fastening solution according to the current state of the art (e.g. EN 1992-4 or ACI 318). For the design of post-installed anchors Hilti is offering appropriate design software (Hilti Profis). Currently, there is no guidance on how to take into account the influence of the anchor channel on the capacity of the post-installed anchors. Therefore, Hilti investigated different configurations to provide guidance on what needs to be considered on site and how the design of post-installed anchors needs to be modified.

Depending on the location of the anchor channel, post-installed anchors need to be installed behind the anchor channel, in front of the anchor channel relative to the edge of the concrete member or next to the anchor channel (Figure 24).

The following recommendations are valid for post-installed anchors at a minimum distance x from the anchor channel. The distance x should be at least one time the diameter of the post-installed anchor.

The post-installed anchors must have a minimum effective embedment depth equal to the one of HAC.



Compared to cast-in and post-installed anchors, in the design of anchor channels the negative influence of the channel profile on the concrete cone capacity is taken into account. In case the post-installed anchors are installed in a distance less than the critical distance $c_{cr,N} = 1.5h_{ef}$, the reduction factor $\psi_{ch,N}$ should be conservatively multiplied to the concrete cone capacity of post-installed anchors.

$$\psi_{ch,N} = (h_{ef,channel}/180)^{0.15} < 1.0$$

The anchor channel must be filled with non-shrink grout having minimum compressive strength 30 N/mm² (e.g. Hilti mortar HY 150 MAX, HY 200 or similar).

Hilti recommends not to use a combination of anchor channels and post-installed anchors to transfer acting loads into the structure. In case of concrete failure, the interaction of anchor channels and post-installed anchors lead to a very complex load-bearing mechanism in terms of load distribution and different stiffness of the anchoring systems. Currently, not even the interaction of anchor groups or groups of anchor channels is covered by published design standards (e.g. EN 1992-4, ACI 318, AC232).

Figure 24: Possible position of post-installed anchors and distance x relative to the anchor channel which cannot be used anymore to transfer the acting loads

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