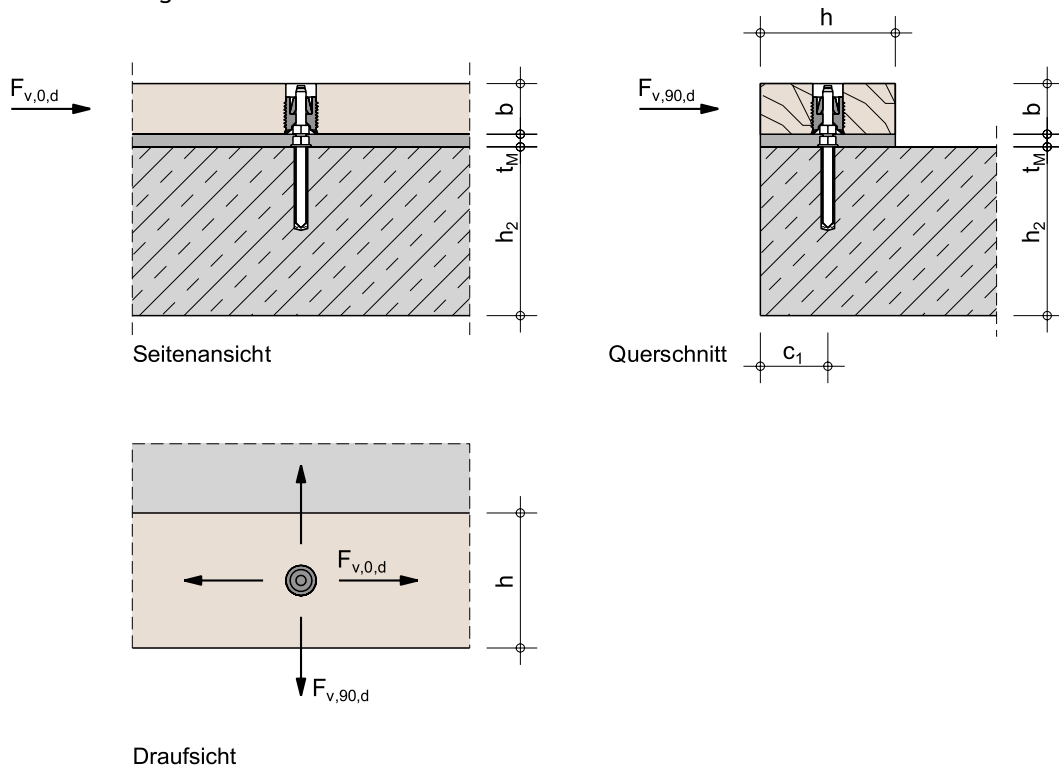


Nachweis Hilti HCW

nach ETA-21/0357 vom 19.04.2021

Anschluss & Geometrie

Holz-Beton Verbindung



Bauteile:	Nadelholz, C24	$b/h = 60/200 \text{ mm}$	$\rho_k = 350 \text{ kg/m}^3$
	Beton: C20/25	gerissener Beton	
	$h_2 = 200 \text{ mm}$	$c_1 = 100 \text{ mm}$	
Verbinder:	Mörtelbett:	$t_M = 10 \text{ mm}$	
	HCW 37x45 M12	Hilti AG	ETA-21/0357
	mit Injektionssystem HIT-HY 200 A + HAS-U M12x180 8.8		ETA-11/0493
		$h_{ef,1} = 70 \text{ mm}$	$T_{inst} = 40 \text{ Nm}$
	Bohrloch: hammergebohrt	Installationsbedingung:	trocken

Beanspruchung

Nutzungsklasse	NKL1 - beheizte Innenräume		
$F_{v,0,d} =$	6.80 kN	KLED: kurz	$k_{mod} = 0.90$
$F_{v,90,d} =$	1.00 kN	KLED: kurz	$k_{mod} = 0.90$

Nachweis:	$0.98 \leq 1.00$	Nachweis erfüllt
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Bemessung

Verbindungsmittelnachweis in Holzbauteil

Beanspruchbarkeit in Faserrichtung

$$F_{v,0,Rk} = 28.80 \text{ kN}$$

(ETA-21/0357, Tab. C.1)

$$F_{v,0,Rd} = k_{mod} * \frac{F_{v,0,Rk}}{\gamma_M} = 0.90 * \frac{28.80}{1.30} = 19.94 \text{ kN}$$

HCW in Faserrichtung:	$\frac{F_{v,0,d}}{F_{v,0,Rd}} = \frac{6.80}{19.94} =$	$0.34 \leq 1.00$
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Beanspruchbarkeit senkrecht zur Faserrichtung

$$F_{v,90,Rk} = 12.50 \text{ kN}$$

(ETA-21/0357, Tab. C.1)

$$F_{v,90,Rd} = k_{mod} * \frac{F_{v,90,Rk}}{\gamma_M} = 0.90 * \frac{12.50}{1.30} = 8.65 \text{ kN}$$

HCW senkrecht zur Faserrichtung:	$\frac{F_{v,90,d}}{F_{v,90,Rd}} = \frac{1.00}{8.65} =$	$0.12 \leq 1.00$
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Kombinierte Beanspruchung

HCW (Kombinierte Beanspruchung):	$\left(\frac{F_{v,0,Ed}}{F_{v,0,Rd}}\right)^2 + \left(\frac{F_{v,90,Ed}}{F_{v,90,Rd}}\right)^2 =$	$0.13 \leq 1.00$
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Verbindungsmittelnachweis im Betonbauteil

Bemessung gemäß DIN EN 1992-4:2019-04

Stahlversagen ohne Hebelarm

Beanspruchbarkeit:

$$V_{Rk,s}^0 = k_6 * A_s * f_{uk} = 0.5 * 84.30 * 800 * 10^{-3} = 33.72 \text{ kN}$$

(ETA-11/0493, Tab. C2)

$$V_{Rk,s} = k_7 * V_{Rk,s}^0 = 1.00 * 33.72 = 33.72 \text{ kN}$$

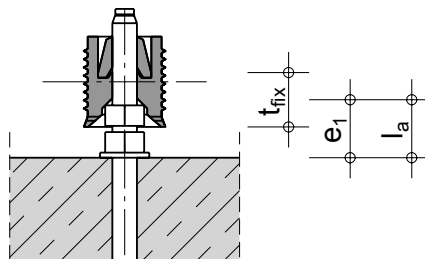
(Gl. 7.35)

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = \frac{33.72}{1.25} = 26.98 \text{ kN}$$

Beanspruchung:

$$V_{Ed} = \sqrt{F_{v,0,d}^2 + F_{v,90,d}^2} = \sqrt{6.80^2 + 1.00^2} = 6.87 \text{ kN}$$

Nachweis Stahlversagen ohne Hebelarm:	$\frac{V_{Ed}}{V_{Rd,s}} = \frac{6.87}{26.98} =$	$0.25 \leq 1.00$
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Stahlversagen mit Hebelarm

Beanspruchbarkeit:

$$e_1 = \frac{t_{fix}}{2} + t_M = \frac{27.5}{2} + 10 = 23.8 \text{ mm}$$

$$l_a = e_1 = 23.8 \text{ mm} \quad (\text{Gl. 6.2})$$

$$\alpha_M = 2.0$$

$$M_{Rk,s}^0 = 1.2 * W_{el} * f_{uk} = 1.2 * 109 * 800 * 10^{-3} = 104.64 \text{ Nm} \quad (\text{ETA-11/0493, Tab. C2})$$

$$M_{Rk,s} = M_{Rk,s}^0 * \left(1 - \frac{N_{Ed}}{N_{Rd,s}}\right) = 104.64 * (1 - 0) = 104.64 \text{ Nm} \quad (\text{Gl. 7.38})$$

$$V_{Rk,s,M} = \frac{\alpha_M * M_{Rk,s}}{l_a} = \frac{2.0 * 104.64}{23.8} = 8.79 \text{ kN} \quad (\text{Gl. 7.37})$$

$$V_{Rd,s,M} = \frac{V_{Rk,s,M}}{\gamma_{Ms}} = \frac{8.79}{1.25} = 7.03 \text{ kN}$$

Beanspruchung:

$$V_{Ed} = \sqrt{F_{v,0,d}^2 + F_{v,90,d}^2} = \sqrt{6.80^2 + 1.00^2} = 6.87 \text{ kN}$$

Nachweis Stahlversagen mit Hebelarm:	$\frac{V_{Ed}}{V_{Rd,s,M}} = \frac{6.87}{7.03} =$	$0.98 \leq 1.00$
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Betonausbruch

Beanspruchbarkeit:

$$k_1 = k_{cr,N} = 7.7 \quad (\text{DIN EN 1992-4:2019-04, 7.2.1.4})$$

$$h_{ef} = 70 \text{ mm} \quad (\text{ETA-11/0493})$$

$$N_{Rk,c}^0 = k_1 * \sqrt{f_{ck}} * h_{ef}^{1.5} = 7.7 * \sqrt{20} * 70^{1.5} * 10^{-3} = 20.17 \text{ kN} \quad (\text{Gl. 7.2})$$

$$s_{cr,N} = 3 * h_{ef} = 3 * 70 = 210.0 \text{ mm}$$

$$A_{c,N}^0 = s_{cr,N} * s_{cr,N} = 210.0 * 210.0 * 10^{-2} = 441.00 \text{ cm}^2 \quad (\text{Gl. 7.3})$$

$$A_{c,N} = (c_1 + 0.5 * s_{cr,N}) * (2 * 0.5 * s_{cr,N}) = (100 + 0.5 * 210.0) * (2 * 0.5 * 210.0) * 10^{-2} = 430.50 \text{ cm}^2$$

$$\psi_{s,N} = 0.7 + 0.3 * \frac{c}{c_{cr,N}} = 0.7 + 0.3 * \frac{100}{105} = 0.99 \leq 1.0 \quad (\text{Gl. 7.4})$$

$$\psi_{re,N} = 1.0 \quad (\text{Gl. 7.5})$$

$$\psi_{ec,N} = 1.0 \quad (\text{Gl. 7.6})$$

$$\psi_{M,N} = 1.0 \quad (\text{Gl. 7.7})$$

$$N_{Rk,c} = N_{Rk,c}^0 * \frac{A_{c,N}}{A_{c,N}^0} * \psi_{s,N} * \psi_{re,N} * \psi_{ec,N} * \psi_{M,N} = 20.17 * \frac{430.50}{441.00} * 0.99 * 1.0 * 1.0 * 1.0 = 19.41 \text{ kN}$$

$$k_8 = 2.00 \quad (\text{ETA-11/0493, Tab. C2})$$

$$V_{Rk,cp} = k_8 * N_{Rk,c} = 2.00 * 19.41 = 38.82 \text{ kN} \quad (\text{Gl. 7.39a})$$

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc}} = \frac{38.82}{1.50} = 25.88 \text{ kN}$$

Beanspruchung:

$$V_{Ed} = \sqrt{F_{v,0,d}^2 + F_{v,90,d}^2} = \sqrt{6.80^2 + 1.00^2} = 6.87 \text{ kN}$$

Nachweis Betonausbruch:	$\frac{V_{Ed}}{V_{Rd,cp}} = \frac{6.87}{25.88} =$	$0.27 \leq 1.00$
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Betonkantenbruch

Beanspruchbarkeit:

$$k_9 = 1.7 \quad (\text{DIN EN 1992-4:2019-04})$$

$$d_{nom} = 12 \text{ mm} \quad (\text{ETA-11/0493})$$

$$l_f = 70 \text{ mm} \quad (\text{ETA-11/0493})$$

$$\alpha = 0.1 * \left(\frac{l_f}{c}\right)^{0.5} = 0.1 * \left(\frac{70}{100}\right)^{0.5} = 0.084 \quad (\text{Gl. 7.42})$$

$$\beta = 0.1 * \left(\frac{d_{nom}}{c}\right)^{0.2} = 0.1 * \left(\frac{12}{100}\right)^{0.2} = 0.065 \quad (\text{Gl. 7.43})$$

$$V_{Rk,c}^0 = k_9 * d_{nom}^\alpha * l_f^\beta * \sqrt{f_{ck}} * c^{1.5} = 1.7 * 12^{0.084} * 70^{0.065} * \sqrt{20} * 100^{1.5} * 10^{-3} = 12.35 \text{ kN} \quad (\text{Gl. 7.41})$$

Abminderung des Bemessungswertes des Widerstandes gemäß [1]:

$$a_3 = \frac{d_{nom}}{2} = \frac{12}{2} = 6 \text{ mm}$$

$$V_{Rk,c,h}^0 = V_{Rk,c}^0 * \frac{(h_{ef} - a_3)}{(e_1 + h_{ef})} = 12.35 * \frac{(70 - 6)}{(23.8 + 70)} = 12.35 * 0.68 = 8.43 \text{ kN} \quad (\text{Gl. 4.8 in [1]})$$

$$A_{c,V}^0 = 4.5 * c^2 = 4.5 * 100^2 * 10^{-2} = 450.00 \text{ cm}^2 \quad (\text{Gl. 7.44})$$

$$A_{c,V} = (2 * 1.5 * c) * 1.5 * c = (2 * 1.5 * 100) * 1.5 * 100 * 10^{-2} = 450.00 \text{ cm}^2$$

$$\psi_{s,V} = 1.000 \quad (\text{Gl. 7.45})$$

$$\psi_{h,V} = \left(\frac{1.5 * c}{h_2}\right)^{0.5} = \left(\frac{1.5 * 100}{200}\right)^{0.5} \geq 1.0 \quad (\text{Gl. 7.46})$$

$$\psi_{ec,V} = 1.000 \quad (\text{Gl. 7.47})$$

$$\alpha_V = \arccos \left(\frac{F_{v,90,d}}{\sqrt{F_{v,0,d}^2 + F_{v,90,d}^2}} \right) = 81.63$$

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + (0.5 * \sin \alpha_V)^2}} = 1.939 \geq 1.0 \quad (\text{Gl. 7.48})$$

$$\psi_{re,V} = 1.000$$

$$V_{Rk,c} = V_{Rk,c,h}^0 * \frac{A_{c,V}}{A_{c,V}^0} * \psi_{s,V} * \psi_{h,V} * \psi_{ec,V} * \psi_{\alpha,V} * \psi_{re,V} = 8.43 * \frac{450.00}{450.00} * 1.000 * 1.000 * 1.000 * 1.939 * 1.000 = 16.35 \text{ kN}$$

$$V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{Mc}} = \frac{16.35}{1.50} = 10.90 \text{ kN}$$

Nachweis Betonkantenbruch:	$\frac{V_{Ed}}{V_{Rd,c}} = \frac{6.87}{10.90} =$	$0.63 \leq 1.00$
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Zusammenstellung der Ergebnisse

Nachweis HCW in Faserrichtung:	$\frac{F_{v,0,d}}{F_{v,0,Rd}} = \frac{6.80}{19.94} =$	$0.34 \leq 1.00$
Nachweis HCW senkrecht zur Faserrichtung:	$\frac{F_{v,90,d}}{F_{v,90,Rd}} = \frac{1.00}{8.65} =$	$0.12 \leq 1.00$
HCW (Kombinierte Beanspruchung):	$\left(\frac{F_{v,0,Ed}}{F_{v,0,Rd}}\right)^2 + \left(\frac{F_{v,90,Ed}}{F_{v,90,Rd}}\right)^2 =$	$0.13 \leq 1.00$
Nachweis Stahlversagen ohne Hebelarm:	$\frac{V_{Ed}}{V_{Ed,s}} = \frac{6.87}{26.98} =$	$0.25 \leq 1.00$
Nachweis Stahlversagen mit Hebelarm:	$\frac{V_{Rd,s,M}}{V_{Ed}} = \frac{7.03}{6.87} =$	$0.98 \leq 1.00$
Nachweis Betonausbruch:	$\frac{V_{Rd,cp}}{V_{Ed}} = \frac{25.88}{6.87} =$	$0.27 \leq 1.00$
Nachweis Betonkantenbruch:	$\frac{V_{Rd,c}}{V_{Ed}} = \frac{6.87}{10.90} =$	$0.63 \leq 1.00$

Nachweis:	$0.98 \leq 1.00$	Nachweis erfüllt
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verwendete Normen

DIN EN 338:2016-07	Bauholz für tragende Zwecke
DIN EN 1992-4:2019-04	Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetontragwerken, Teil 4
DIN EN 1995-1-1:2010-12	Eurocode 5: Bemessung und Konstruktion von Holzbauteilen, Teil 1-1
DIN EN 1995-1-1/A2:2014-07	Änderung A2 zu EC5
DIN EN 1995-1-1/NA:2013-08	Nationaler Anhang (EC5)
ETA-11/0493 vom 10.12.2021	Injektionssystem Hilti HIT-HY 200-A Hilti Aktiengesellschaft, 9494 Schaan, Fürstentum Liechtenstein
ETA-21/0357 vom 19.04.2021	Fastening element Hilti HCW, HCW L Hilti Aktiengesellschaft, 9494 Schaan, Fürstentum Liechtenstein
[1]	Heft 615 - Deutscher Ausschuss für Stahlbeton, Berlin 2019 Erläuterung zu DIN EN 1992-4 Bemessung der Verankerung von Befestigungen in Beton