Punktgestützte Flachdecken aus Brettsperrholz, neue Möglichkeiten für den Holzbau

Dr. Roland Maderebner

universität innsbruck

Arbeitsbereich
für Holzbau

universität innsbruck

Arbeitsbereich Holzbau
Universität Innsbruck

Roland Maderebner | 14.05.2020

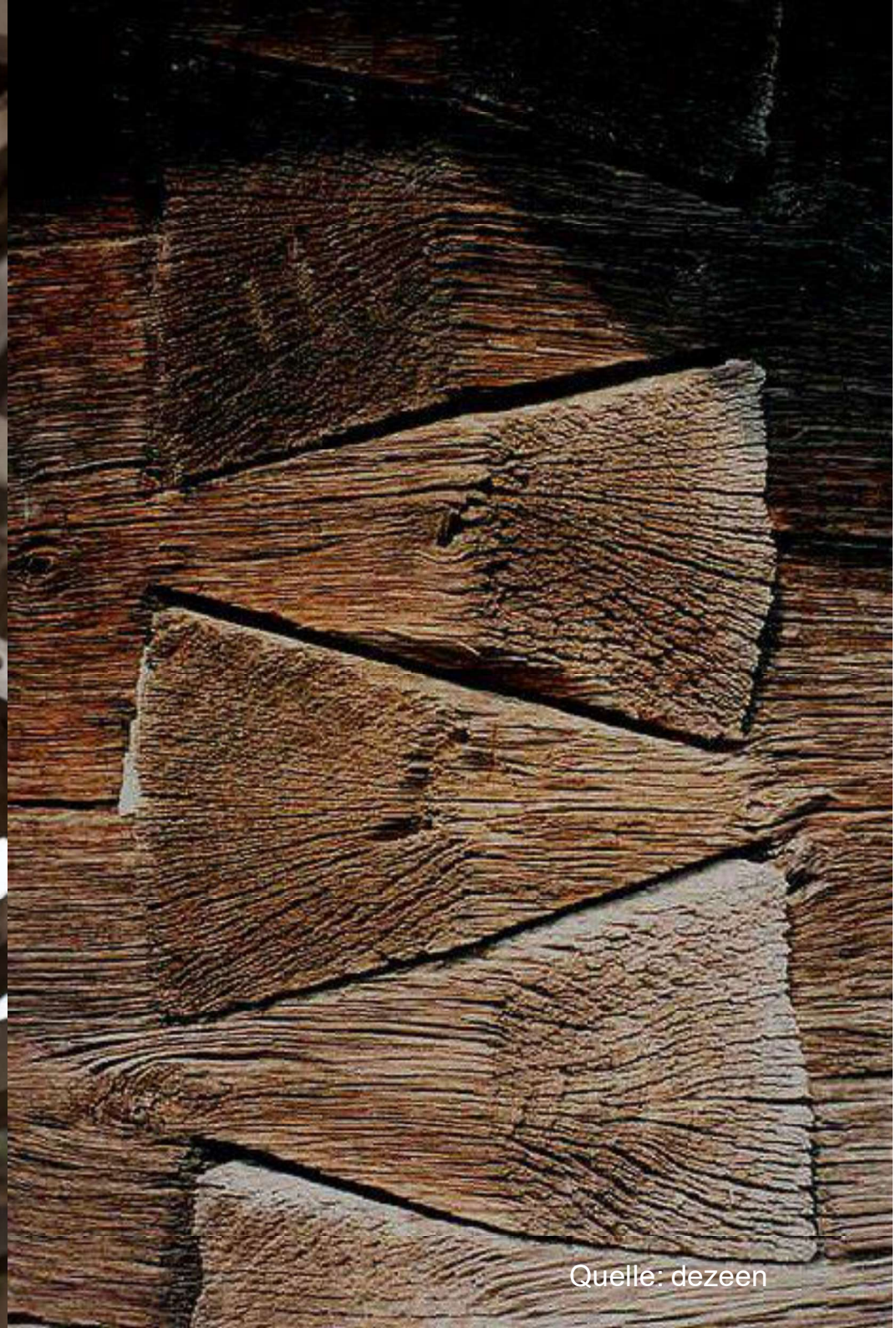
Quelle: dezeen

Quelle: dezeen

Quelle: dezeen

Quelle: dezeen

Quelle: dezeen



Quelle: dezeen

Quelle: Getzner GesmbH

TS3

TIMBER STRUCTURES 3.0

STÜTZE-PLATTE-FERTIG

(TS3, Stefan Zöllig)

universität
innsbruck

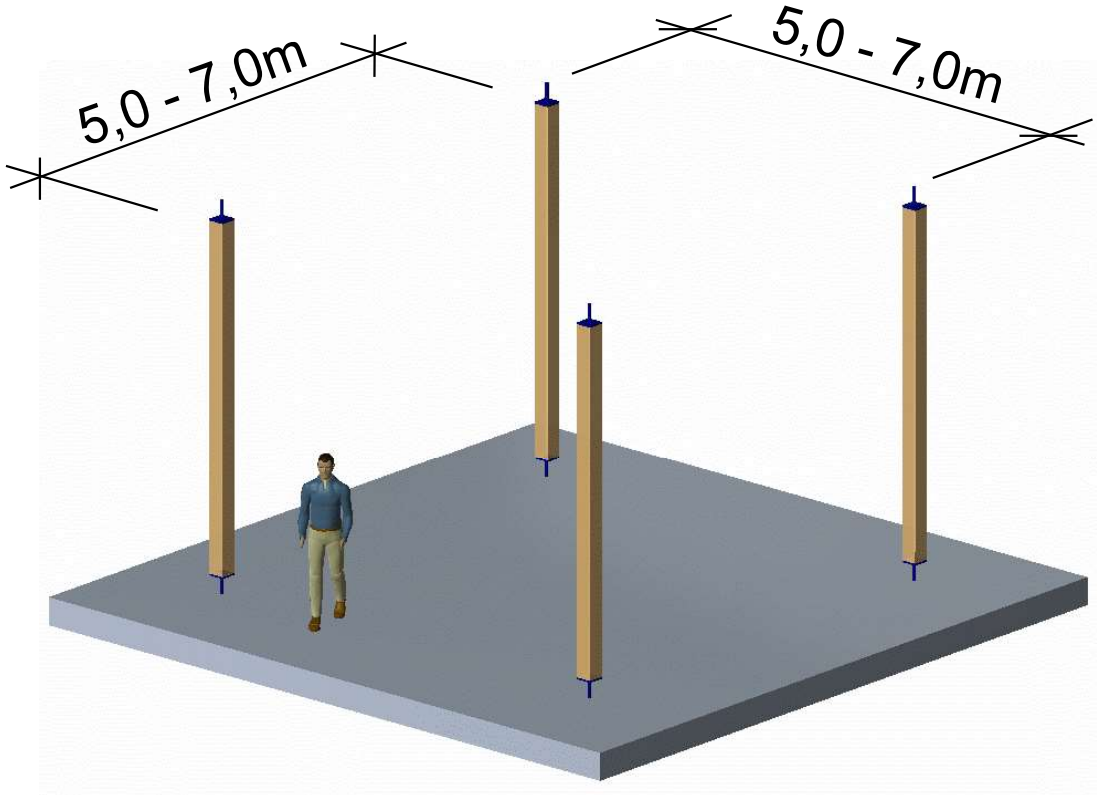
PUNKTGESTÜTZTE FLACHDECKEN AUS BRETTSPERRHOLZ

– NEUE MÖGLICHKEITEN FÜR DEN HOLZBAU –

… eine seltene Konstruktionsmethode …

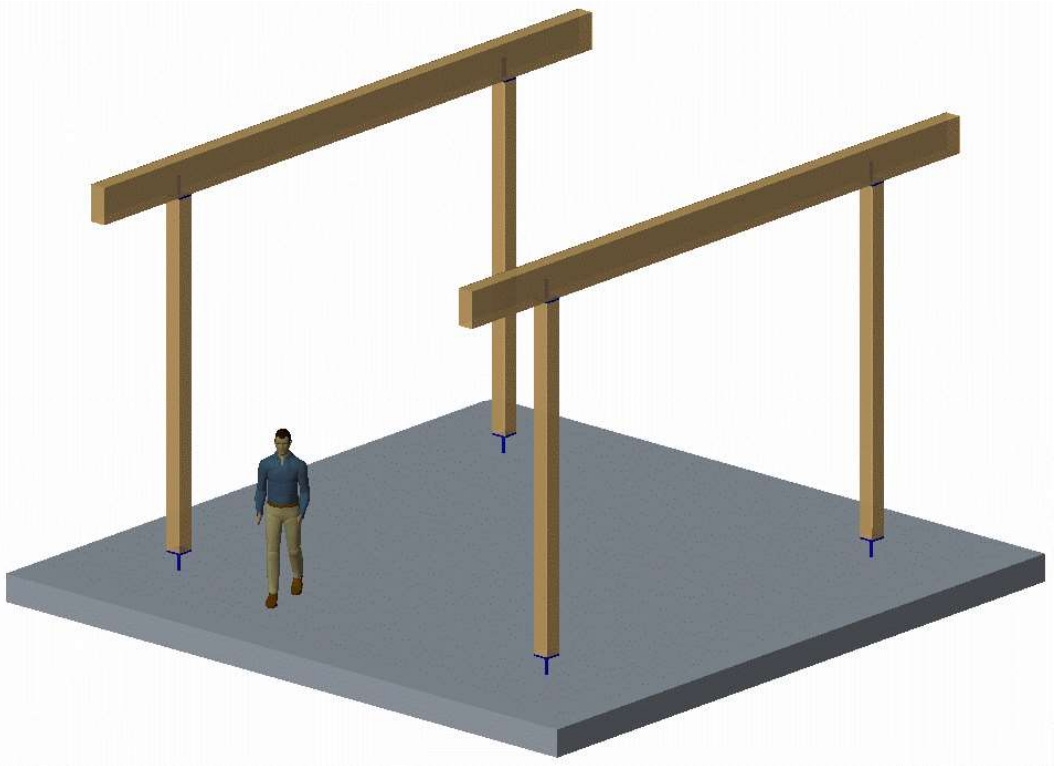
universität
innsbruck

STAND DER TECHNIK



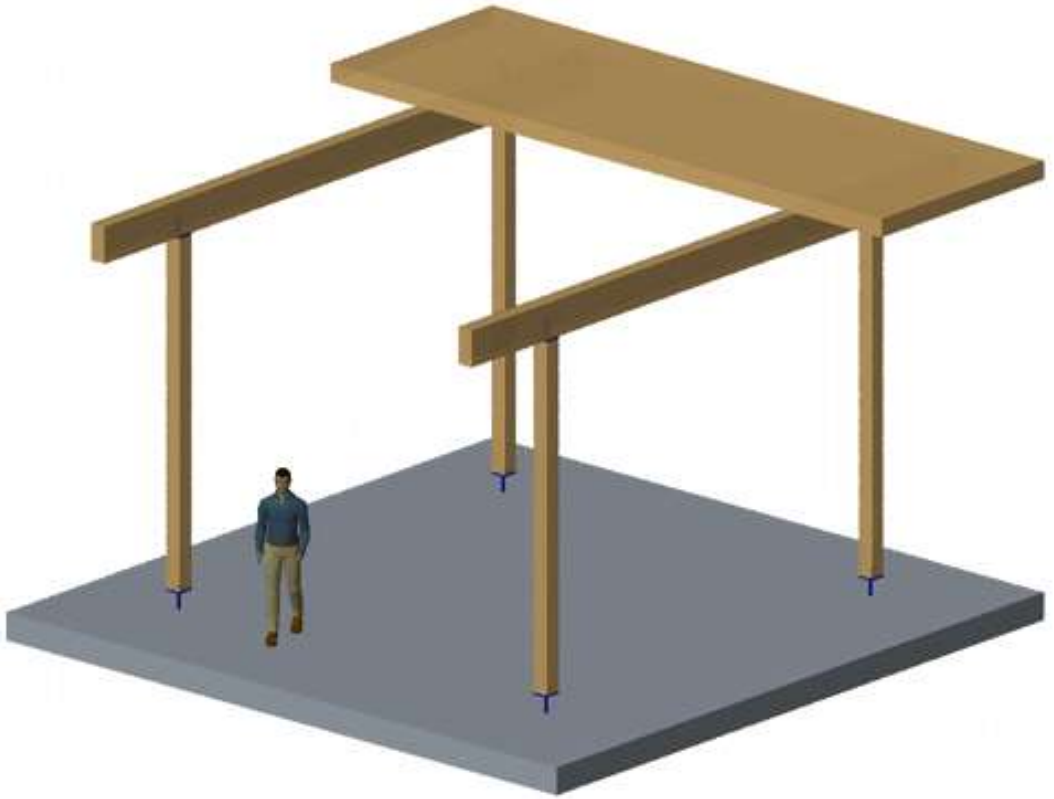
universität
innsbruck

STAND DER TECHNIK



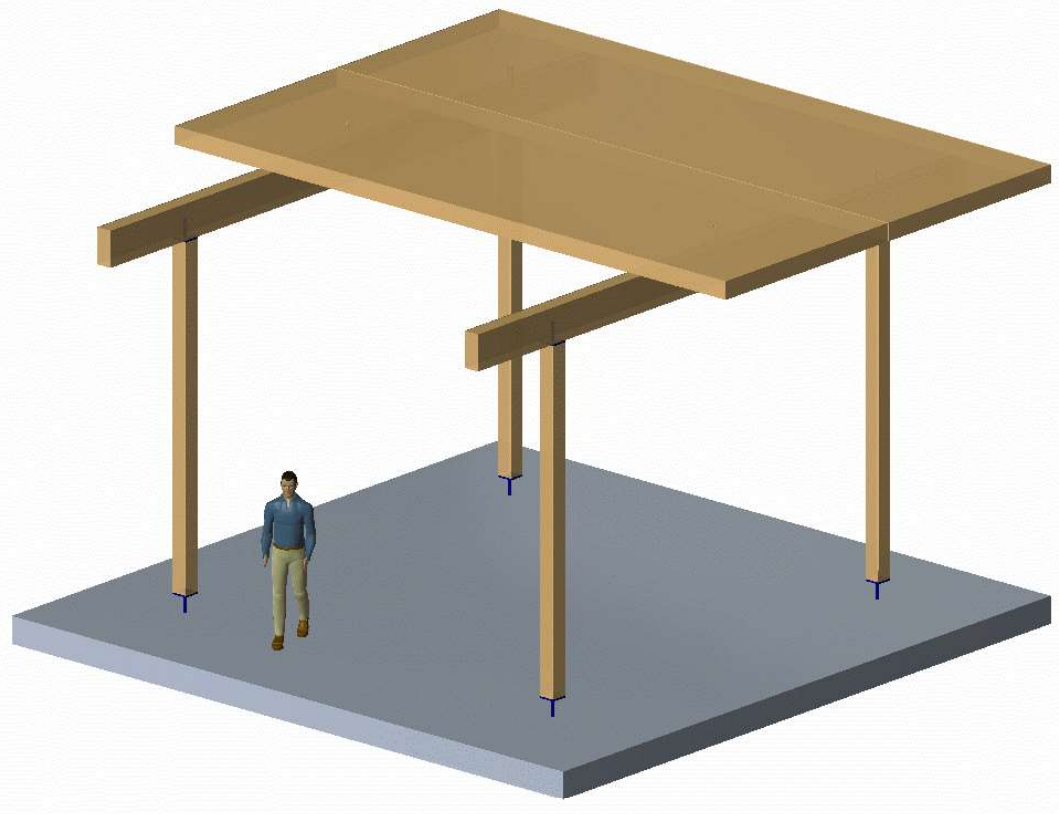
universität
innsbruck

STAND DER TECHNIK



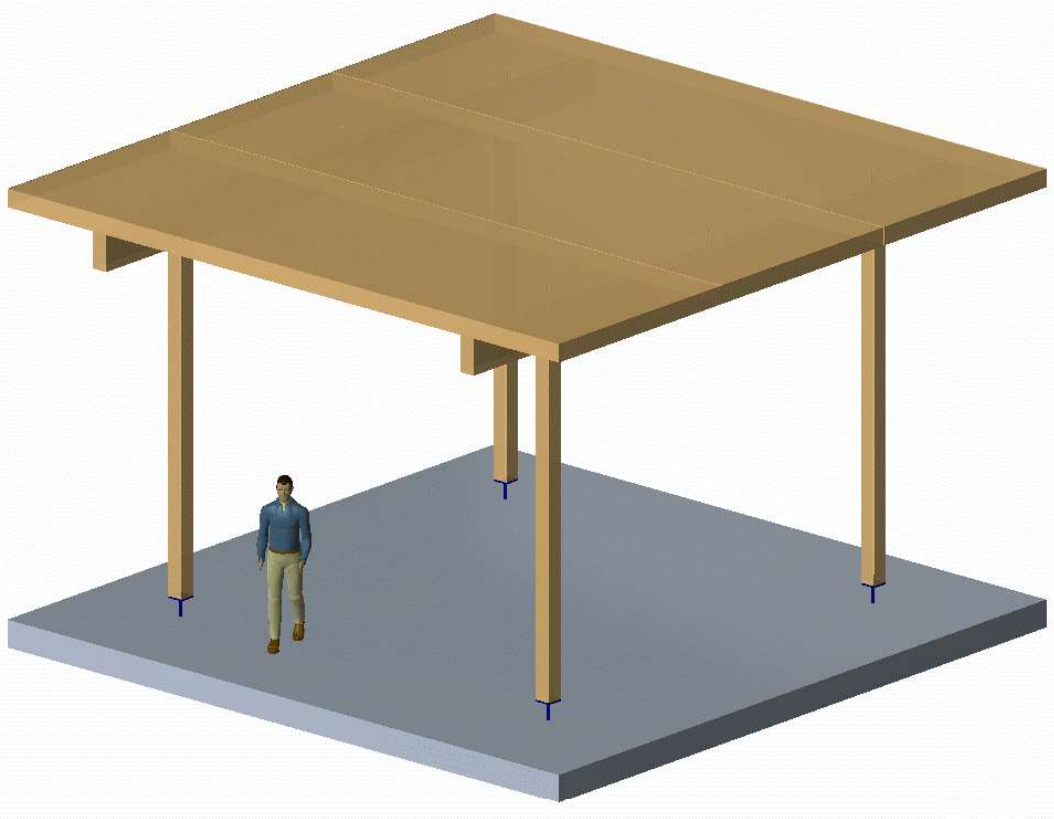
universität
innsbruck

STAND DER TECHNIK



universität
innsbruck

STAND DER TECHNIK



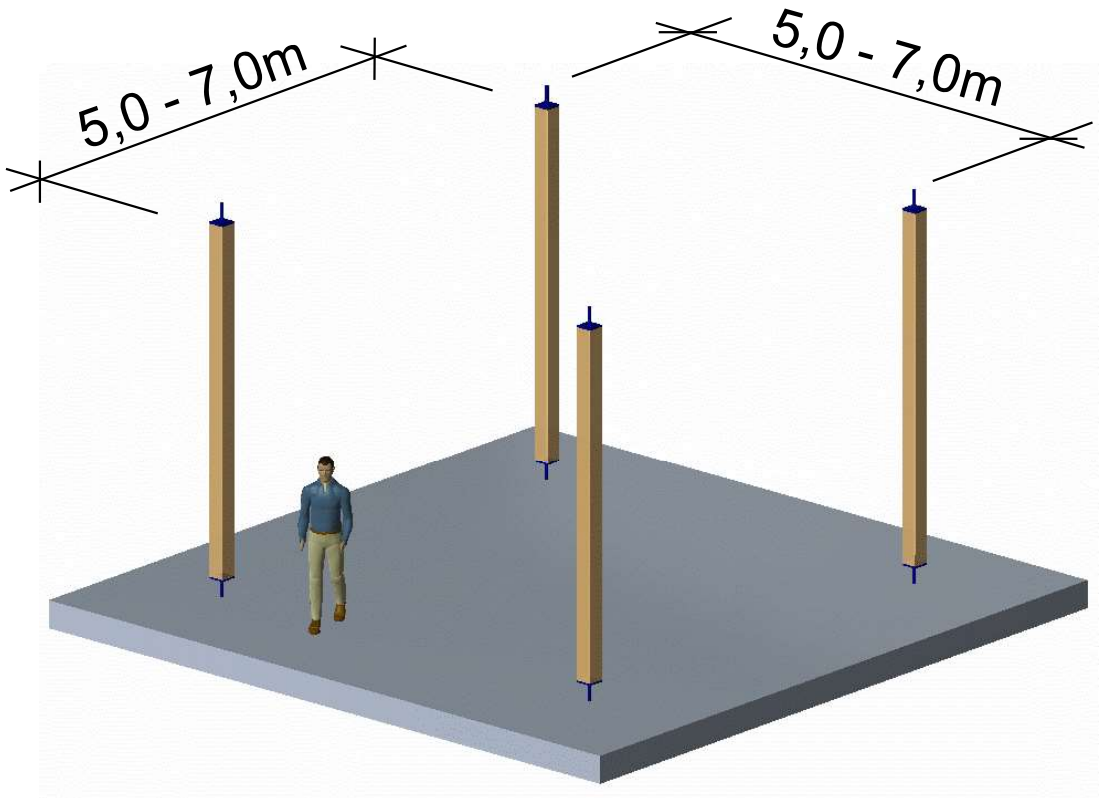
Quelle: acton ostry architects; 2018

Quelle: http://www.structuremag.org

Quelle: http://www.structuremag.org

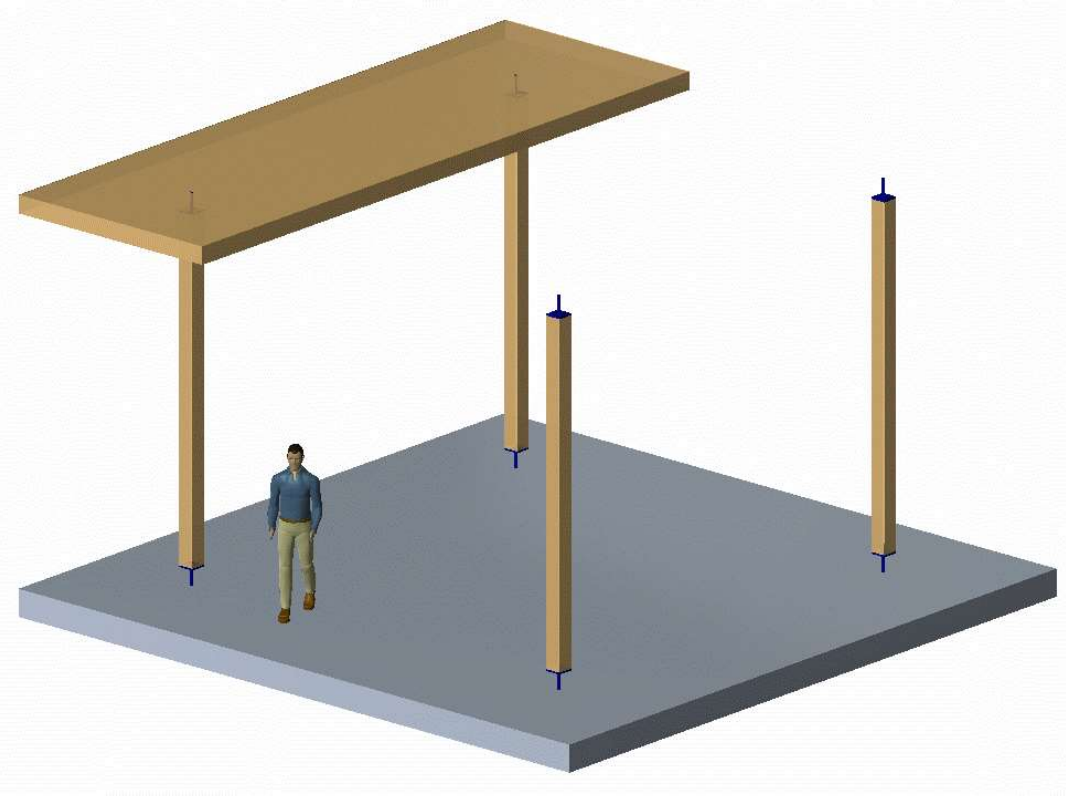
universität
innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG



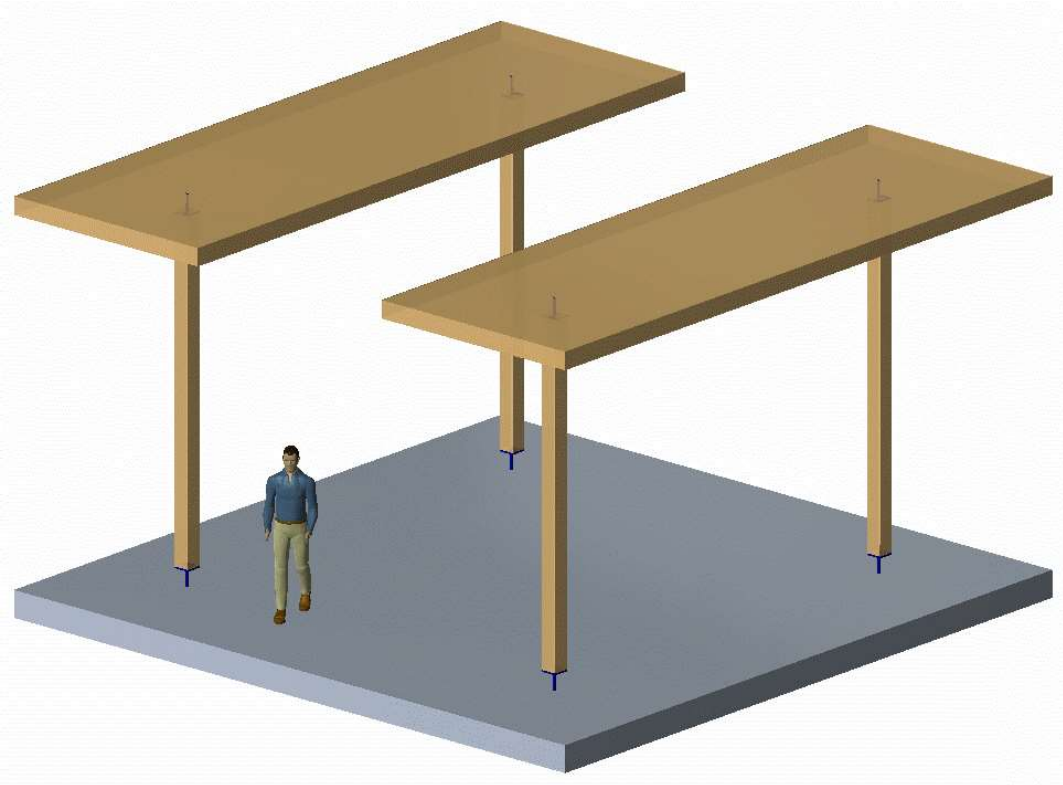
universität
innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG



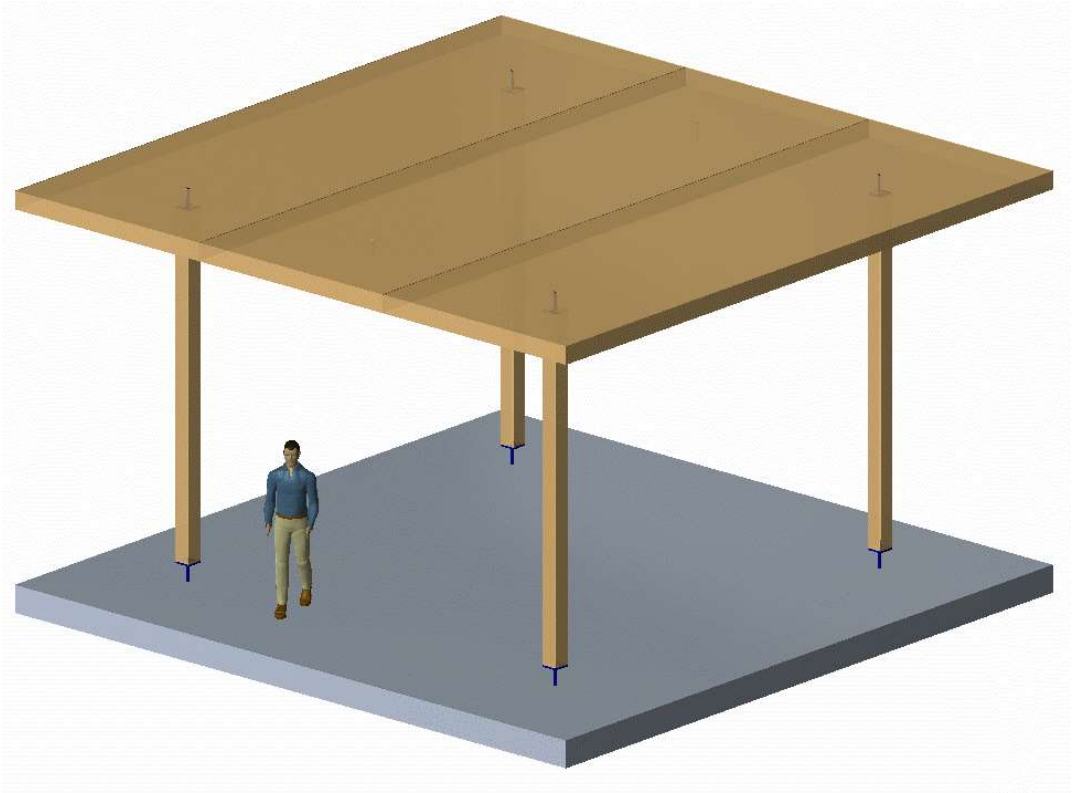
universität
innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG



universität
innsbruck

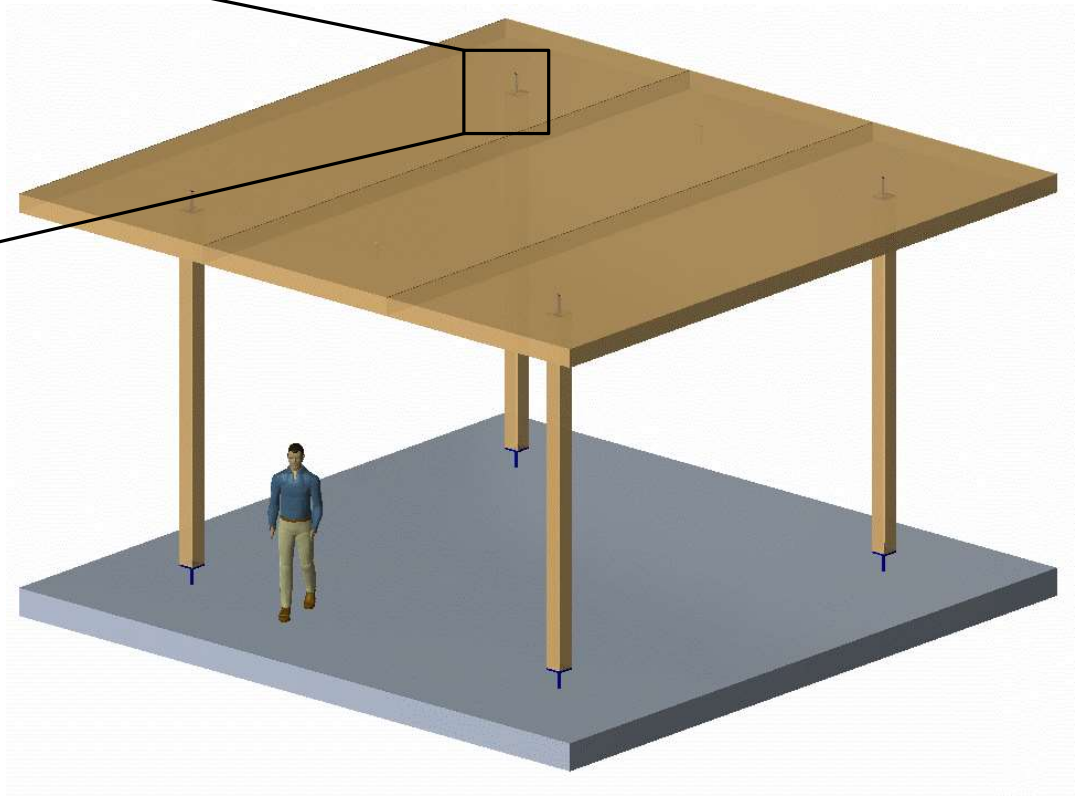
PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG



universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG

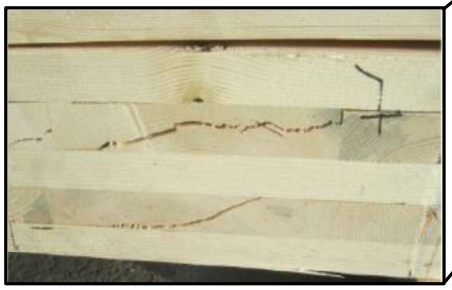
Querdruckversagen



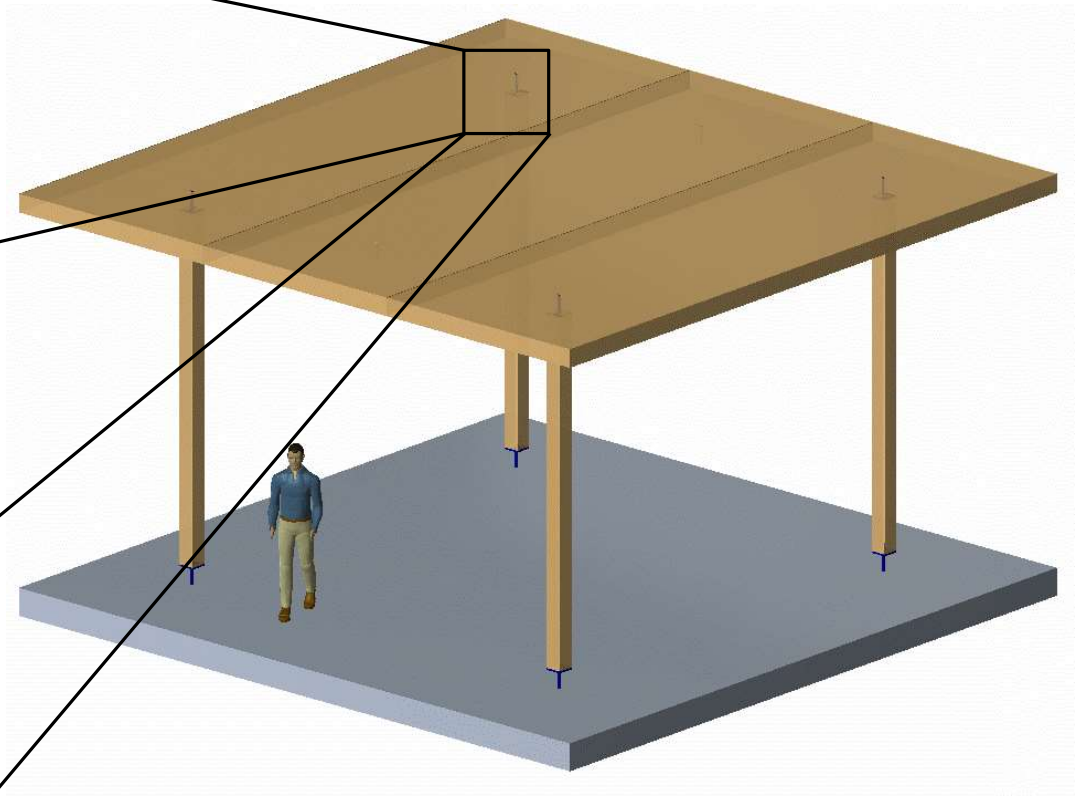
universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG

Querdruckversagen



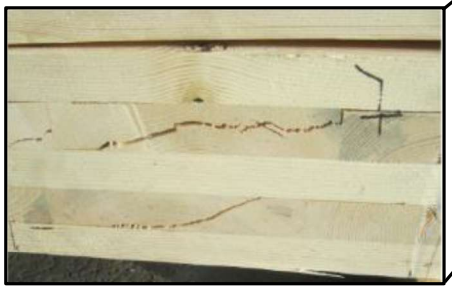
Rollschubversagen



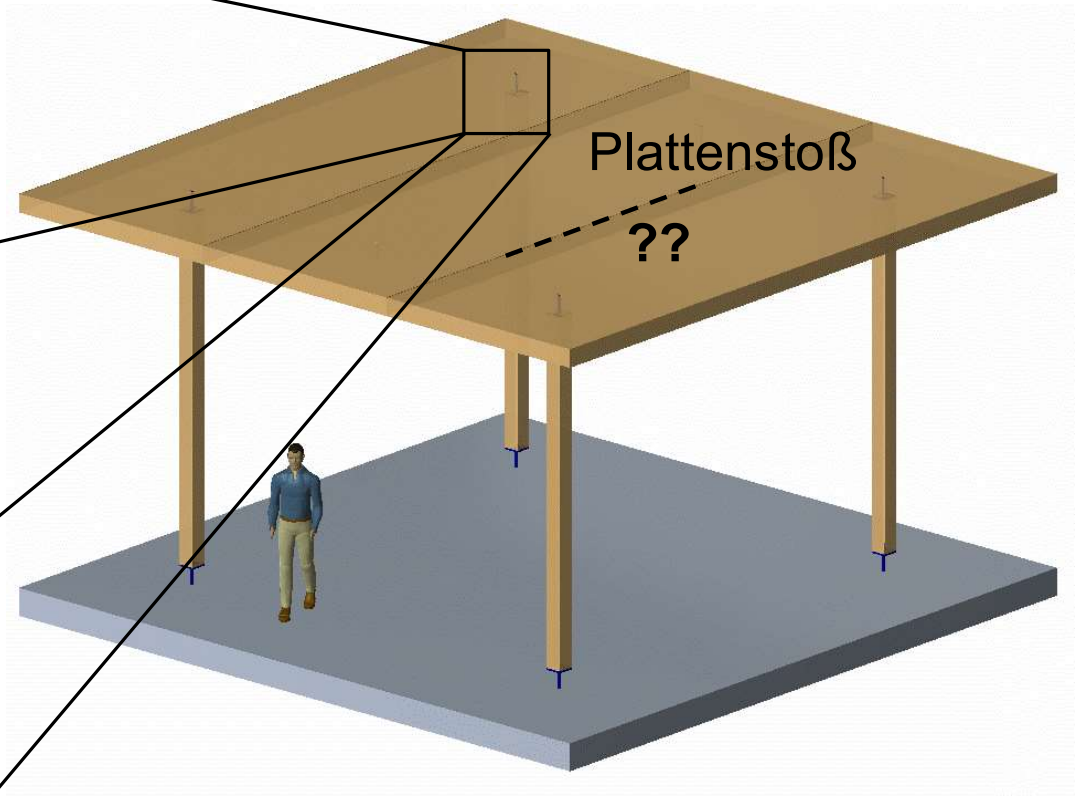
universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | HERAUSFORDERUNG

Querdruckversagen



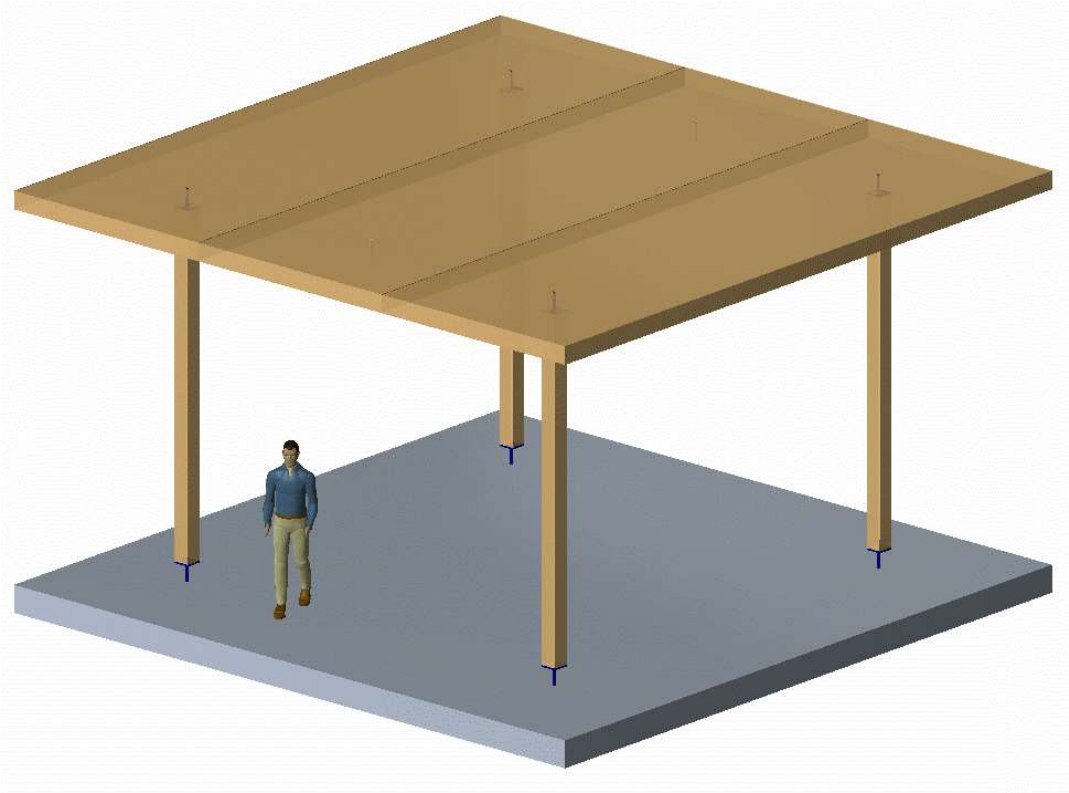
Rollschubversagen



universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | LÖSUNGSANSATZ

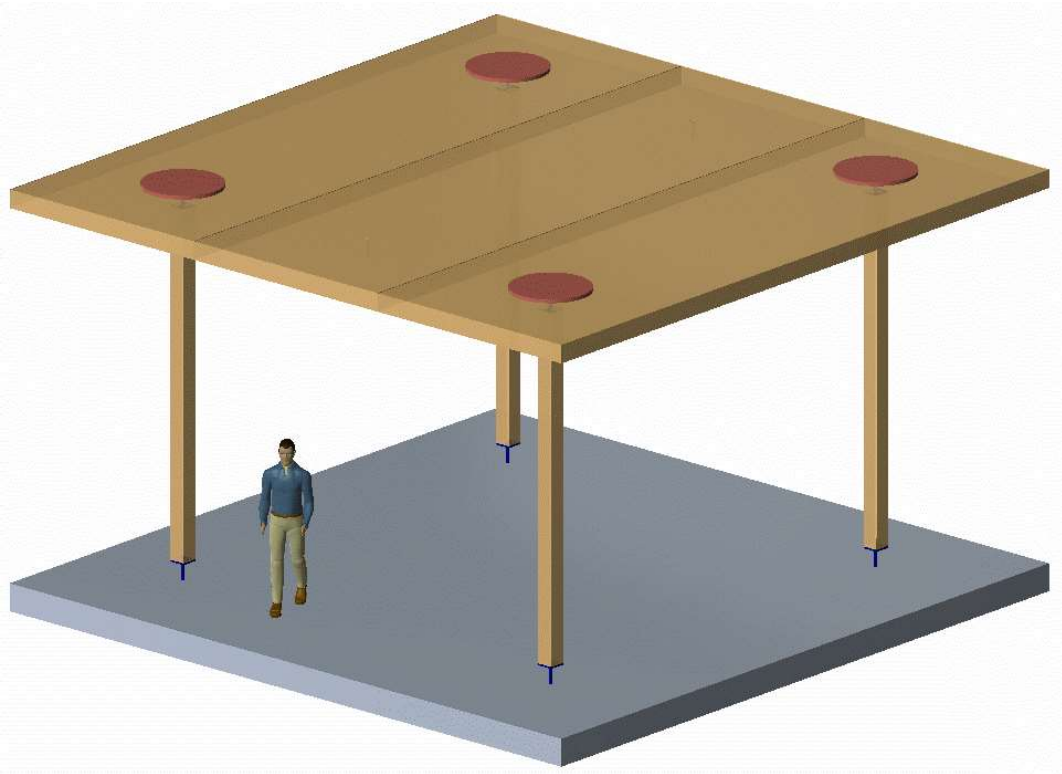
AUS FICHTENHOLZ



universität
innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | LÖSUNGSANSATZ

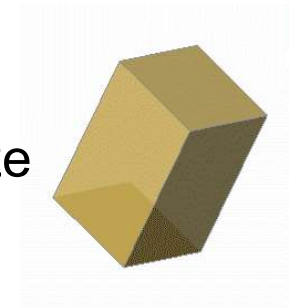
STEP 1: KONZENTRIERTE LASTEINLEITUNG



universität innsbruck

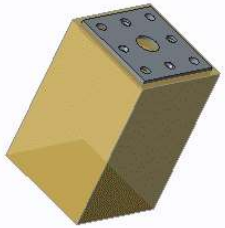
PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER

Stütze



universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER

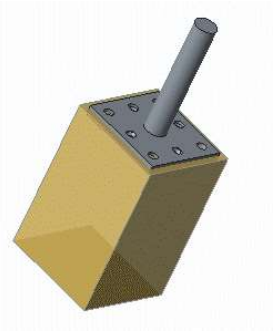
Stütze  Stützenkopf

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER

Lastdurchleitung

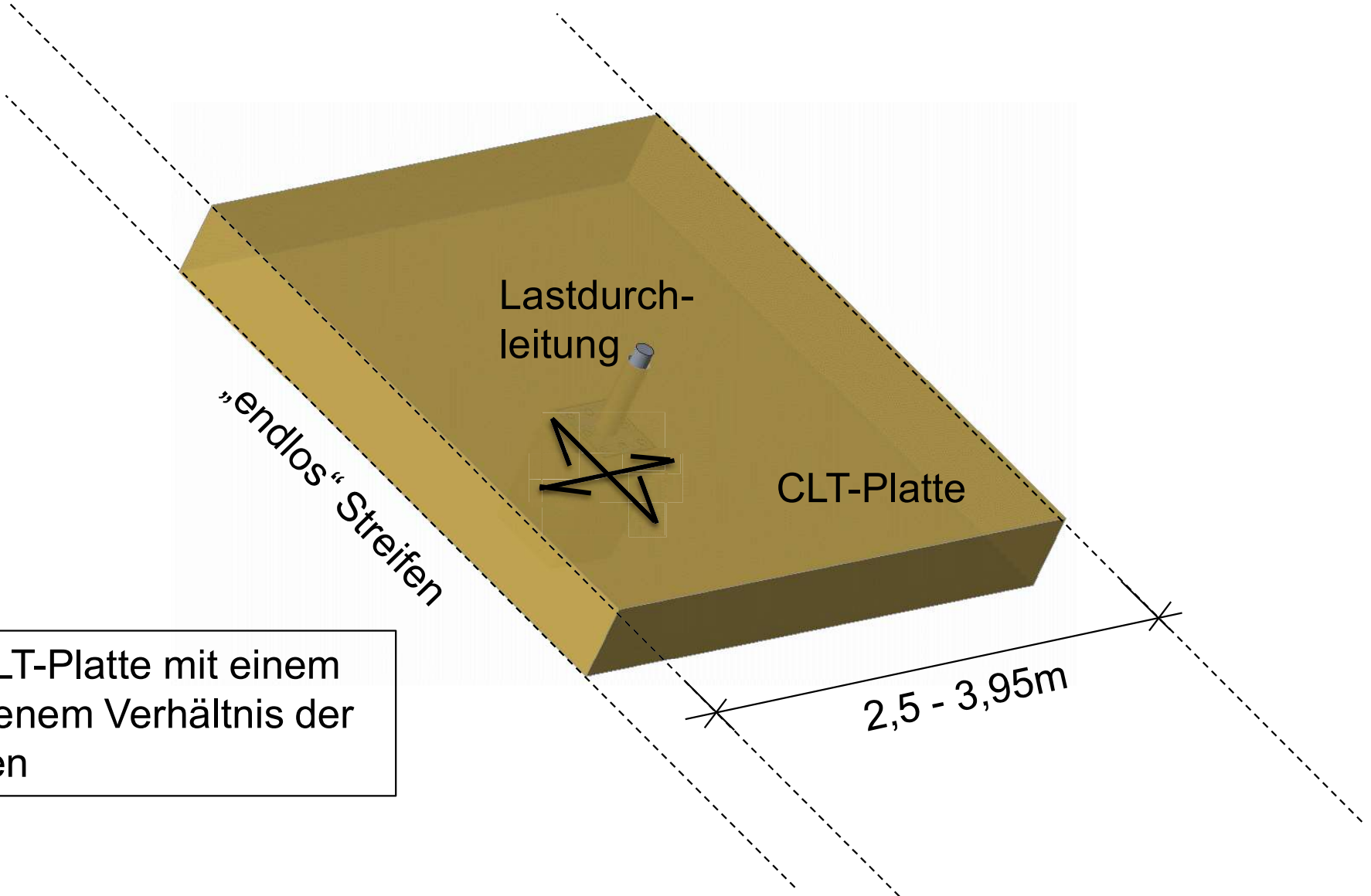
Stütze



Stützenkopf

universität innsbruck

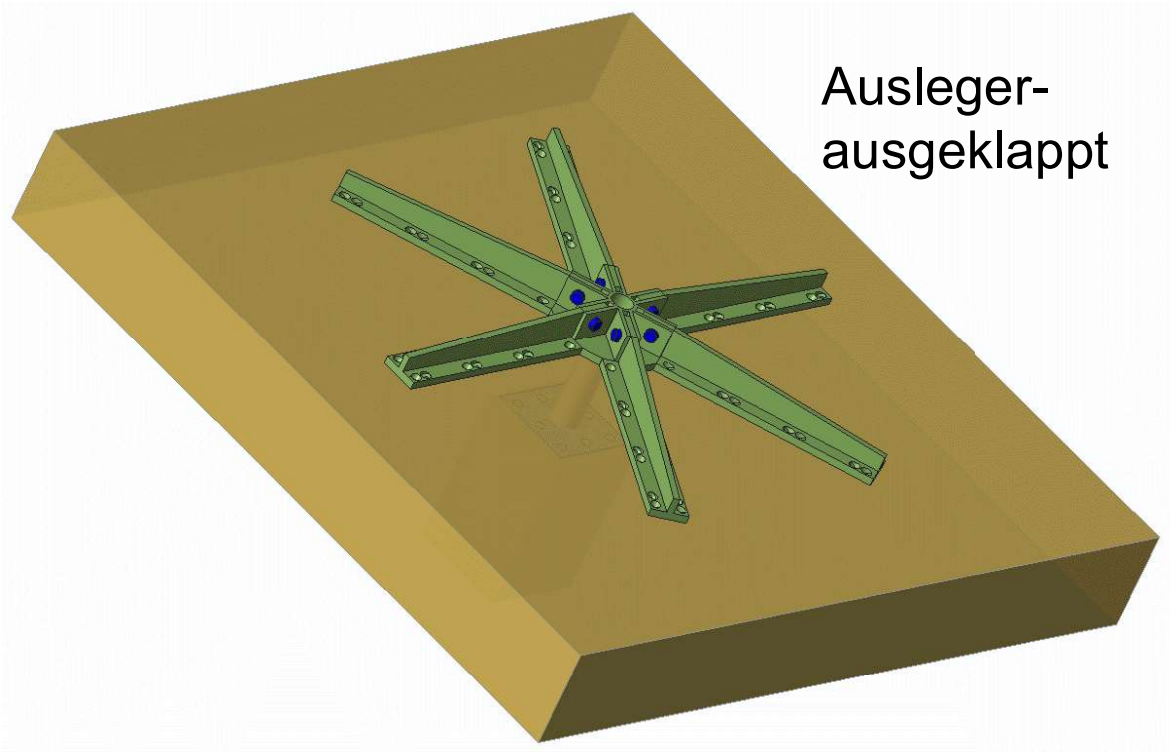
PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER



Wichtig: CLT-Platte mit einem ausgewogenem Verhältnis der Steifigkeiten

universität innsbruck

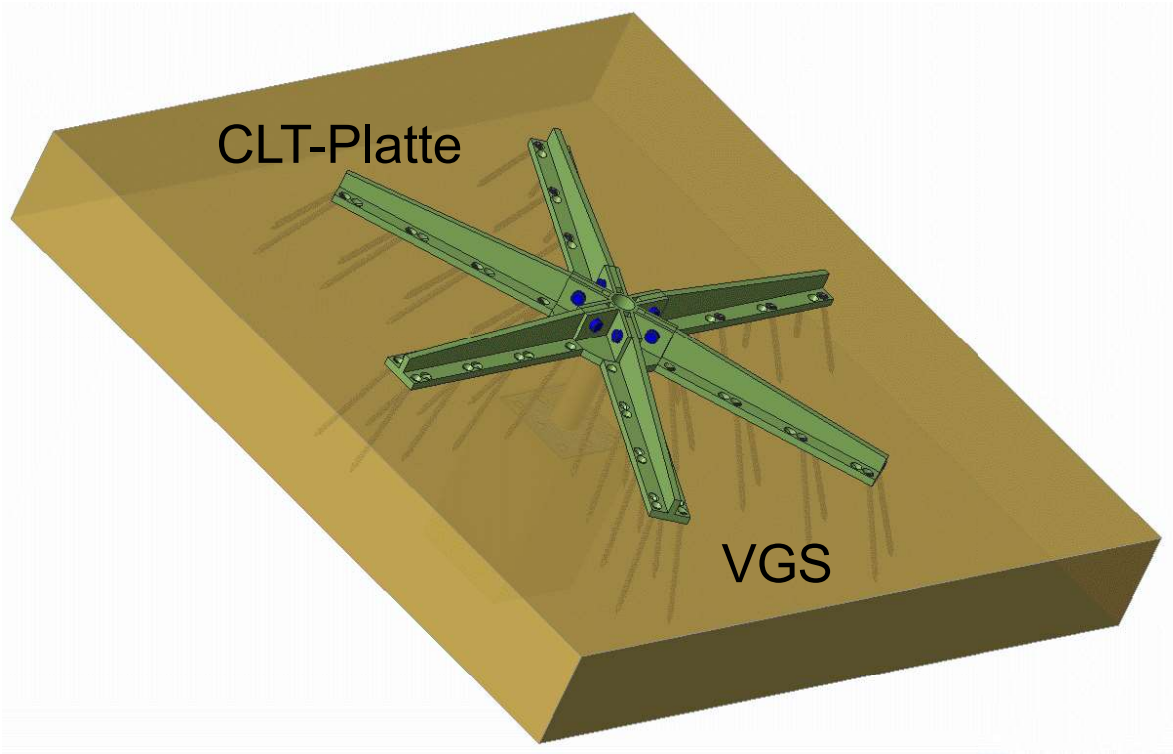
PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER



Ausleger-
ausgeklappt

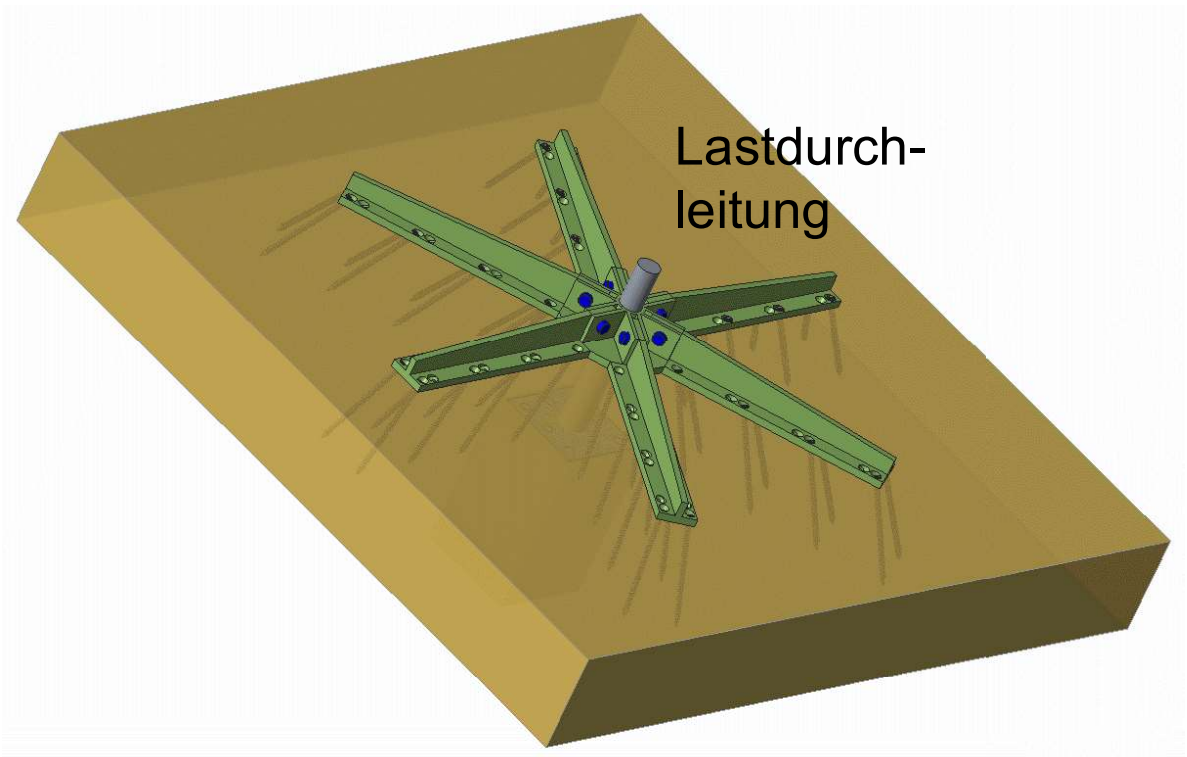
universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER



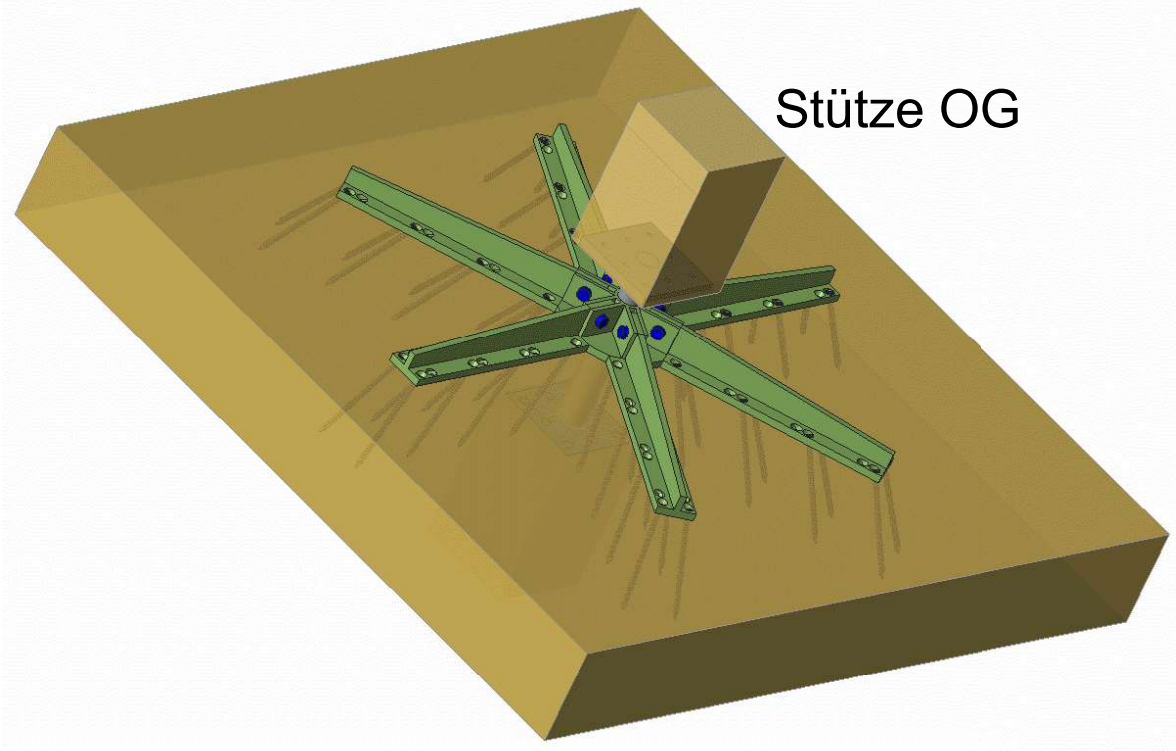
universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER



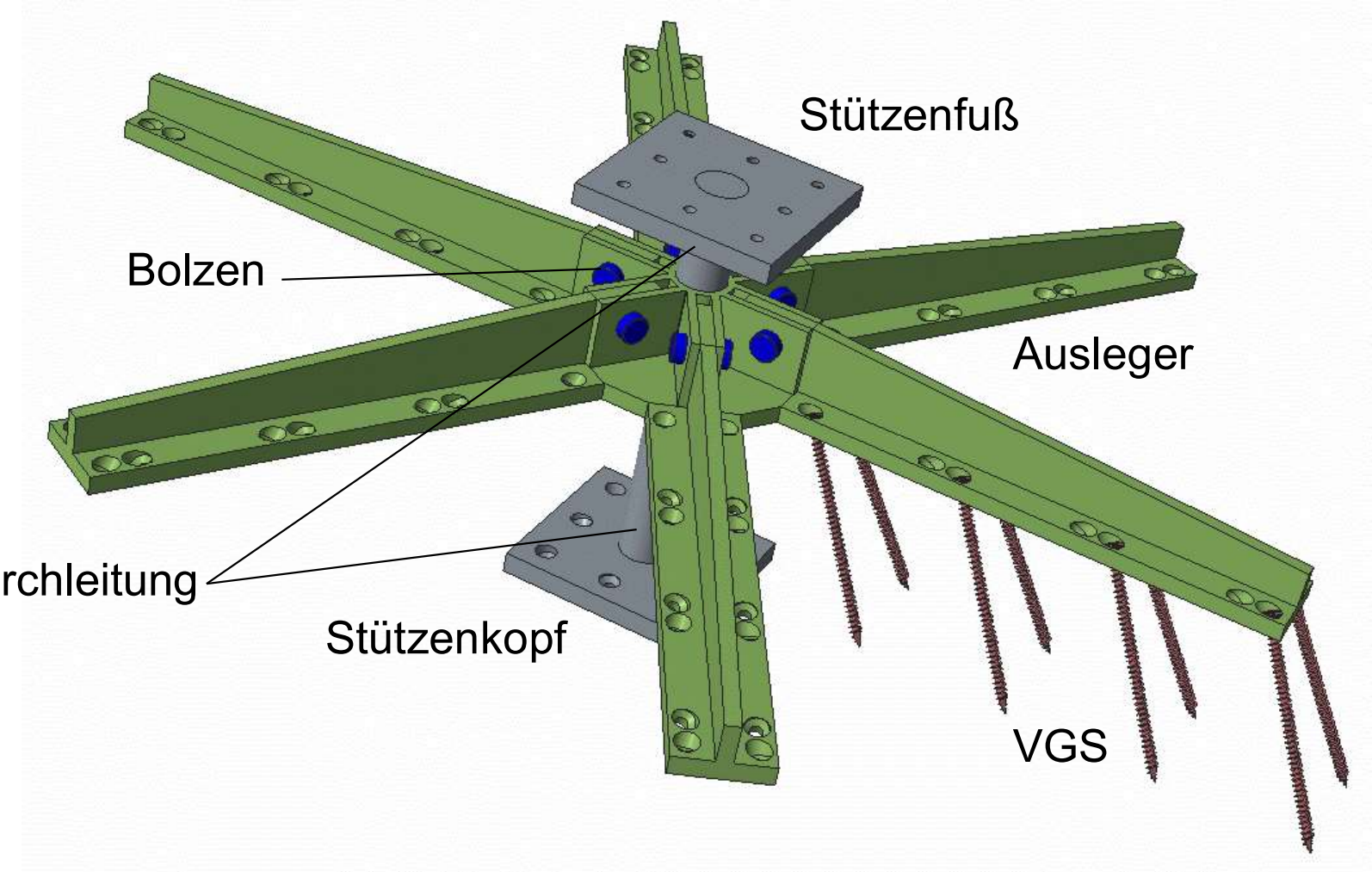
universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | AUFLAGER



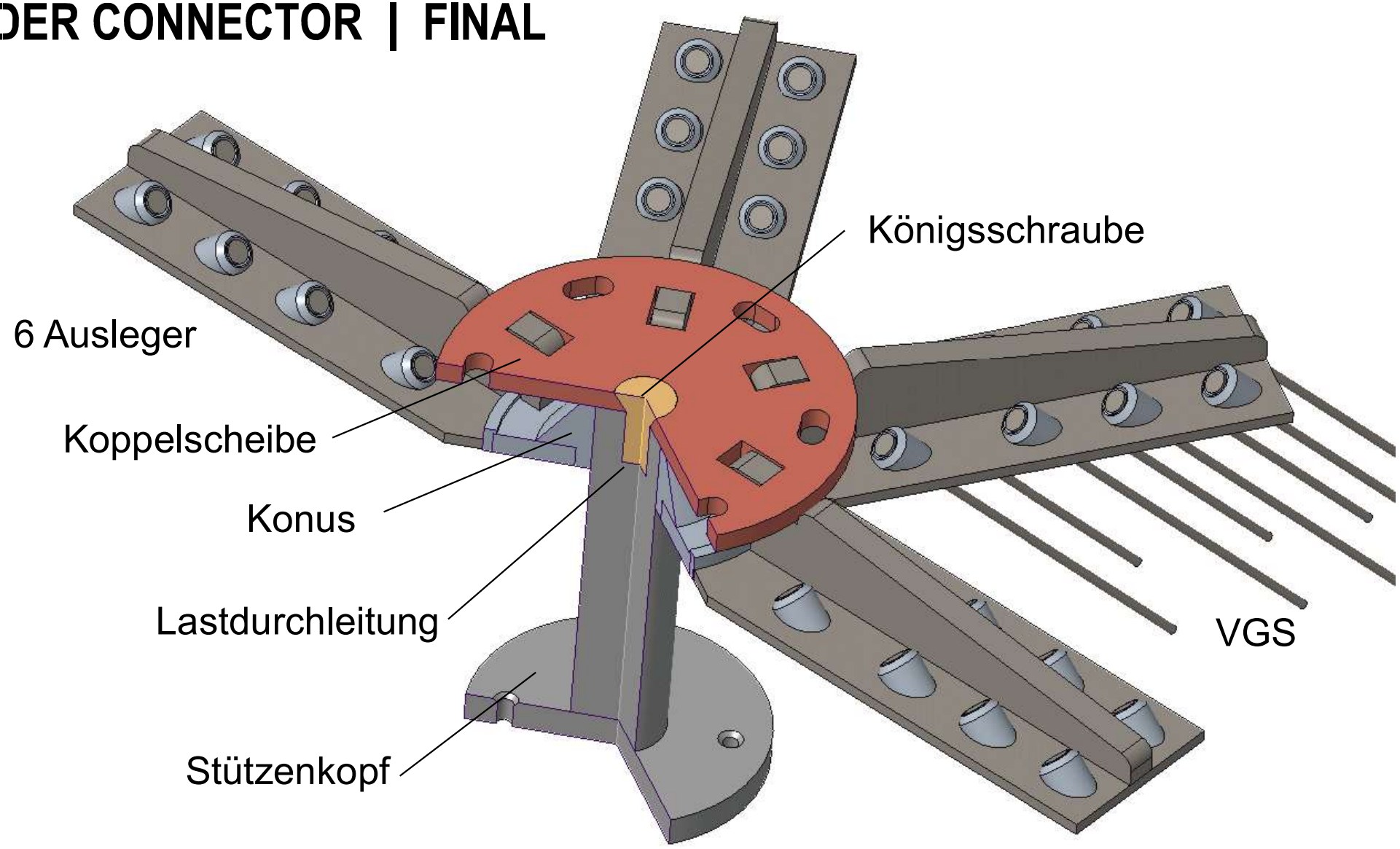
universität innsbruck

SPIDER CONNECTOR | PROTOTYPE OF CONCEPT



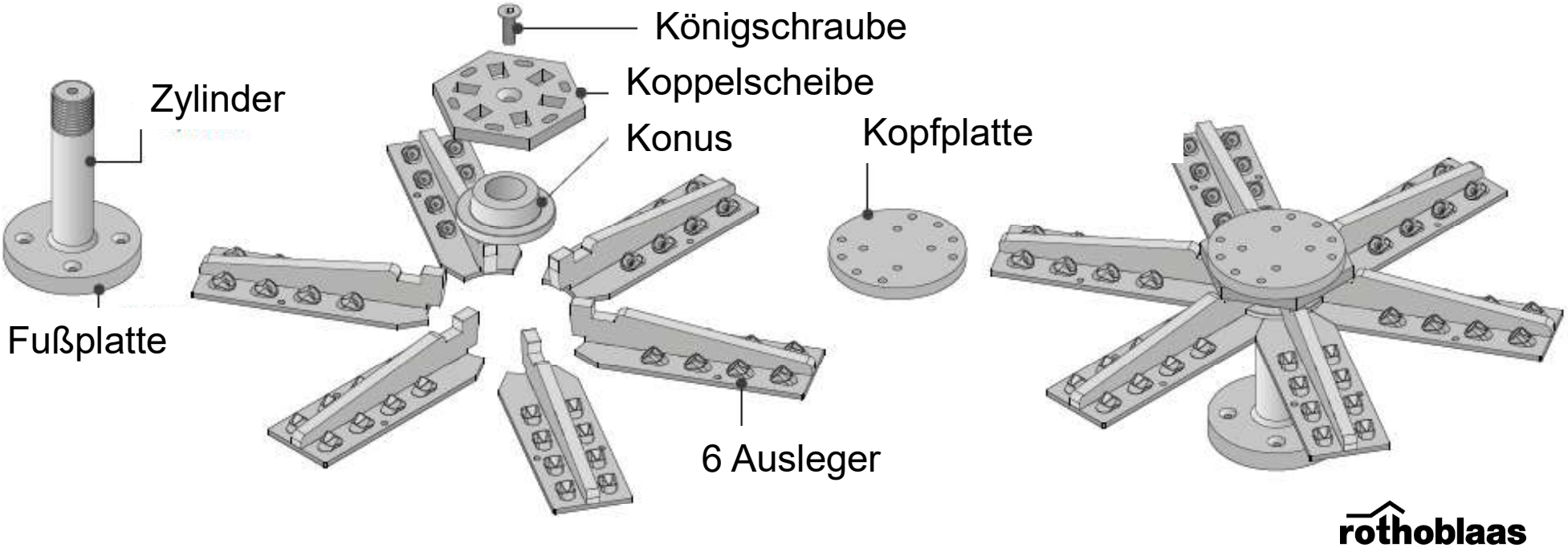
universität innsbruck

SPIDER CONNECTOR | FINAL



universität innsbruck

SPIDER CONNECTOR | FINALE VERSION

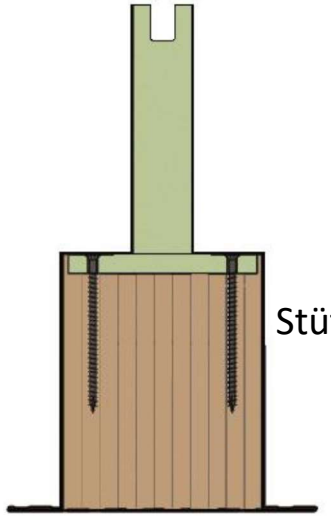


rothoblaas

universität innsbruck

SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

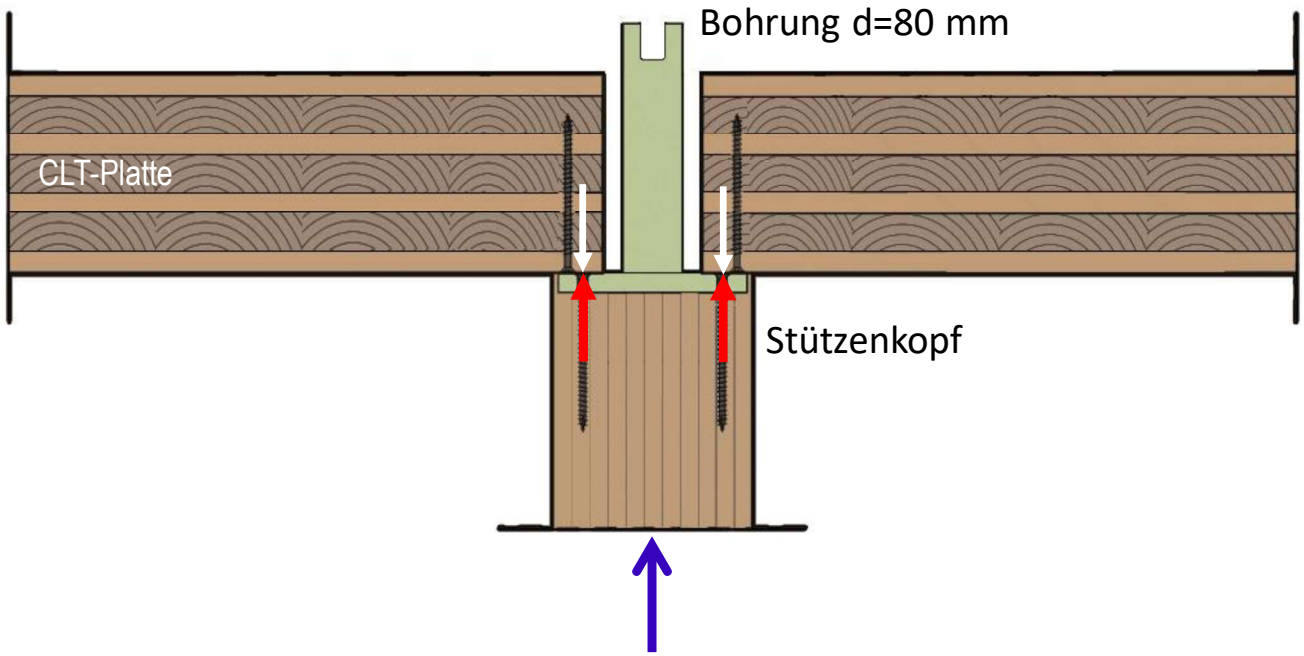


universität innsbruck

SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

① Auflagerung (Montage)



universität innsbruck

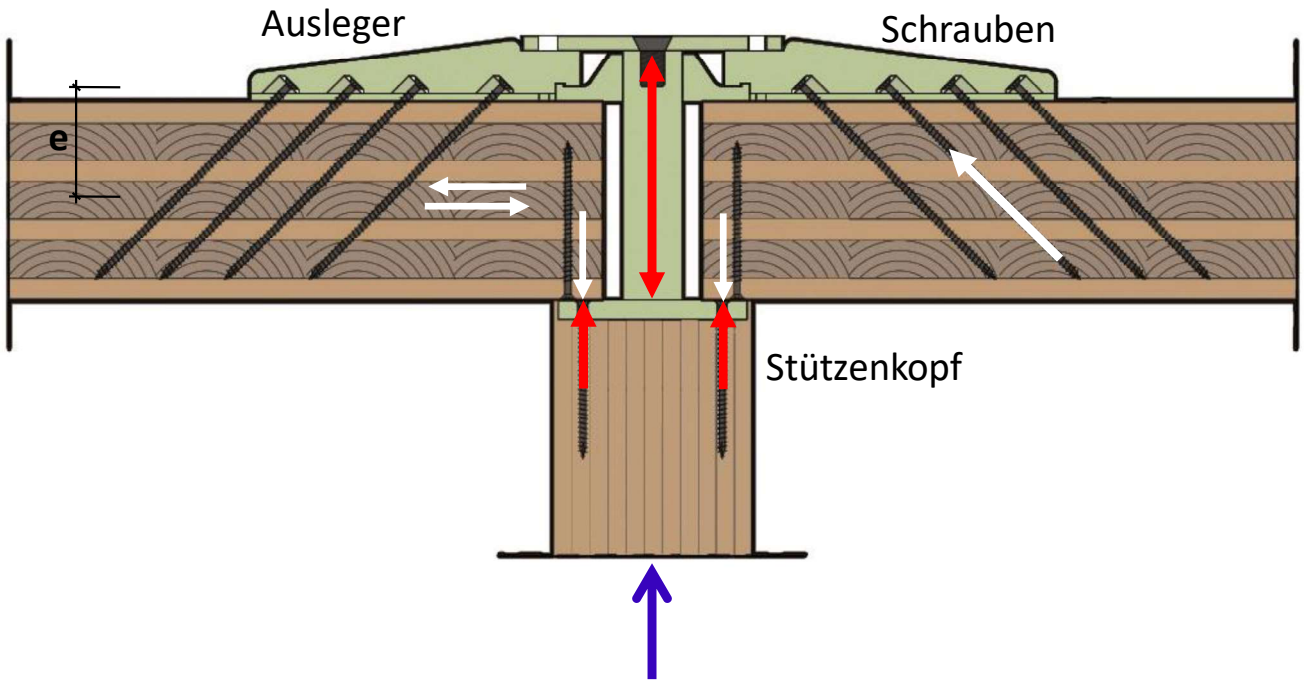
SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

① Auflagerung

② Aufhängung

③ Verstärkung (V+M)

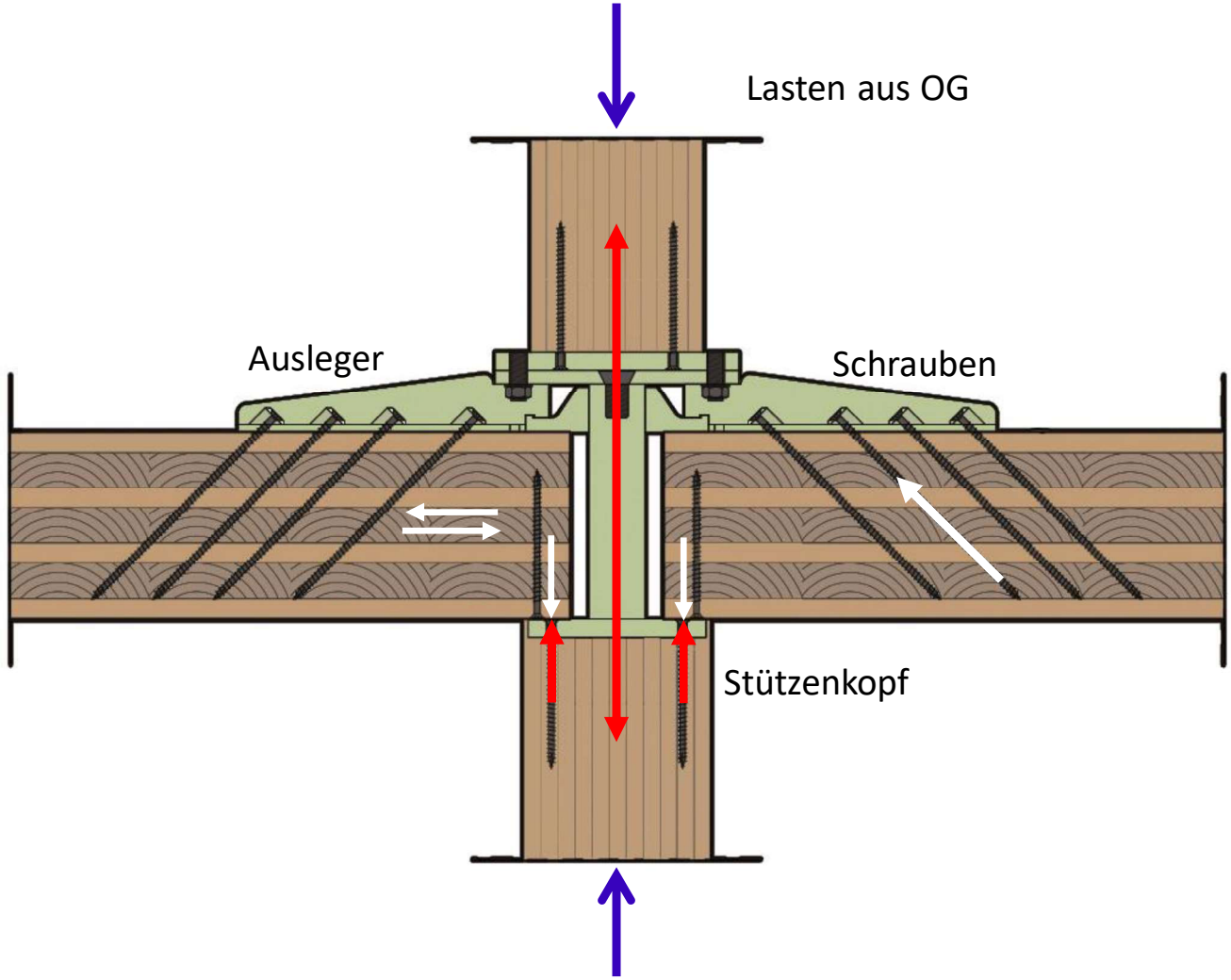


universität innsbruck

SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

1. Auflagerung
2. Aufhängung
3. Verstärkung
4. Durchleitung

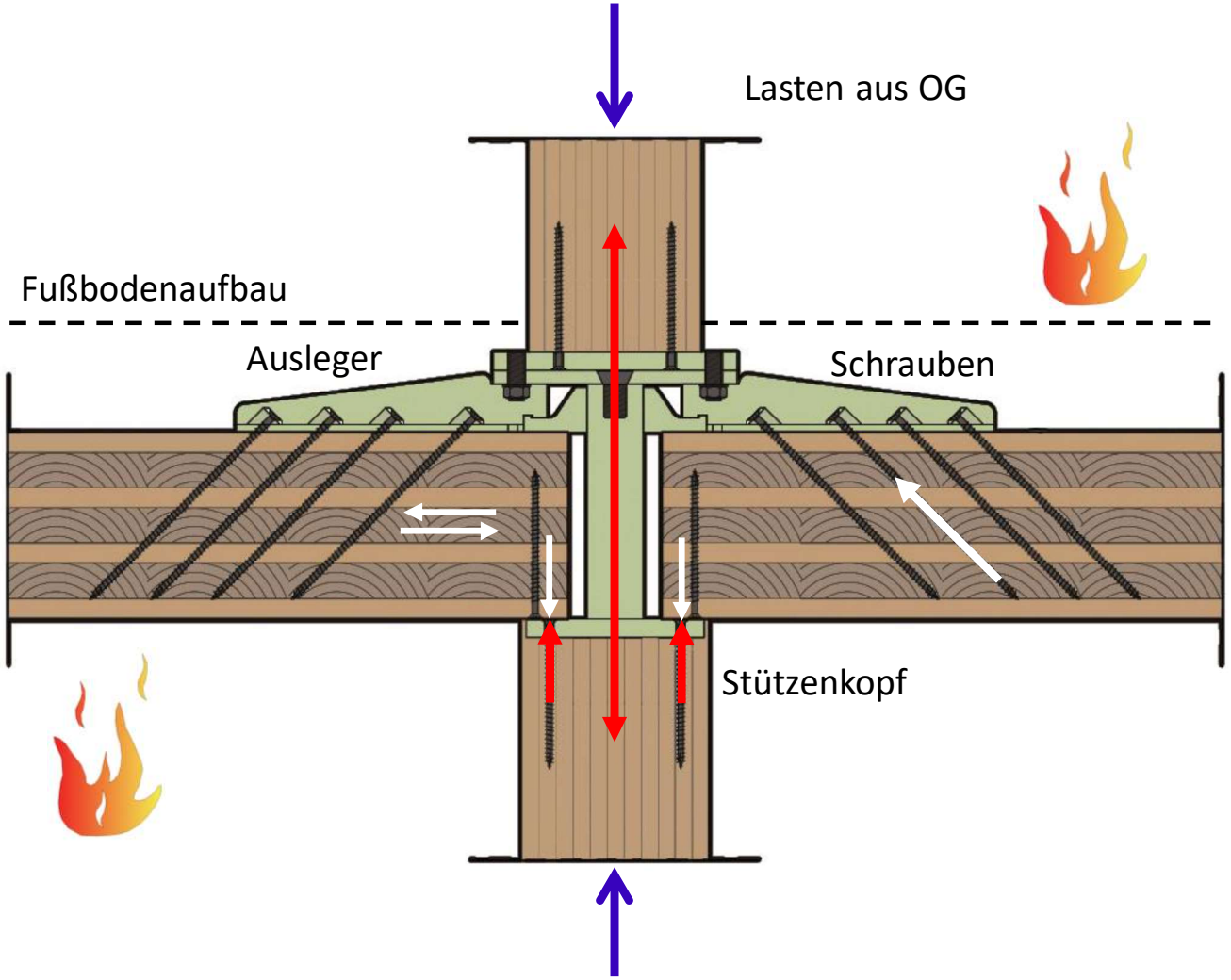


universität innsbruck

SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

1. Auflagerung
2. Aufhängung
3. Verstärkung
4. Durchleitung
5. Brandschutz

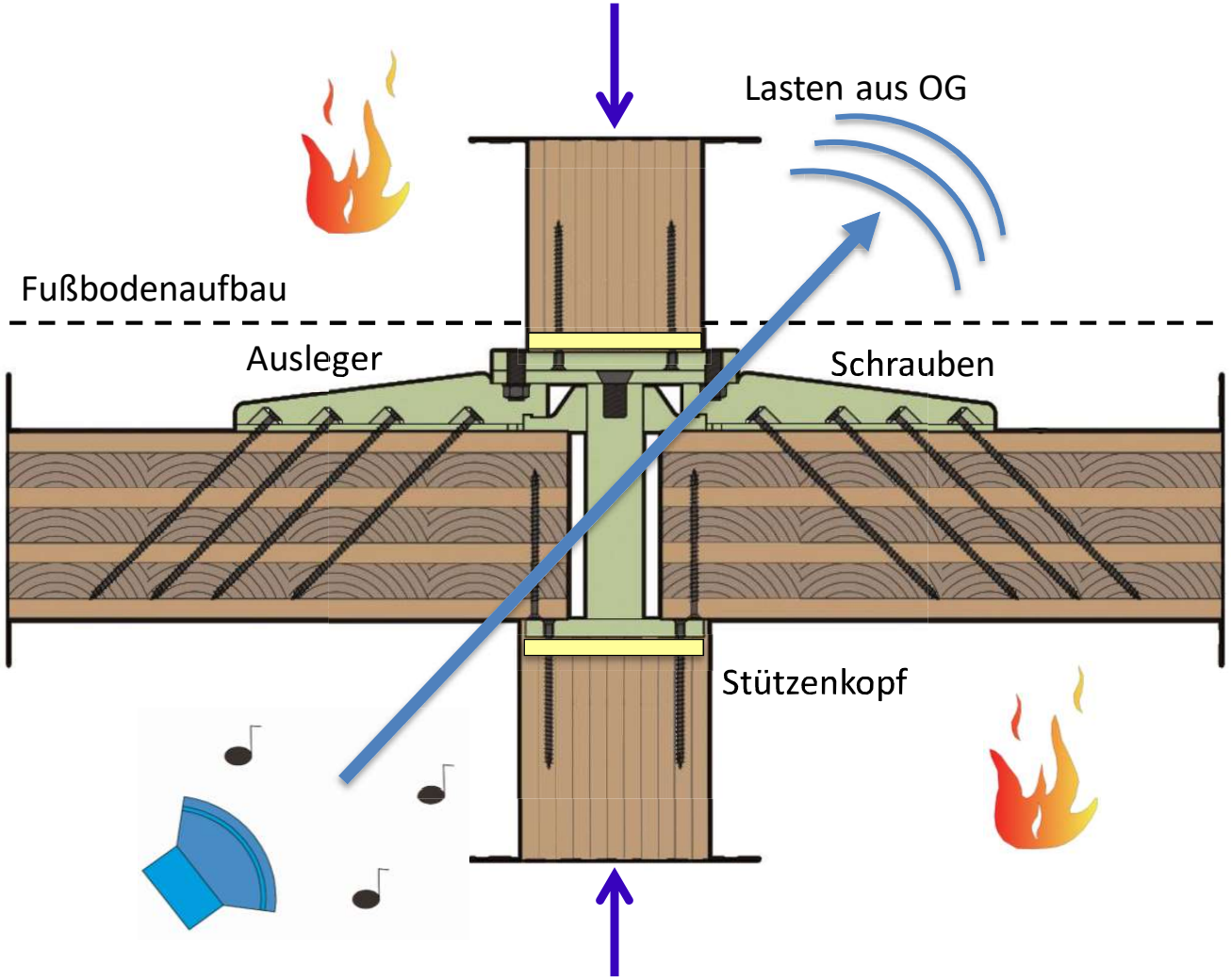


universität innsbruck

SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

1. Auflagerung
2. Aufhängung
3. Verstärkung
4. Durchleitung
5. Brandschutz
6. Schallschutz

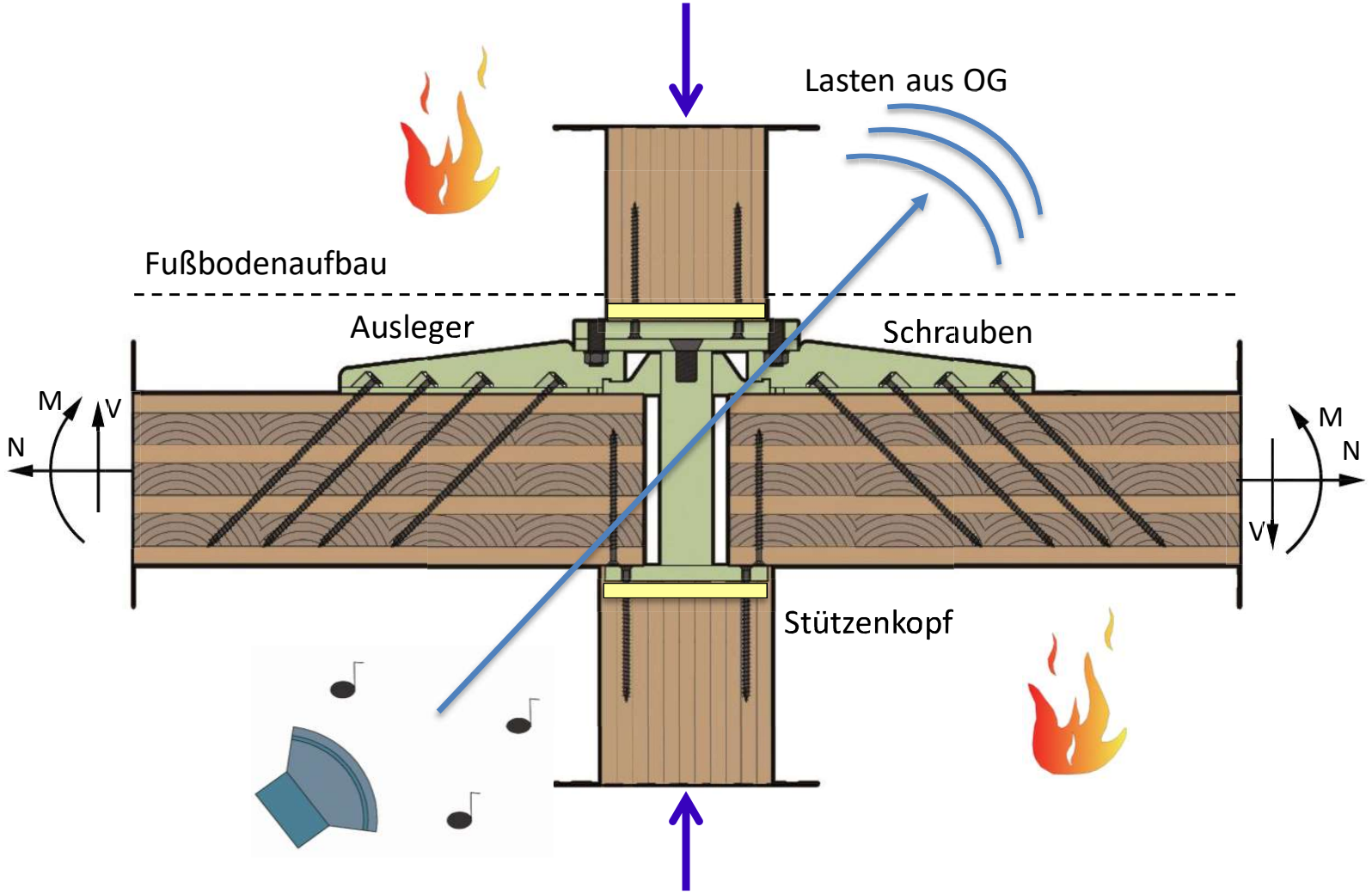


universität innsbruck

SPIDER CONNECTOR | SCHNITT

- TRAGVERHALTEN

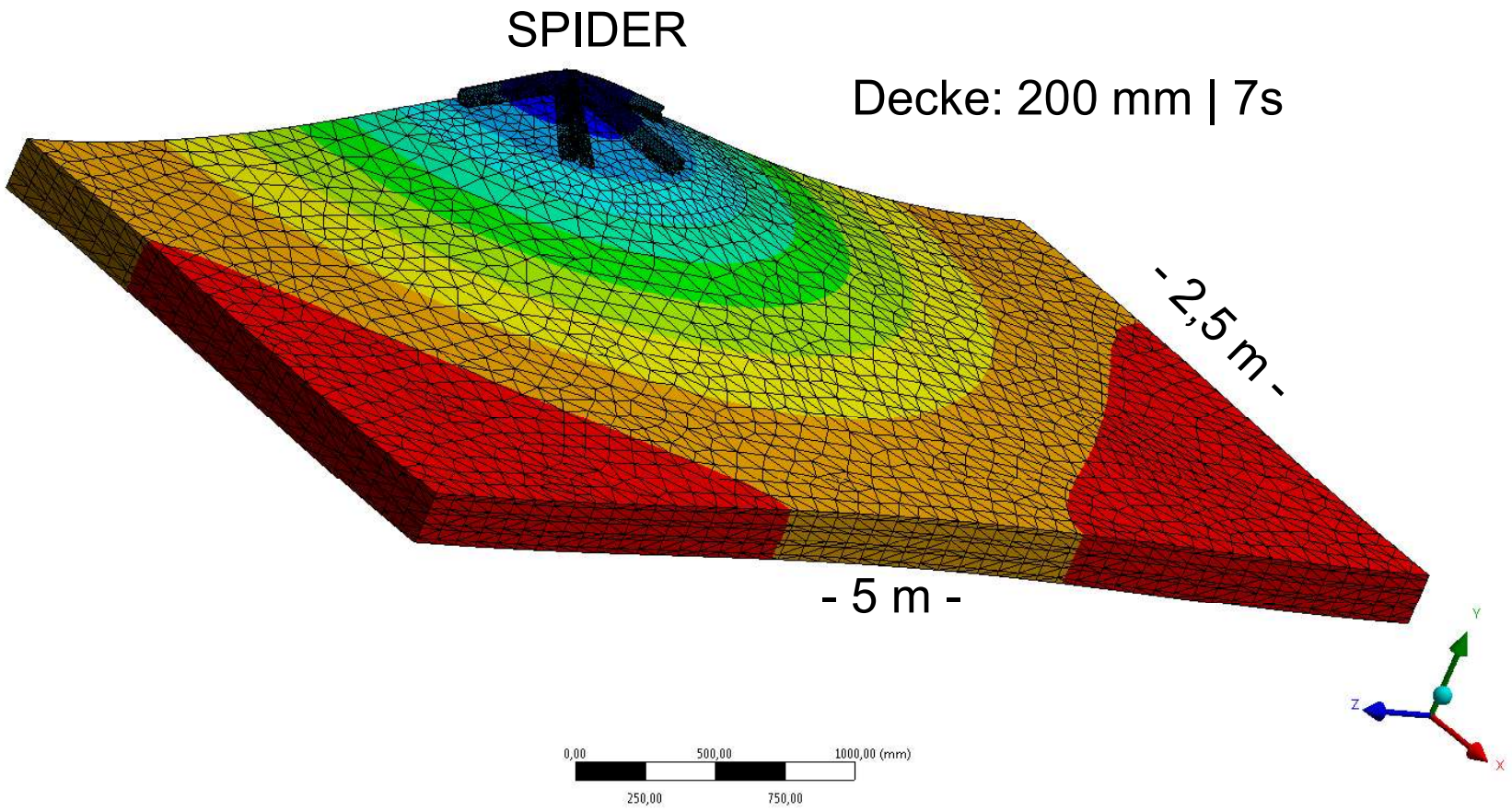
1. Auflagerung
2. Aufhängung
3. Verstärkung
4. Durchleitung
5. Brandschutz
6. Schallschutz
7. Plattenstoß?



universität innsbruck

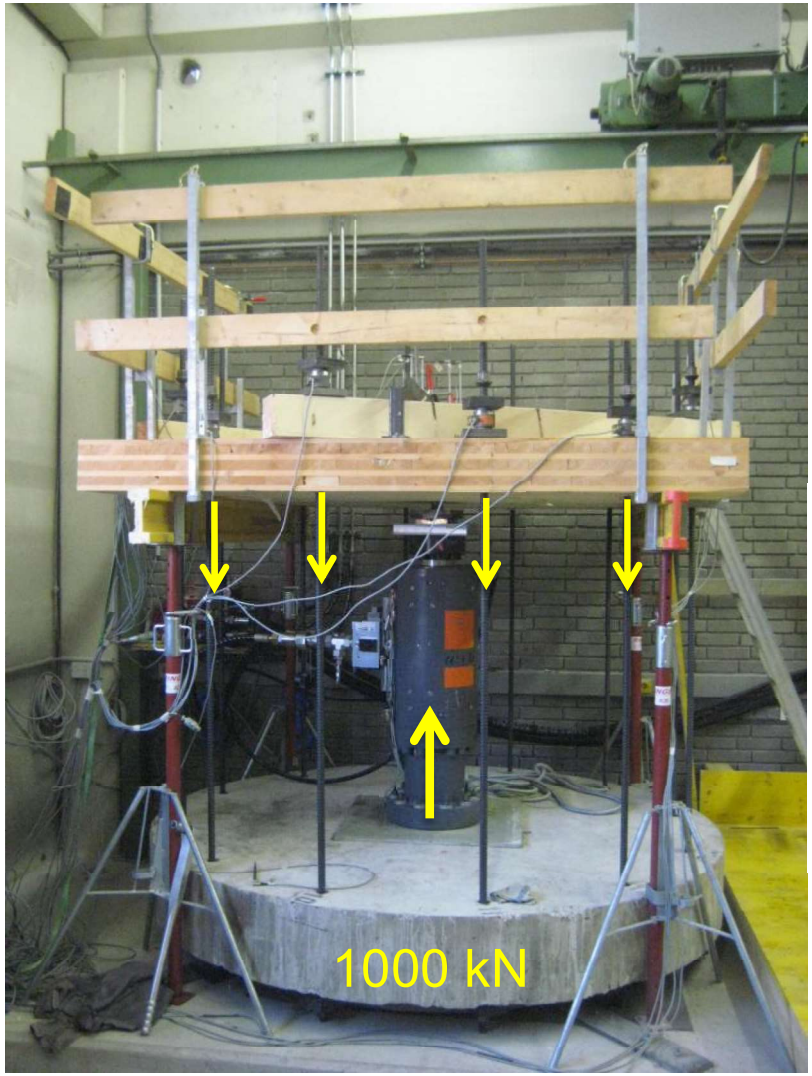
SPIDER CONNECTOR

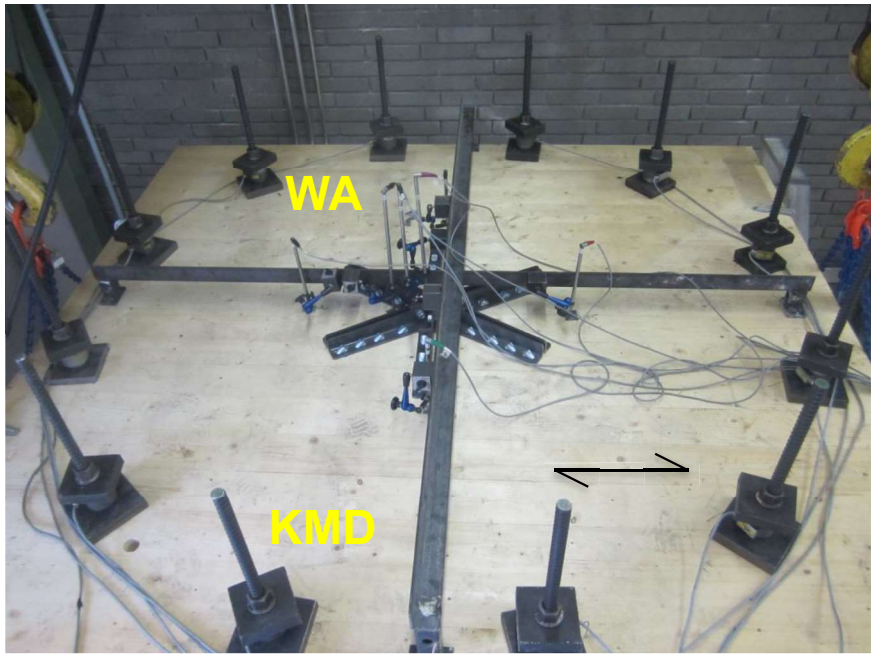
TRAGVERHALTEN GESAMTSYSTEM



universität
innsbruck

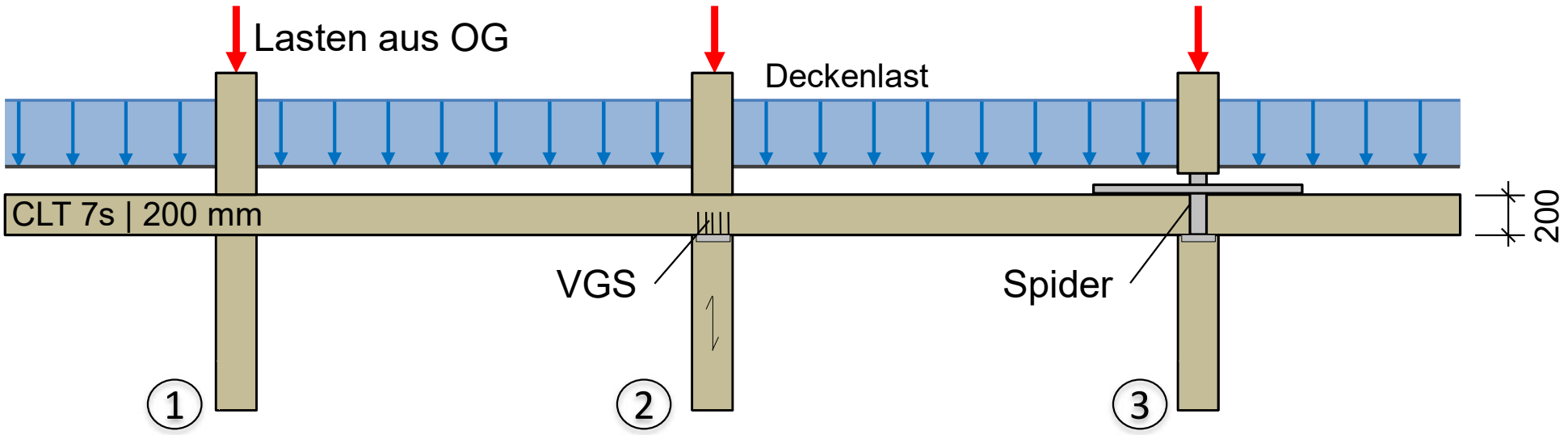
EXPERIMENTELLE UNTERSUCHUNGEN | »DURCHSTANZEN«

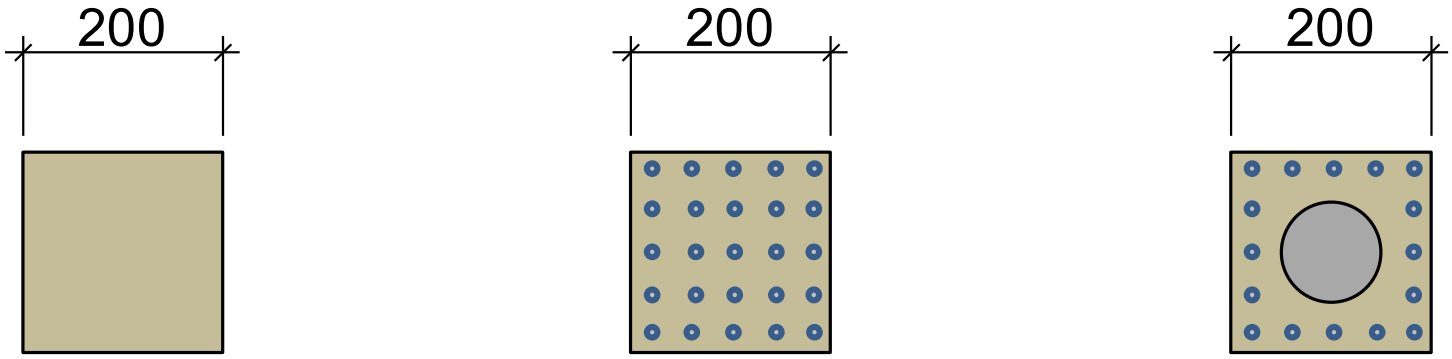




universität innsbruck

VERSUCHSSETUP

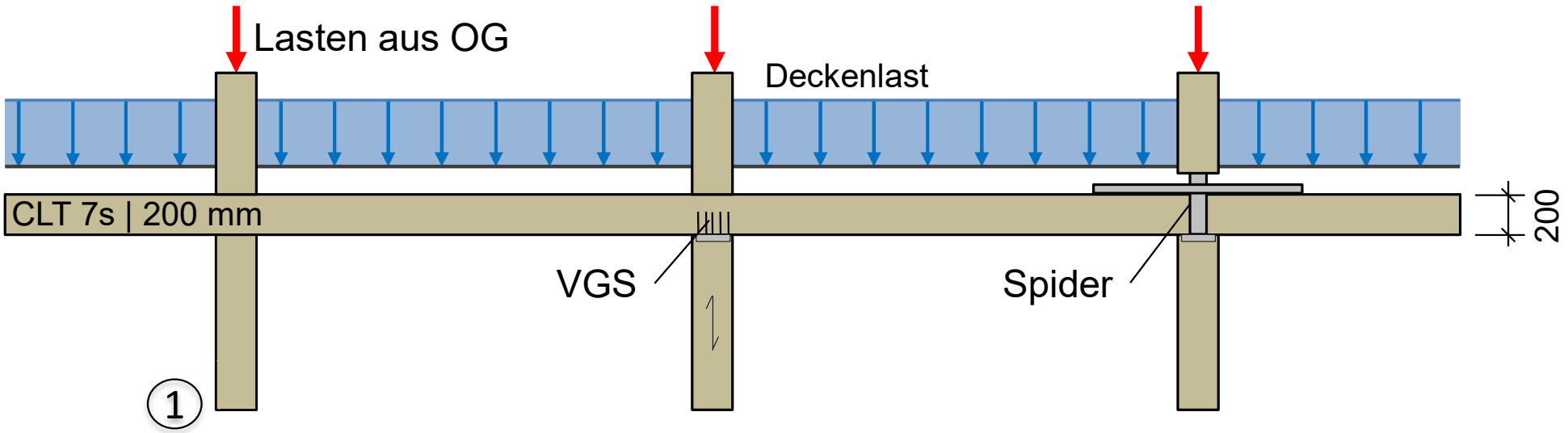


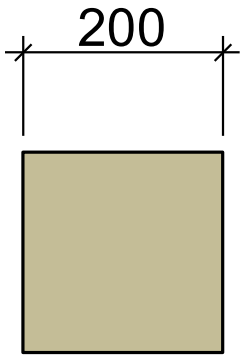


A_{Holz}=400 cm² A_{Holz}=400 cm² A_{Holz}=321 cm²

universität innsbruck

VERSUCHSSETUP

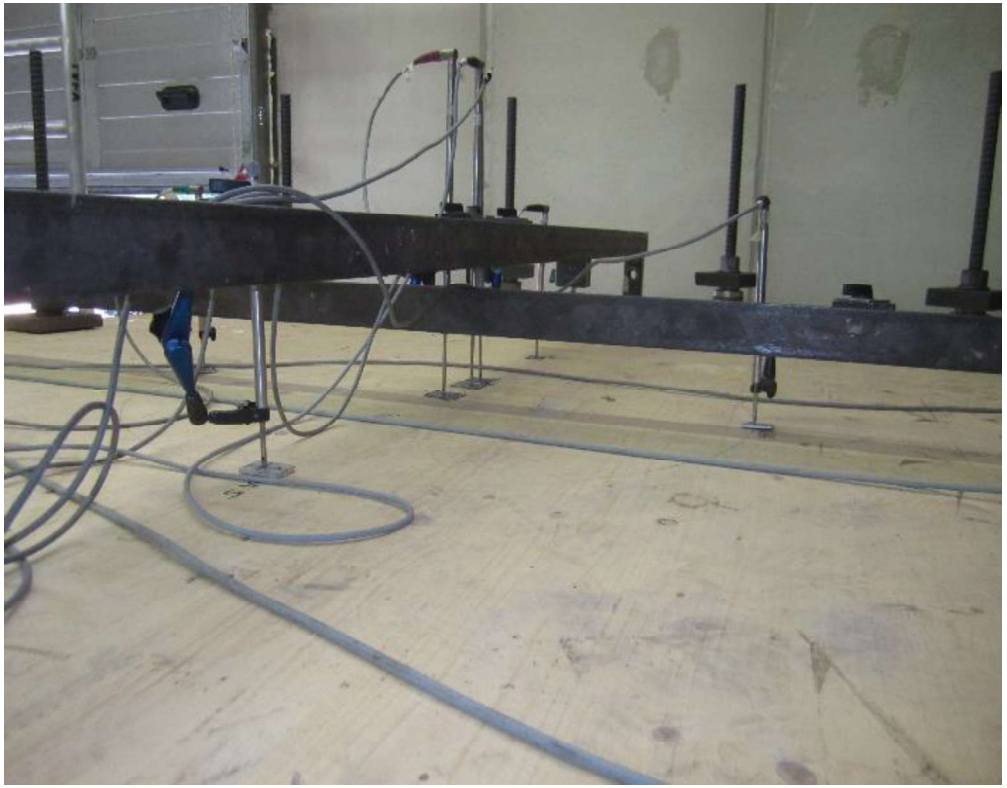




A_{Holz}=400 cm²

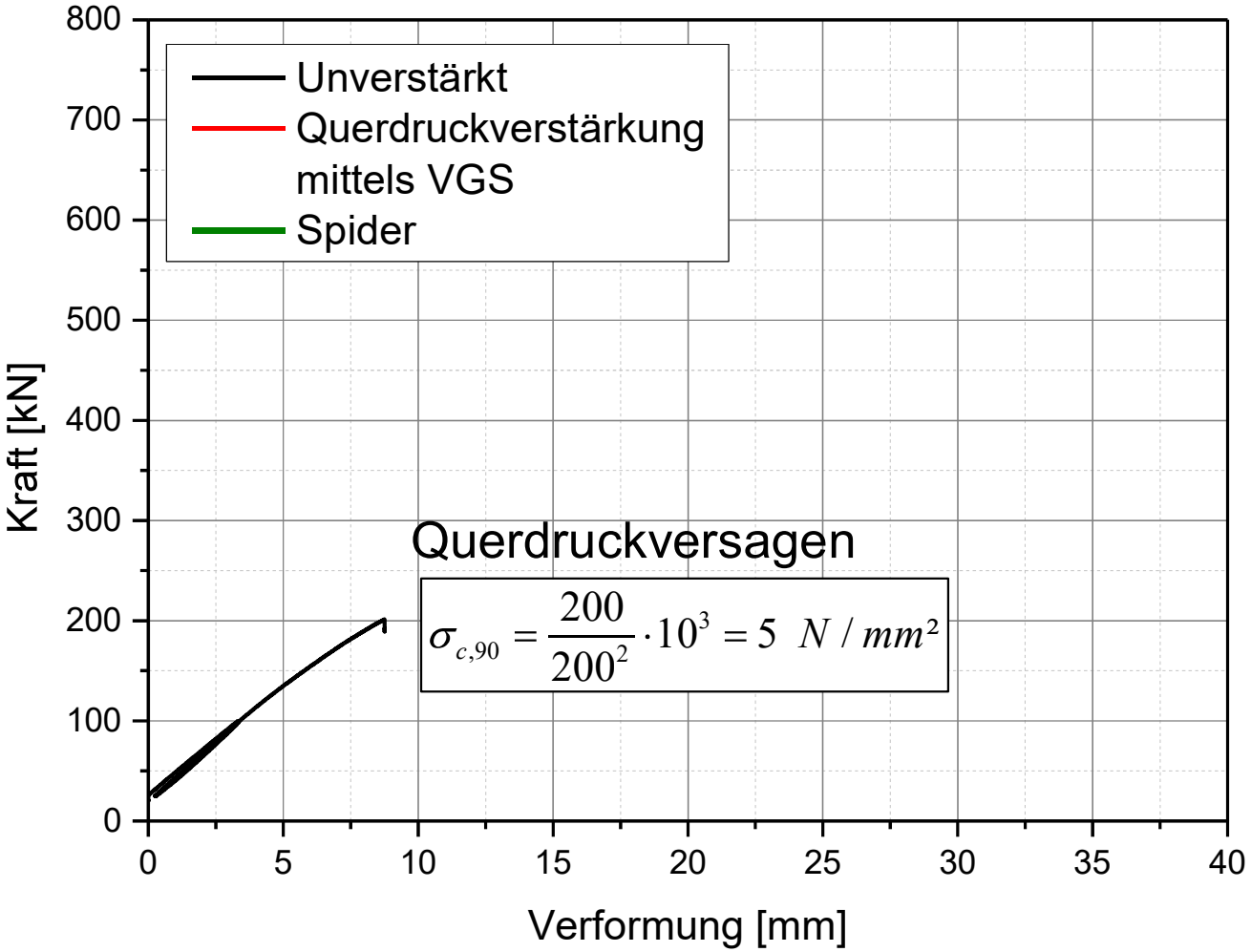
universität
innsbruck

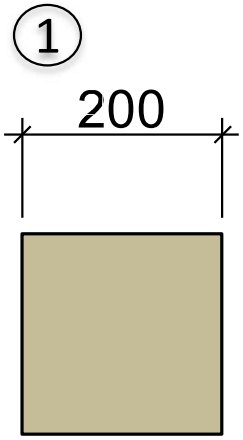
① REFERENZ - unverstärkt



universität innsbruck

① REFERENZ - unverstärkt



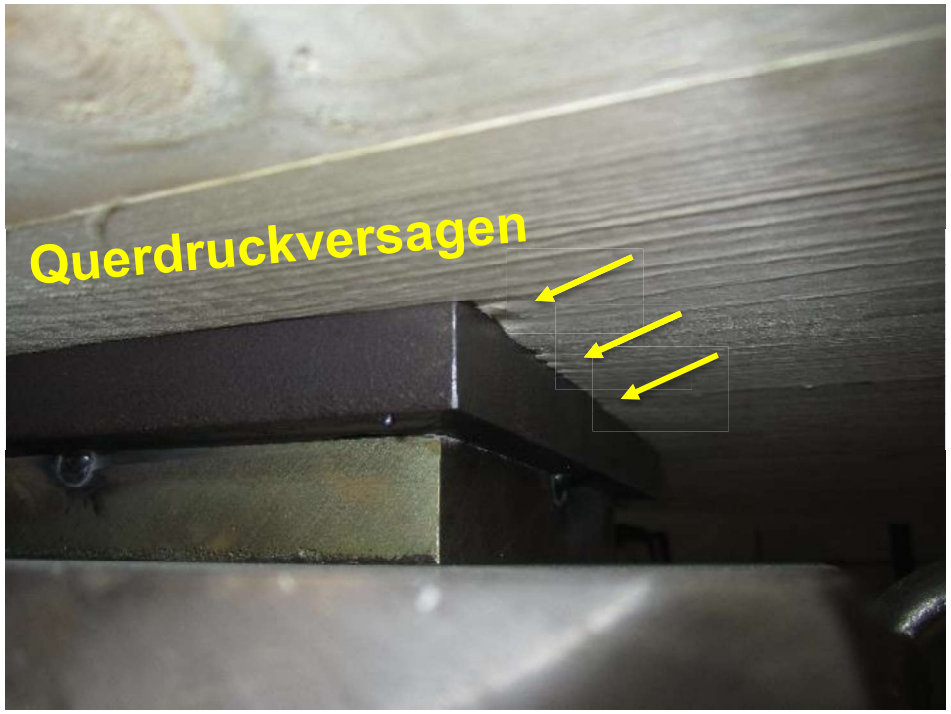


A_{Holz}=400 cm²

Anmerkung EC 5, Anhang K: $f_{c,90,R\,k} = f_{c,90,lay,k} \cdot k_{c,90} = 3 \cdot 1,8 = 5,4 \ N/mm^2$

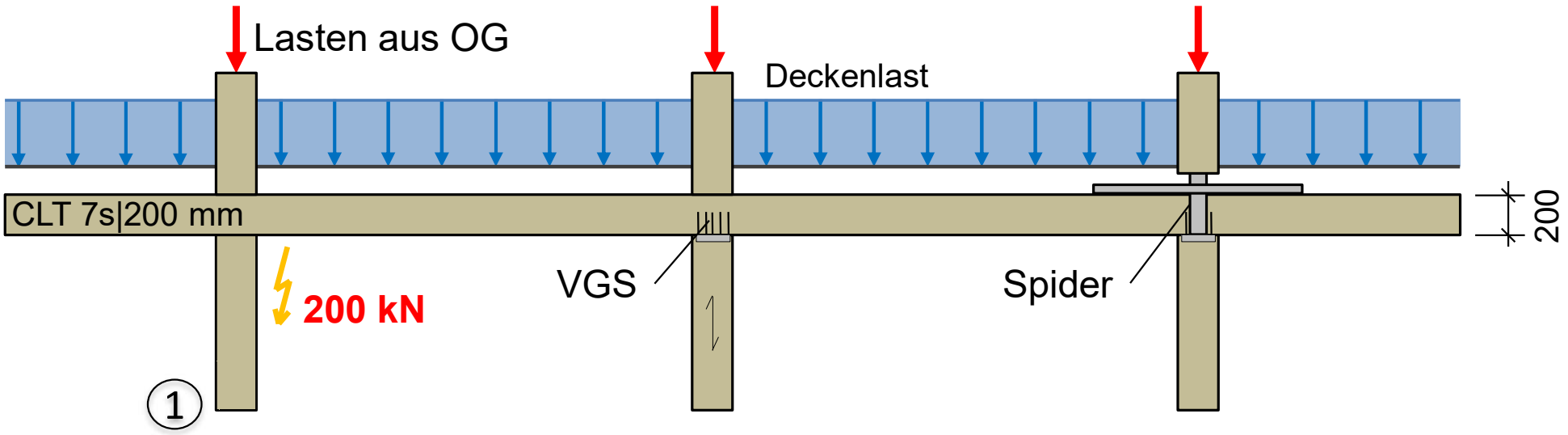
universität innsbruck

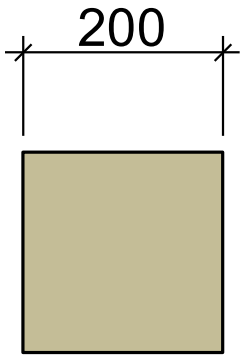
① REFERENZ - unverstärkt



universität innsbruck

ERGEBNISSE

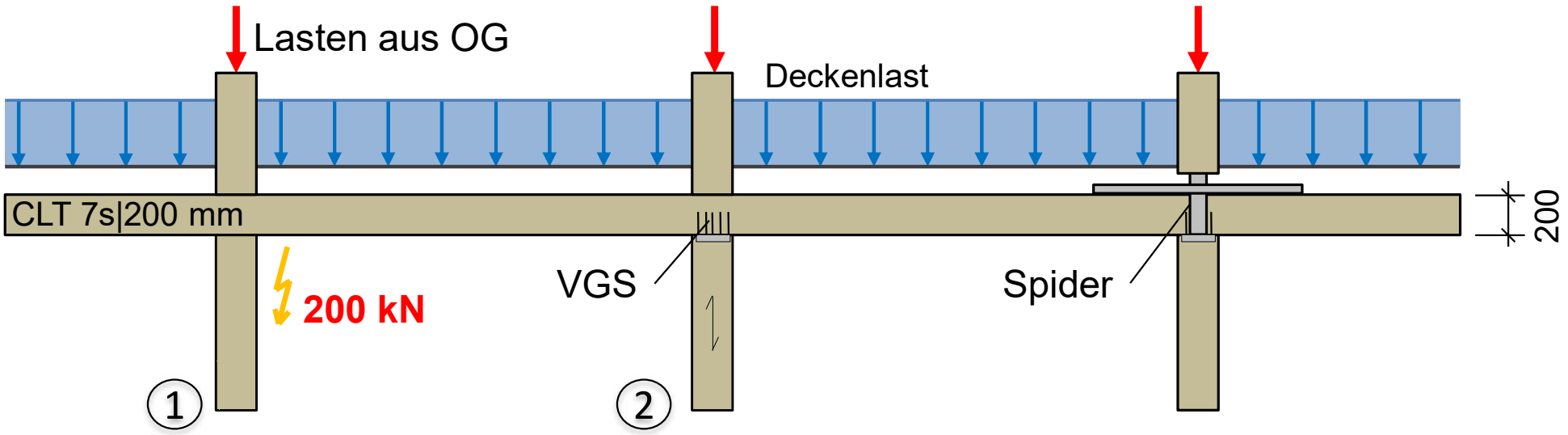


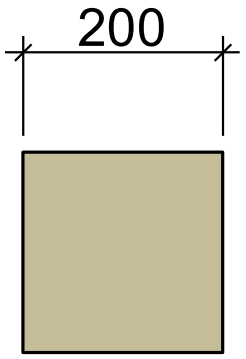


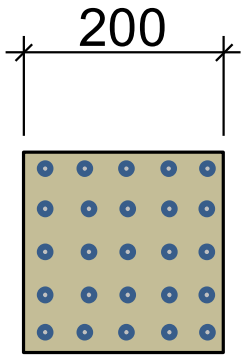
A_{Holz}=400 cm²

universität innsbruck

ERGEBNISSE





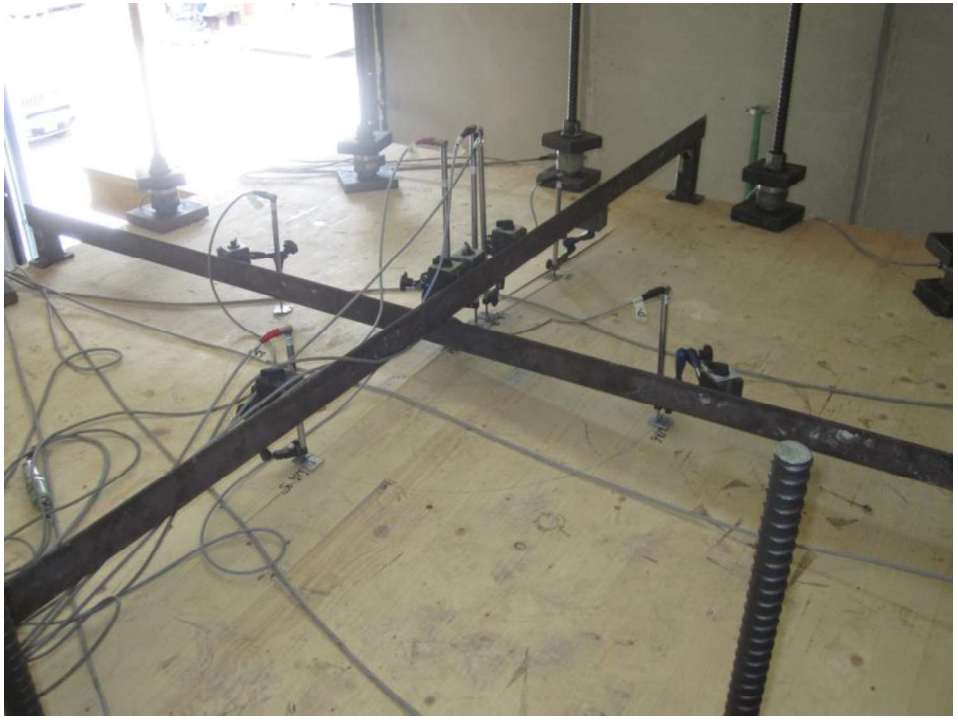


A_{Holz}=400 cm²

A_{Holz}=400 cm²

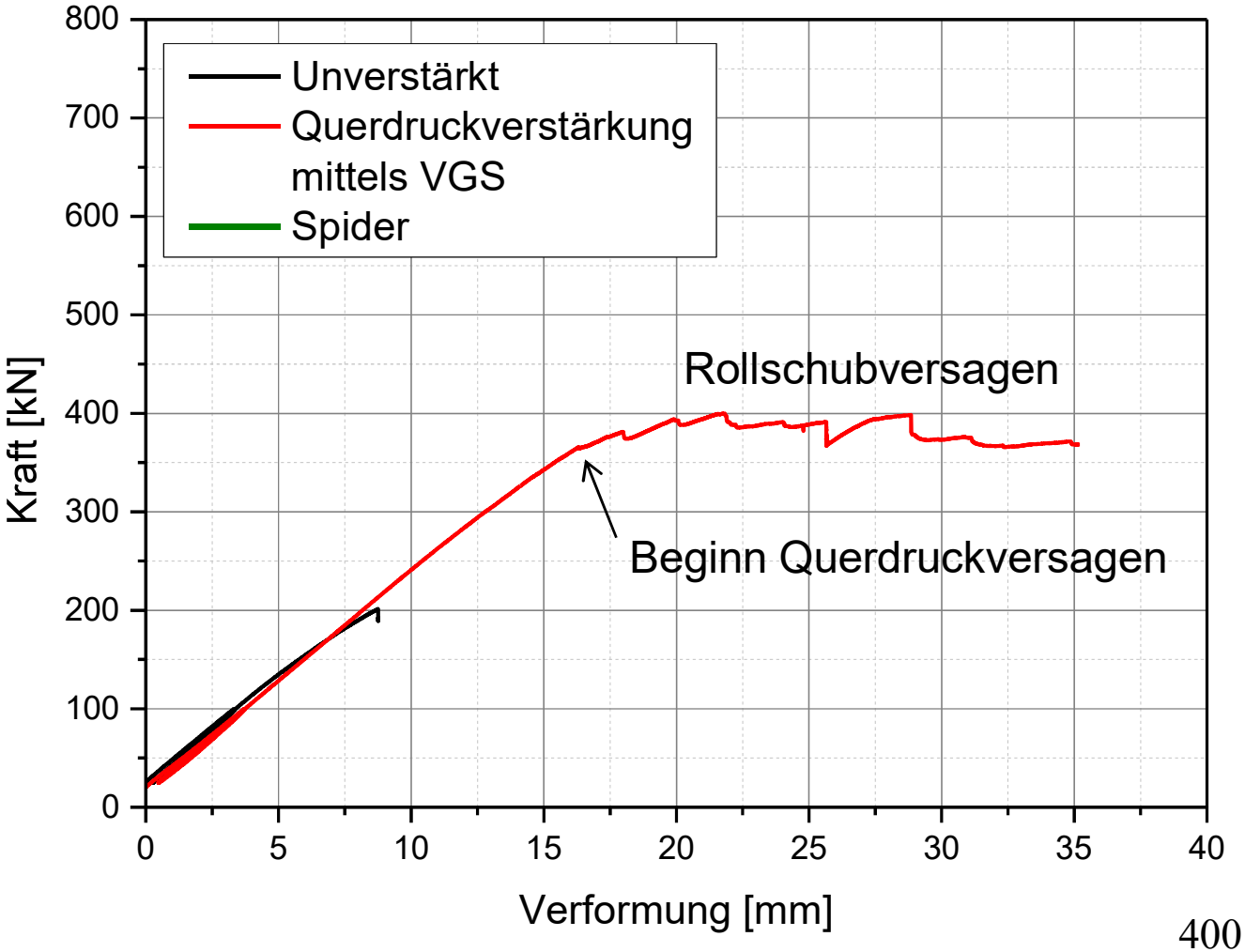
universität innsbruck

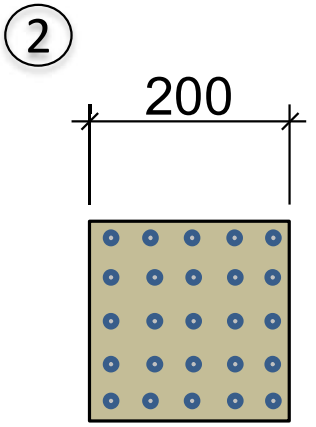
② VERSTÄRKUNG MITTELS VGS



universität innsbruck

② VERSTÄRKUNG MITTELS VGS





A_{Holz}=400 cm²

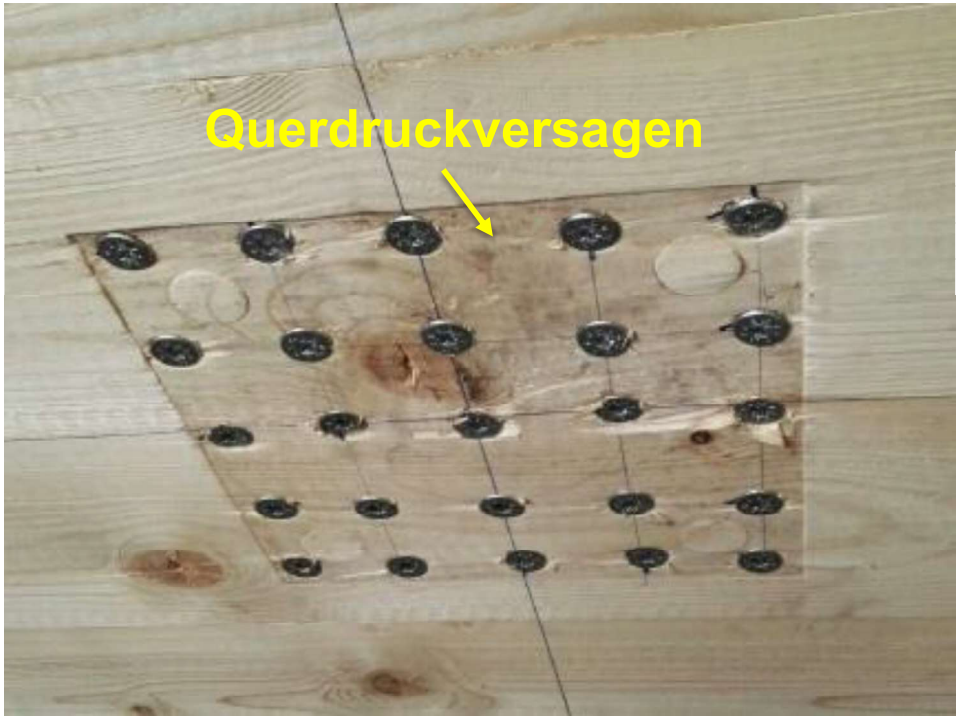
$$\sigma_{c,90} = \frac{400}{200^2} \cdot 10^3 = 10 \ \ N/mm^2$$

universität
innsbruck

② VERSTÄRKUNG MITTELS VGS

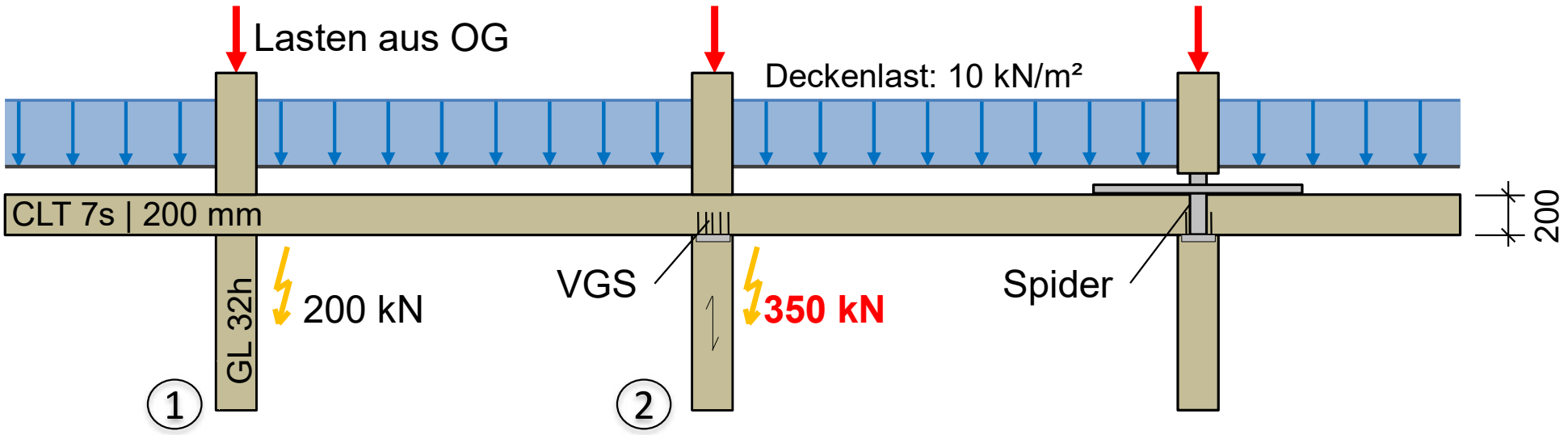
universität innsbruck

② VERSTÄRKUNG MITTELS VGS



universität innsbruck

ERGEBNISSE

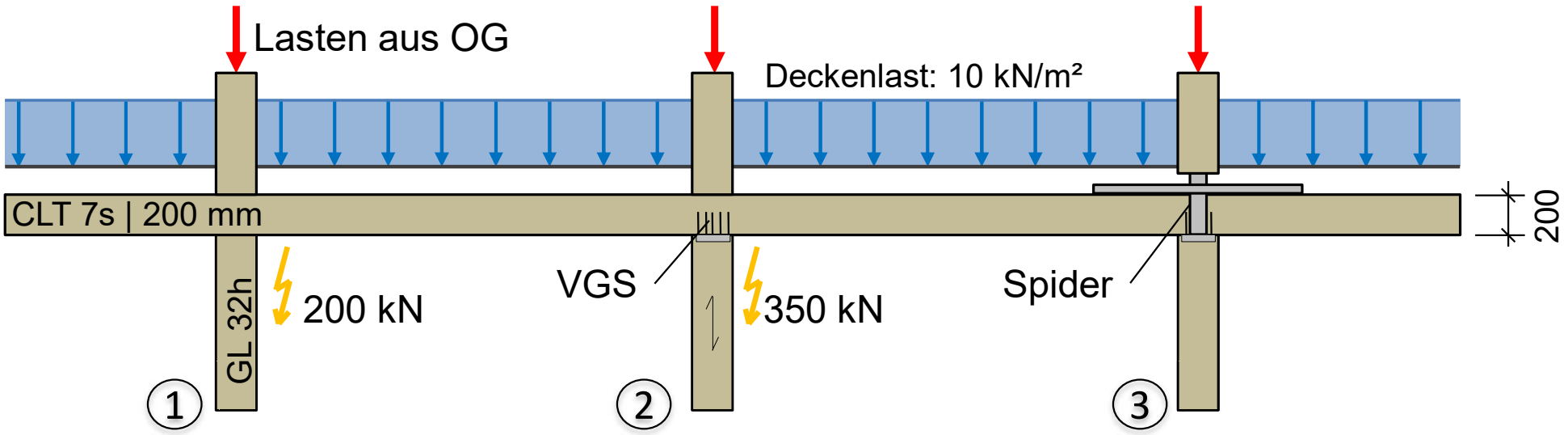


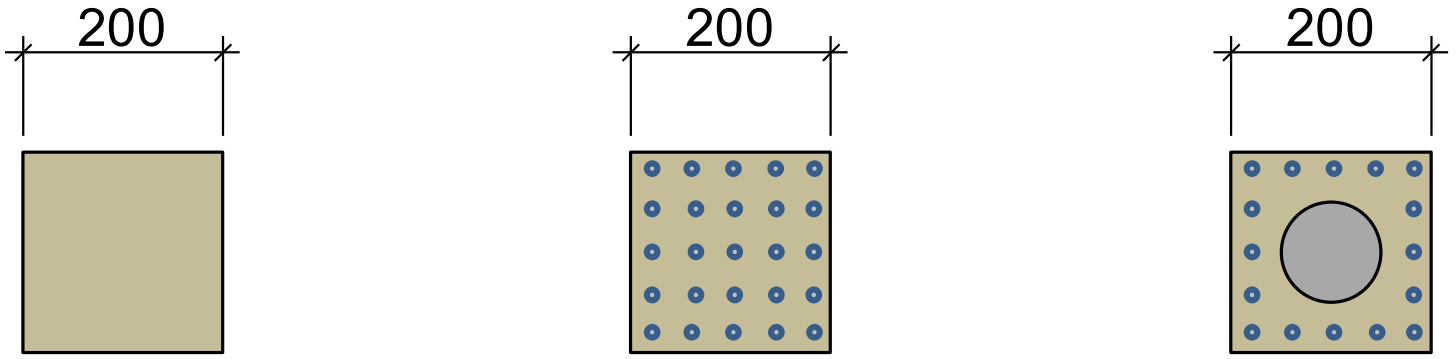
A_{Holz}=400 cm²

A_{Holz}=400 cm²

universität innsbruck

ERGEBNISSE





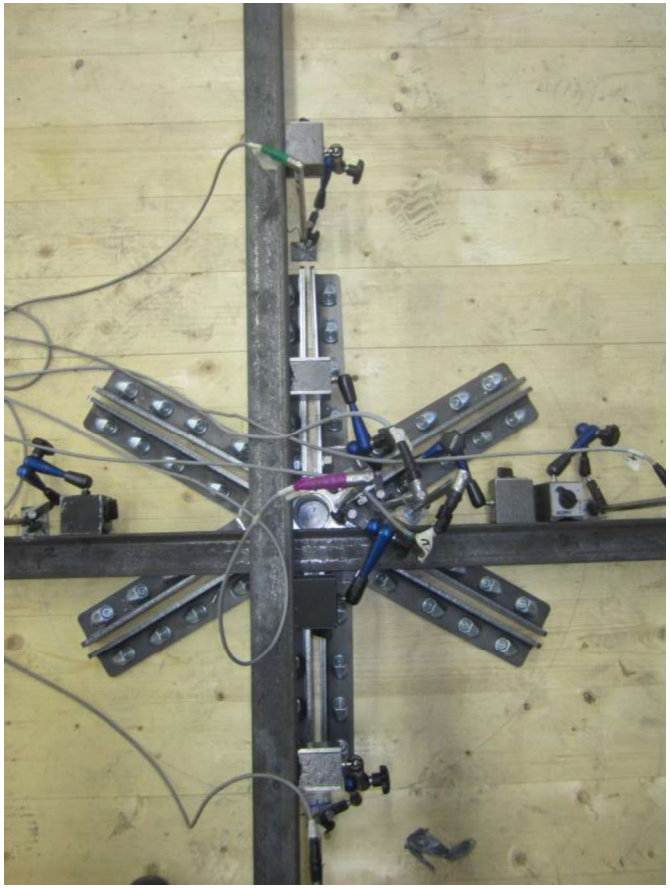
A_{Holz}=400 cm²

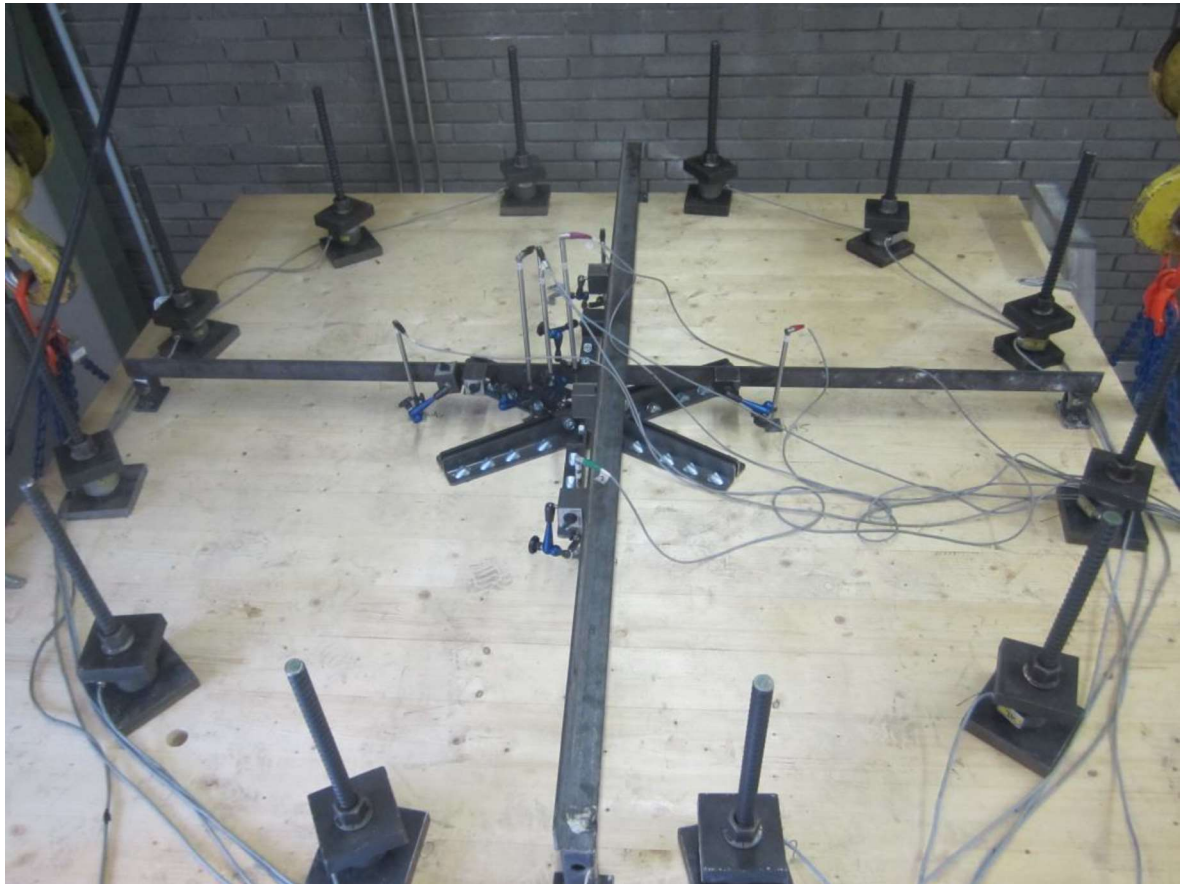
A_{Holz}=400 cm²

A_{Holz}=321 cm²

universität
innsbruck

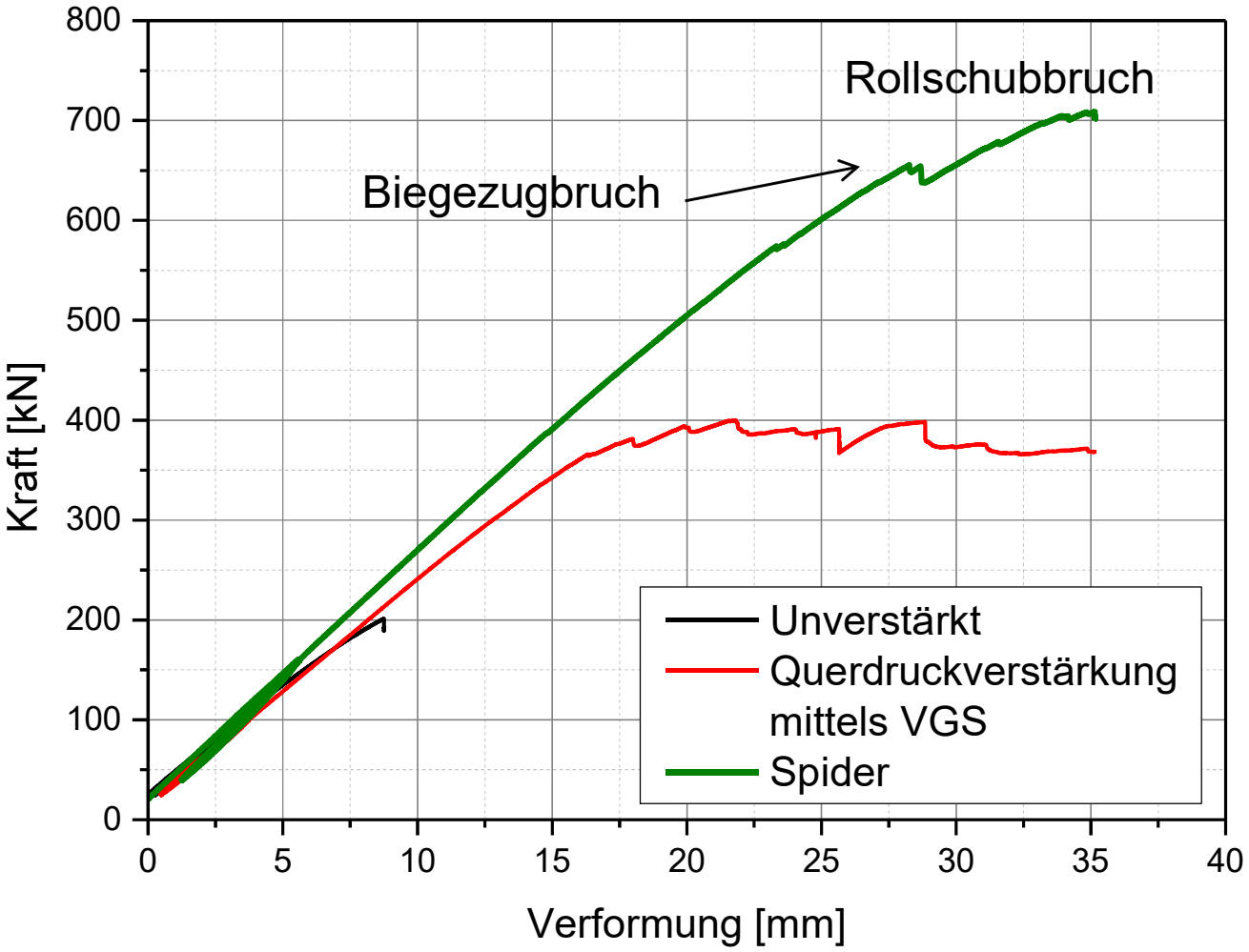
③ SPIDER CONNECTOR - VERSUCHSAUFBAU

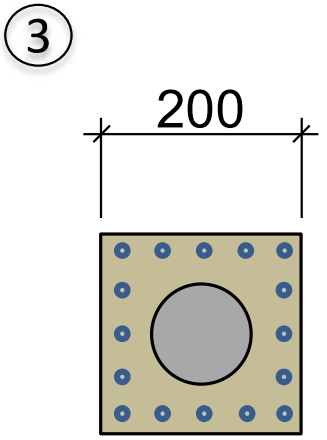




universität innsbruck

③ SPIDER CONNECTOR

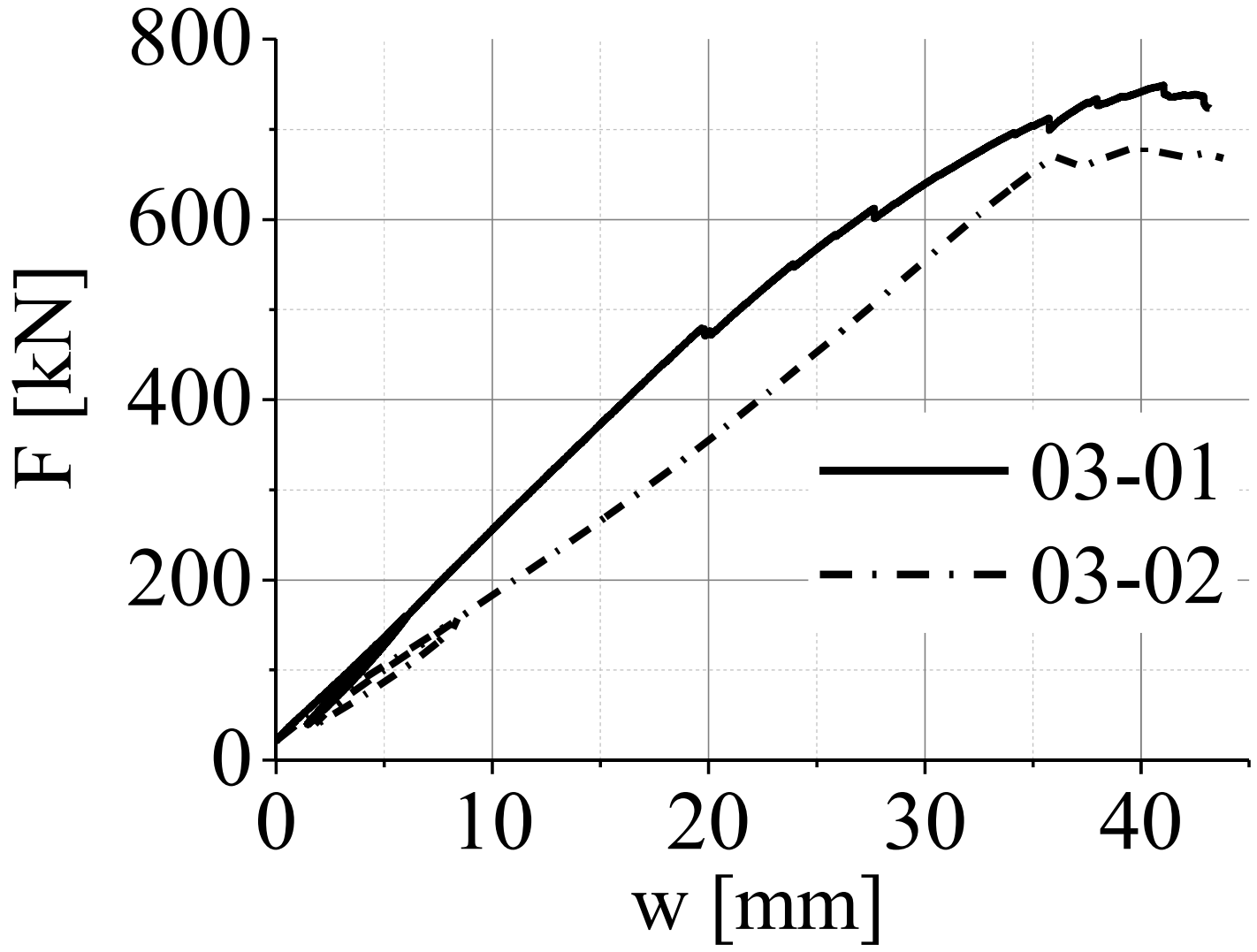




A_{Holz}=321 cm²

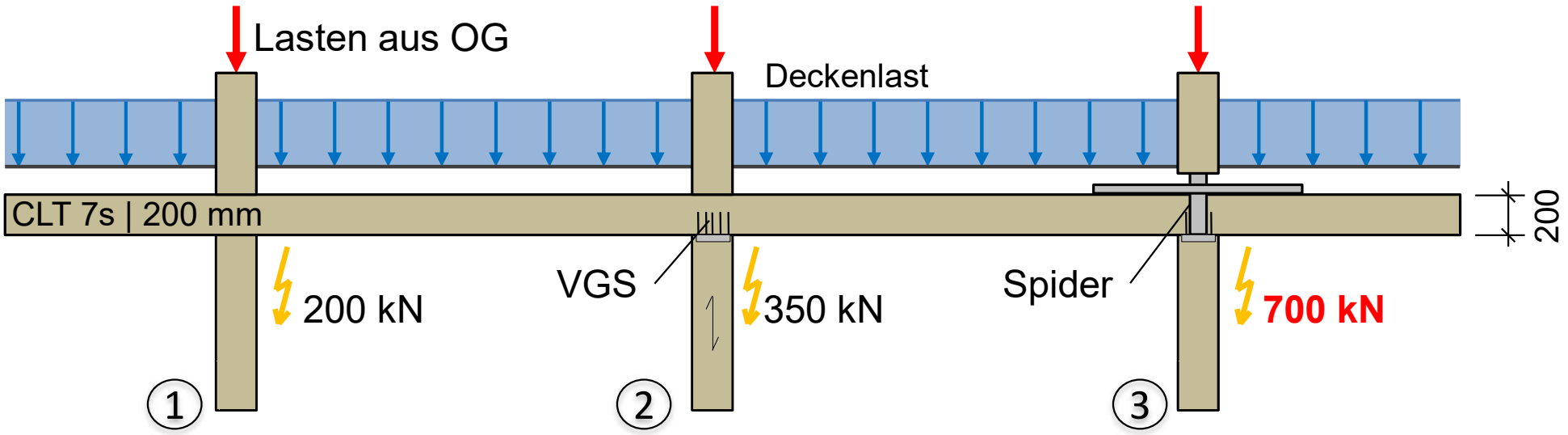
universität innsbruck

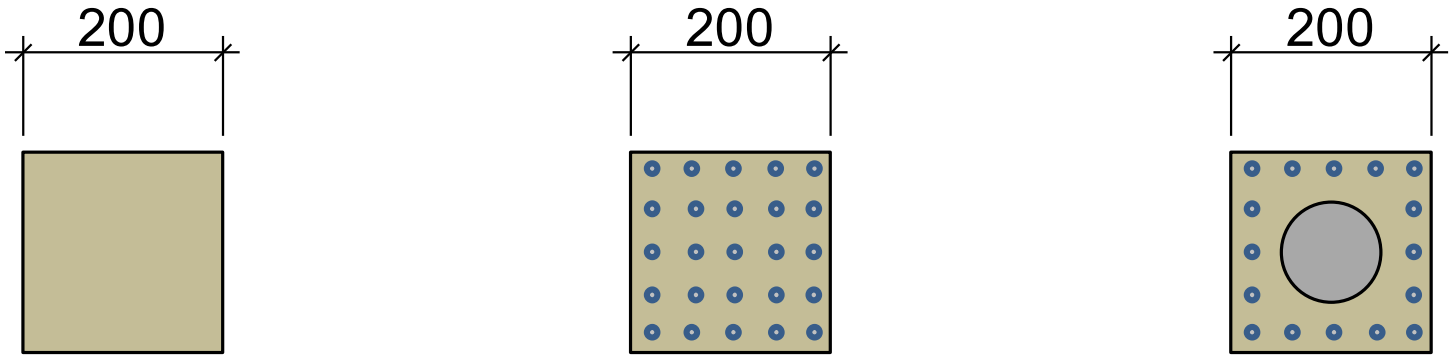
③ SPIDER CONNECTOR | DUKTILITÄT



universität innsbruck

ERGEBNISSE





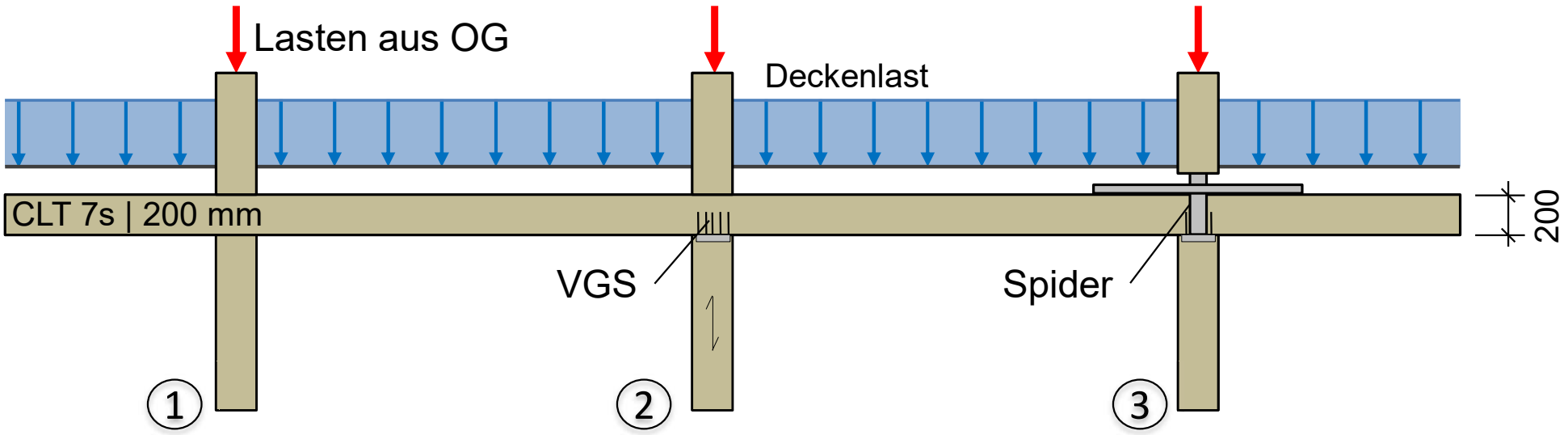
A_{Holz}=400 cm²

A_{Holz}=400 cm²

A_{Holz}=321 cm²

universität innsbruck

CHARAKTERISTISCHE KENNWERTE



$$F_{est,Rk} = 170 \text{ kN}$$

$$F_{est,Rd} = k_{mod} \cdot \frac{F_{est,Rk}}{\gamma_M} = \underline{\underline{108 \text{ kN}}}$$

$$(A_e = 10 \text{ m}^2)$$

$$F_{est,Rk} = 300 \text{ kN}$$

$$F_{est,Rd} = \underline{\underline{192 \text{ kN}}}$$

$$(A_e = 18 \text{ m}^2)$$

$$F_{Rk} = 627 \text{ kN}$$

$$F_{Rd} = \underline{\underline{400 \text{ kN}}}$$

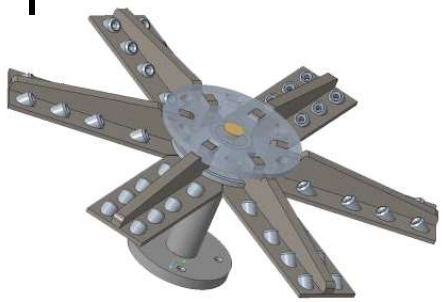
$$(A_e = 40 \text{ m}^2)$$

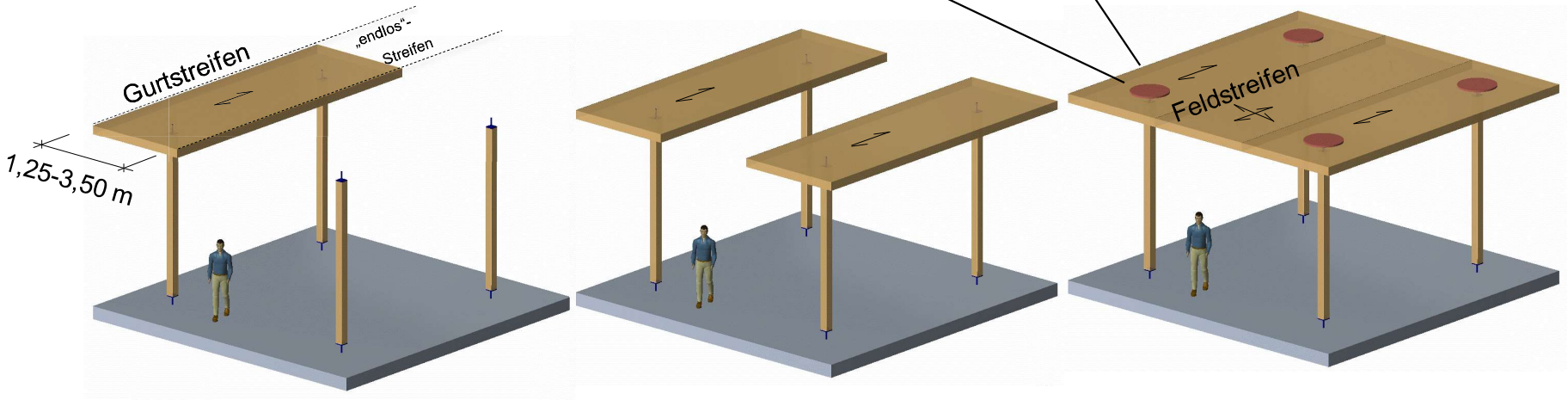
100 % → +78 % → +270 %

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | GESAMTKONZEPT

STEP 1

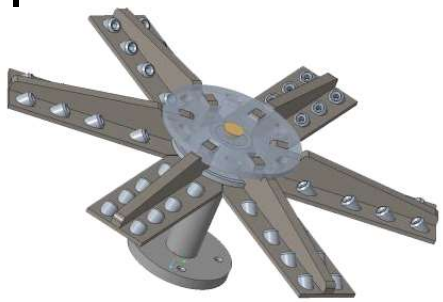




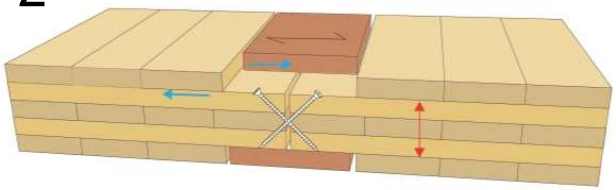
universität innsbruck

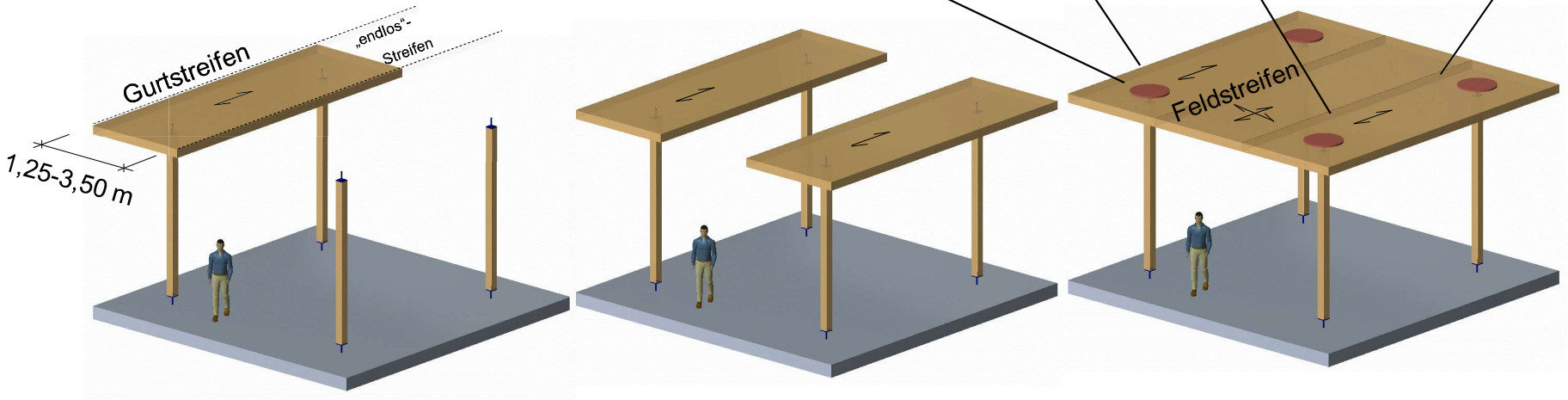
PUNKTGESTÜTZTE FLACHDECKEN | GESAMTKONZEPT

STEP 1



STEP 2

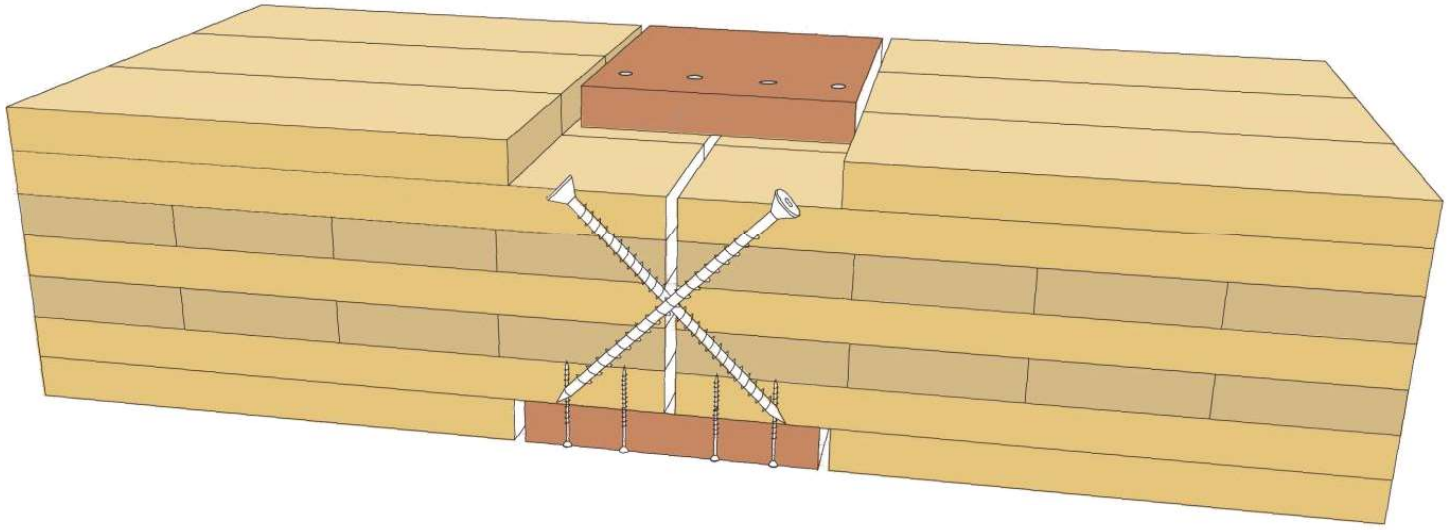




universität innsbruck

SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

- Schraubenpressverklebung



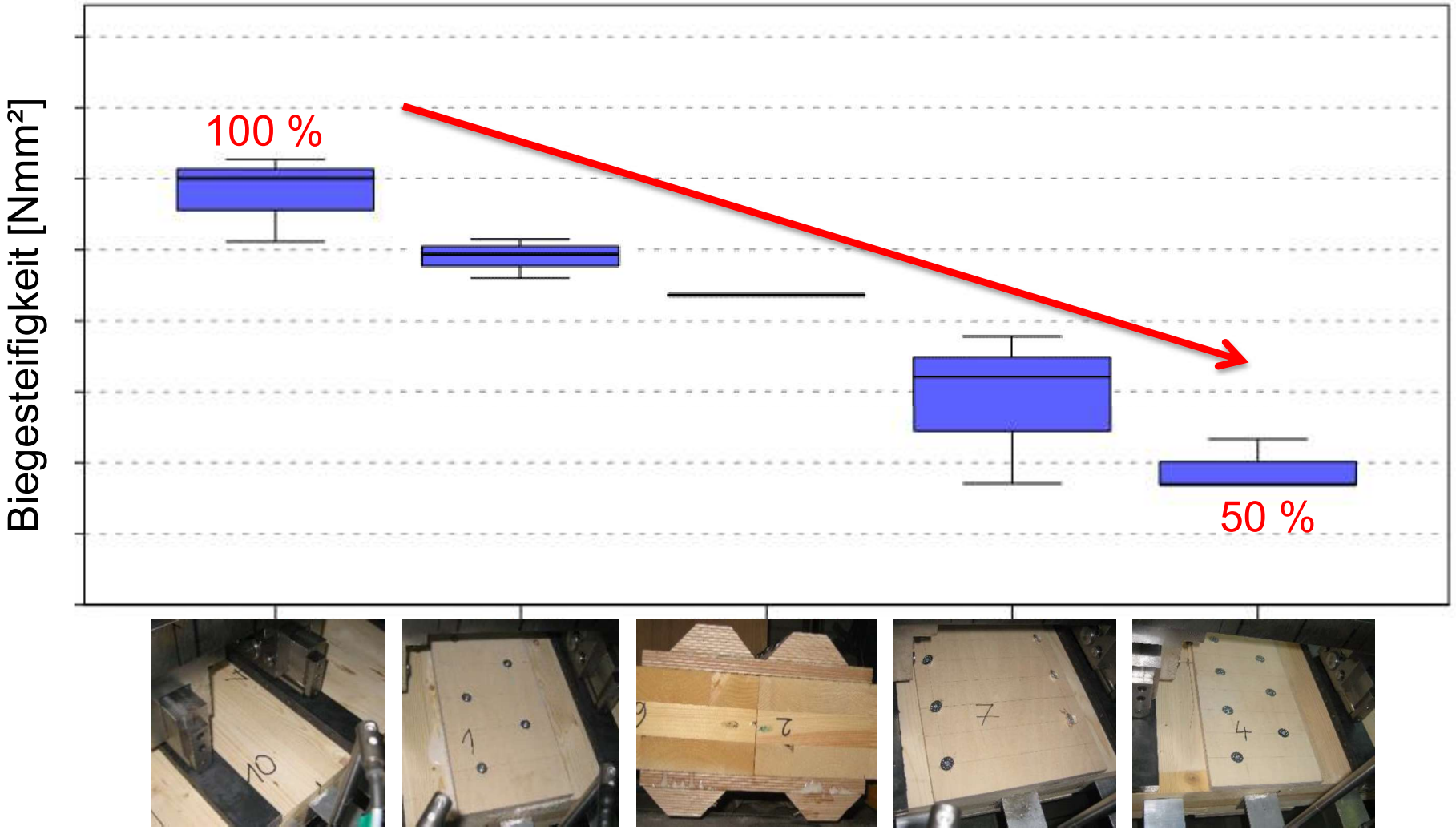
universität
innsbruck

SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

VERSUCHE

universität innsbruck

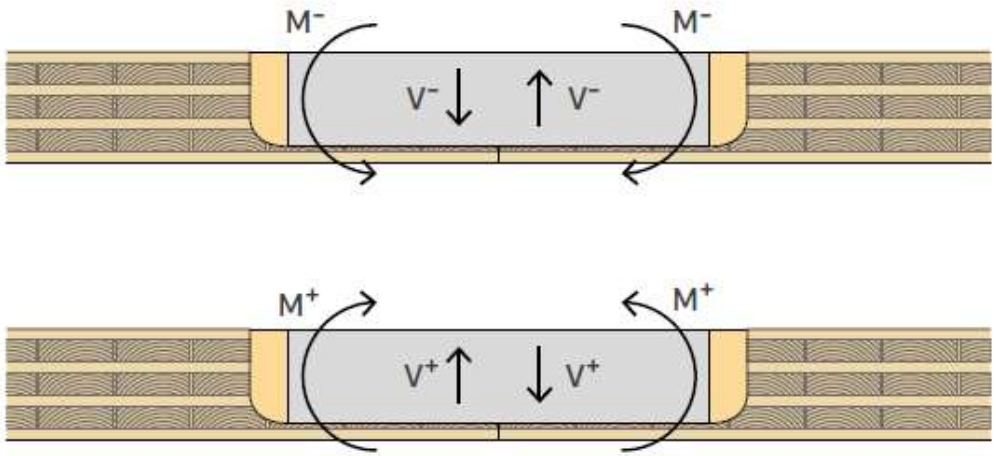
SPIDER CONNECTOR SYSTEM | PLATTENSTOSS



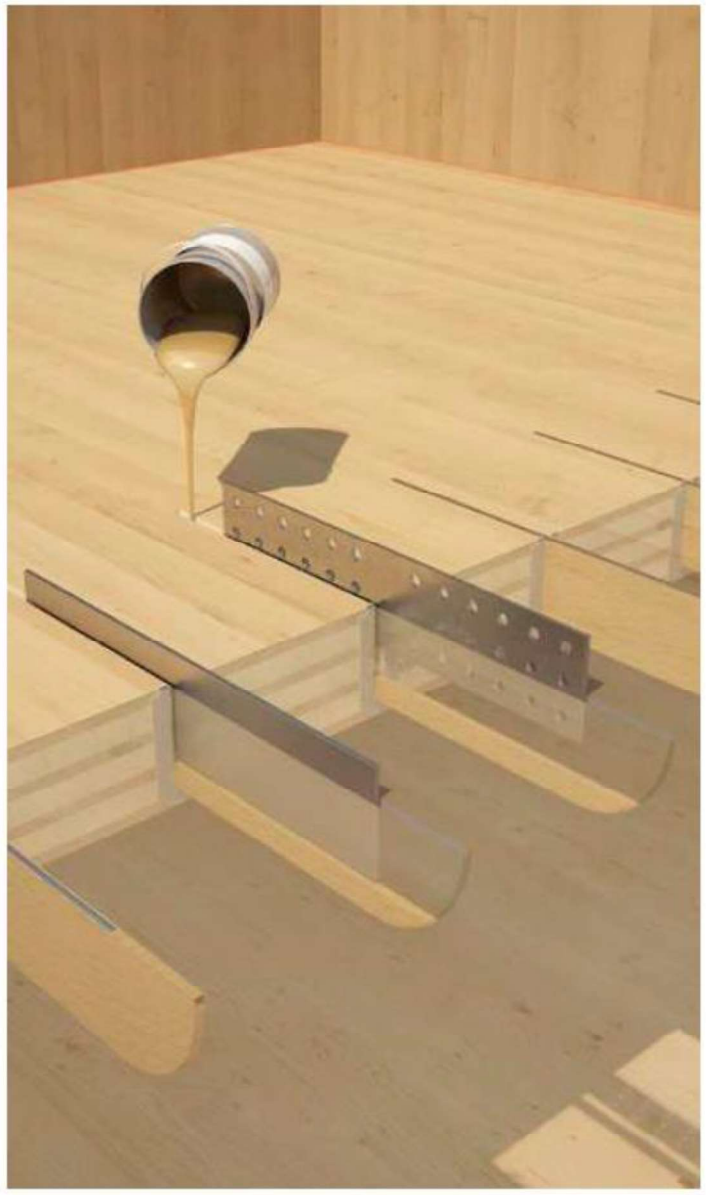
universität innsbruck

SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

- Eingeklebte Stahlbleche



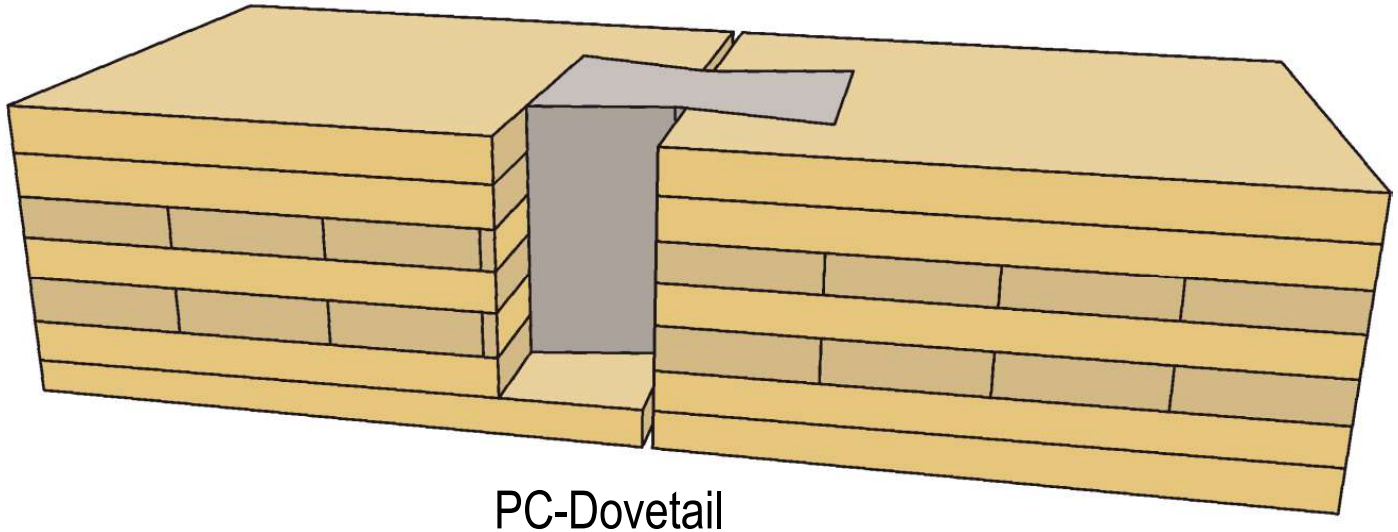
$$\tau_{tor,d} = \frac{3 \cdot M_d}{a^3}$$



universität innsbruck

SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

- REAKTIONSHARZ



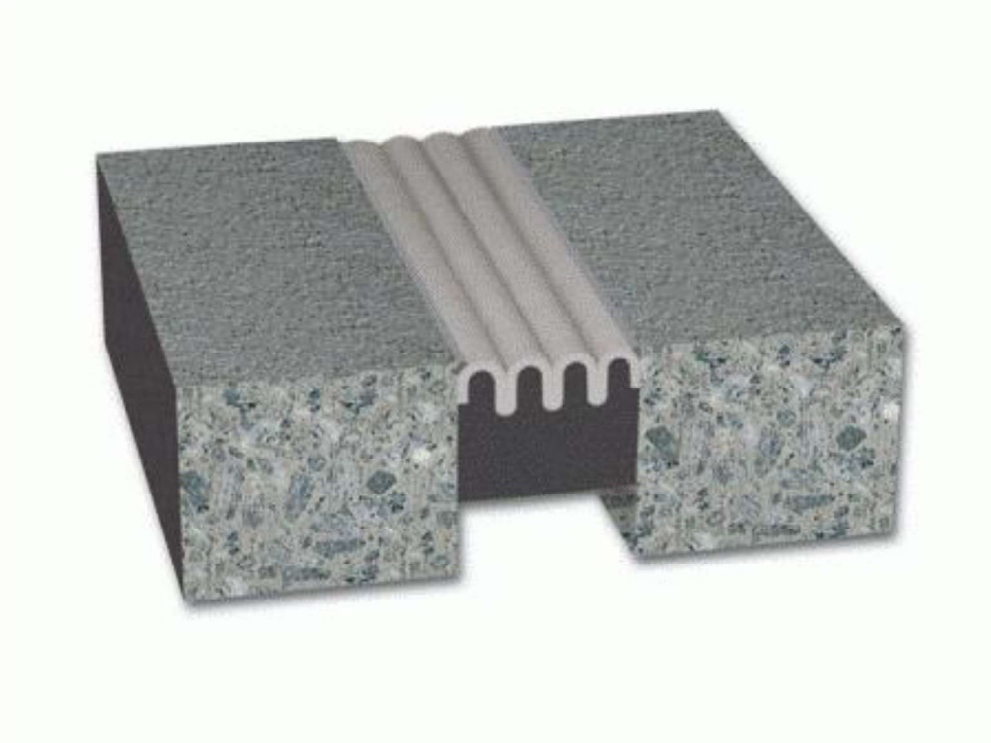
PC-Dovetail

- Harz
- Härter
- Sand
- …

universität innsbruck

SPIDER CONNECTOR SYSTEM | REAKTIONSHARZE

- Polymerbeton ist im Bauwesen weit verbreitet




BODAN

universität innsbruck

SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

- Reaktionsharz: Konsistenz beliebig einstellbar

universität
innsbruck

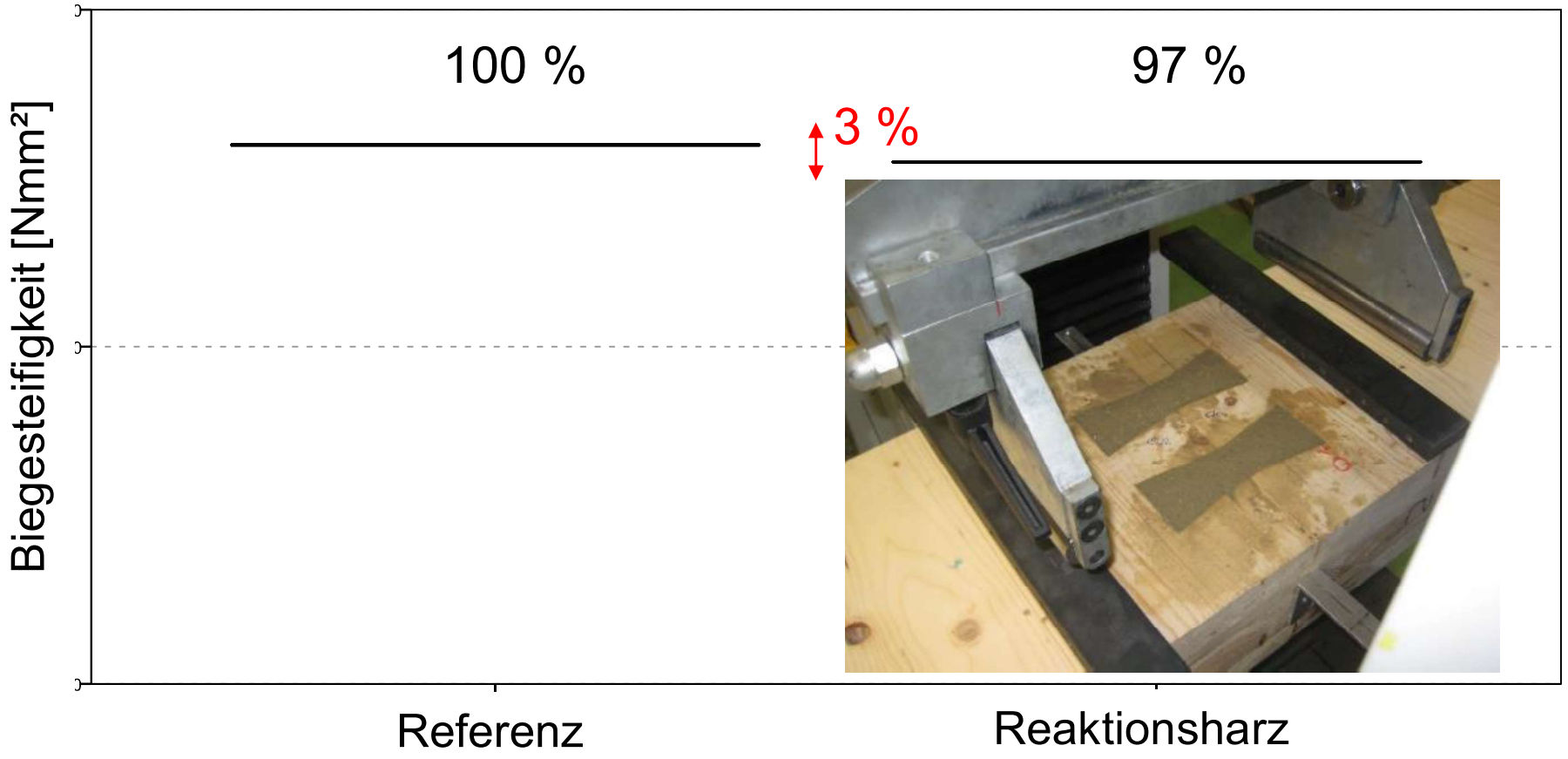
universität
innsbruck

REAKTIONSHARZ | VERSUCHE IM LABOR

universität innsbruck

SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

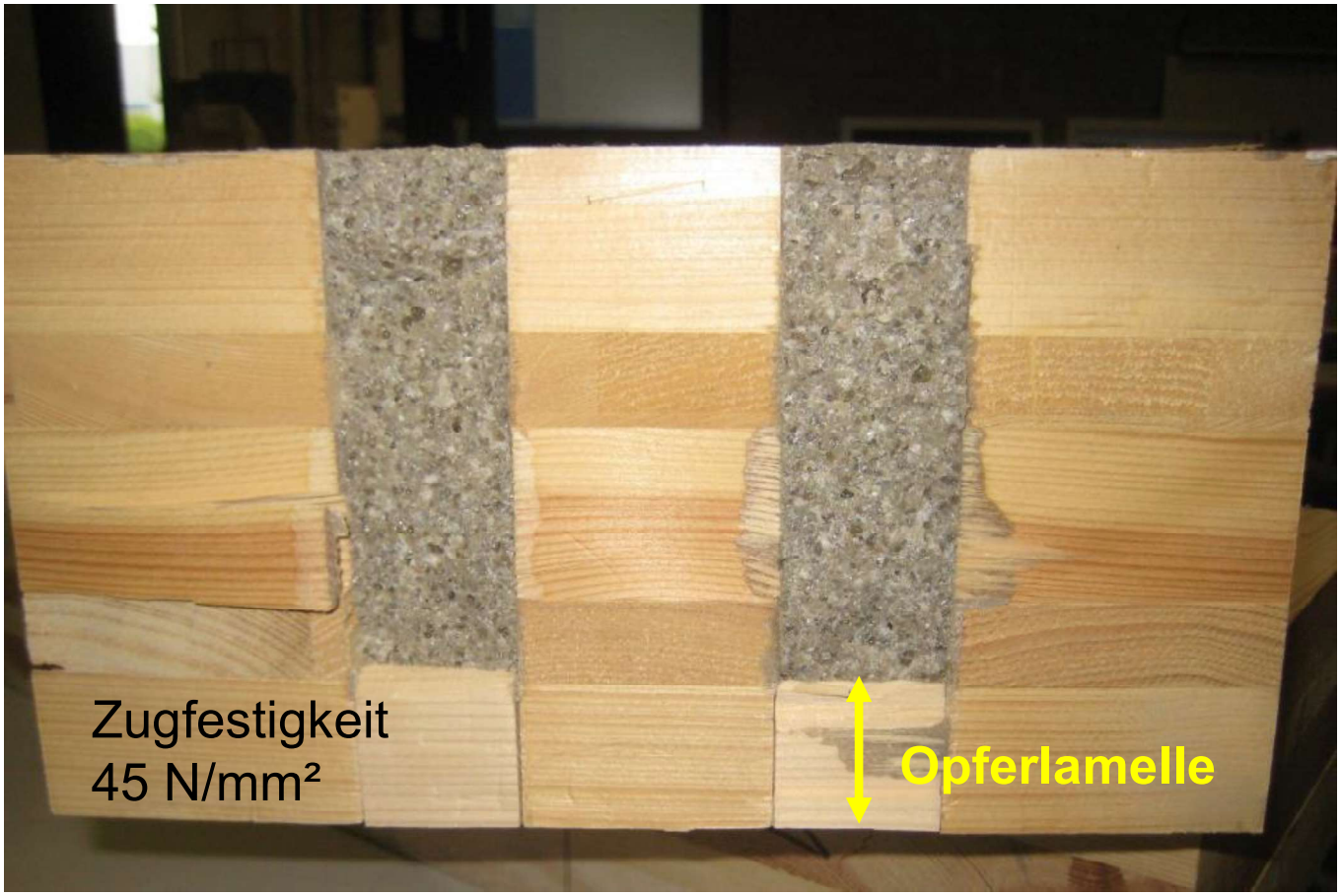
- REAKTIONSHARZ: Biegesteifigkeit



universität innsbruck

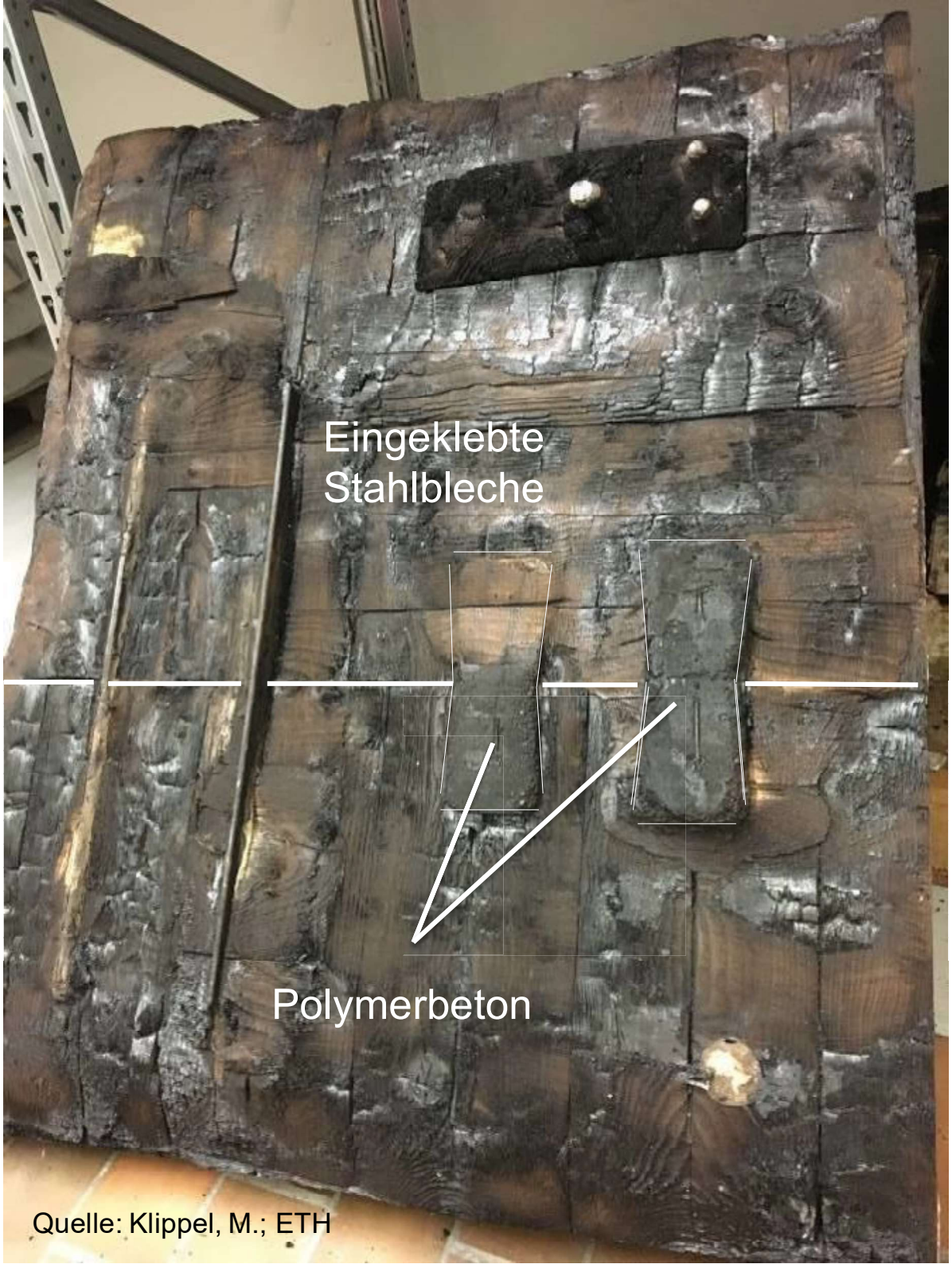
SPIDER CONNECTOR SYSTEM | PLATTENSTOSS

PC-DOVETAIL: Brandschutz



Quelle: Klippel, M.; ETH

Quelle: Klippel, M.; ETH

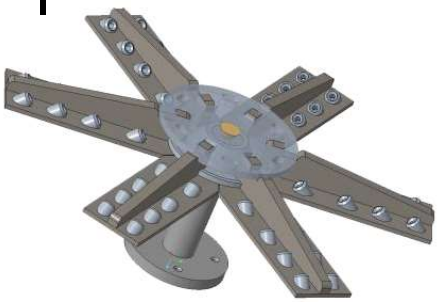


Quelle: Klippel, M.; ETH

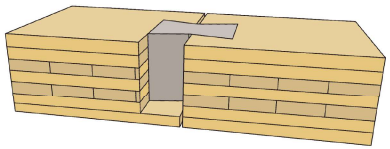
universität innsbruck

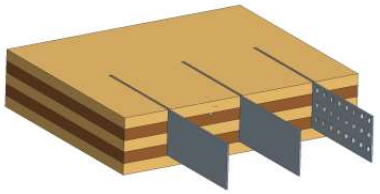
PUNKTGESTÜTZTE FLACHDECKEN | GESAMTKONZEPT

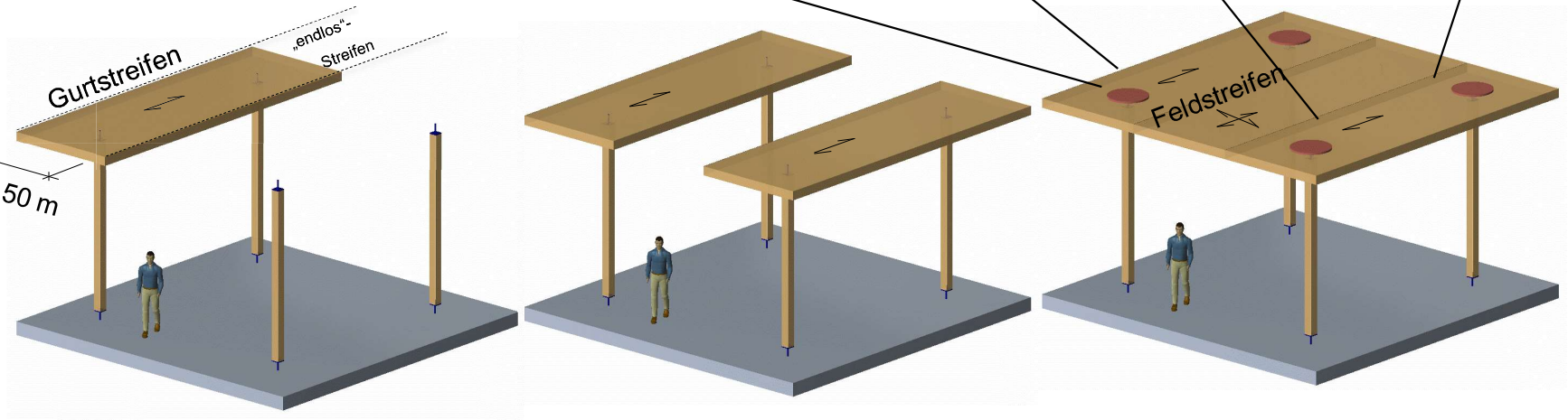
STEP 1



STEP 2







SPIDER CONNECTOR

(ETA-19/0700)

Stütze – Platte – Stütze

«Bauen ohne Unterzug»

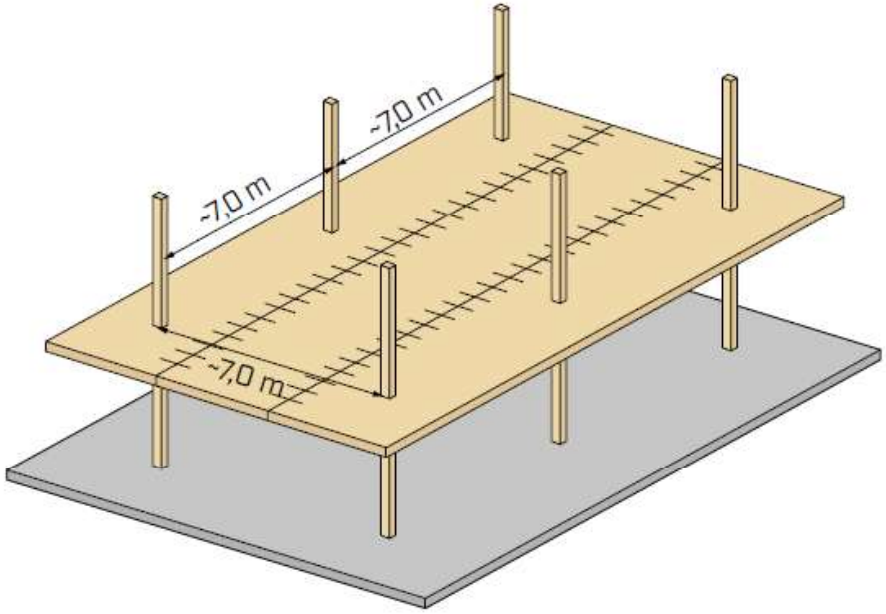
CLT–Platte: 16 - 32 cm

Stützenraster: bis 7,5 m

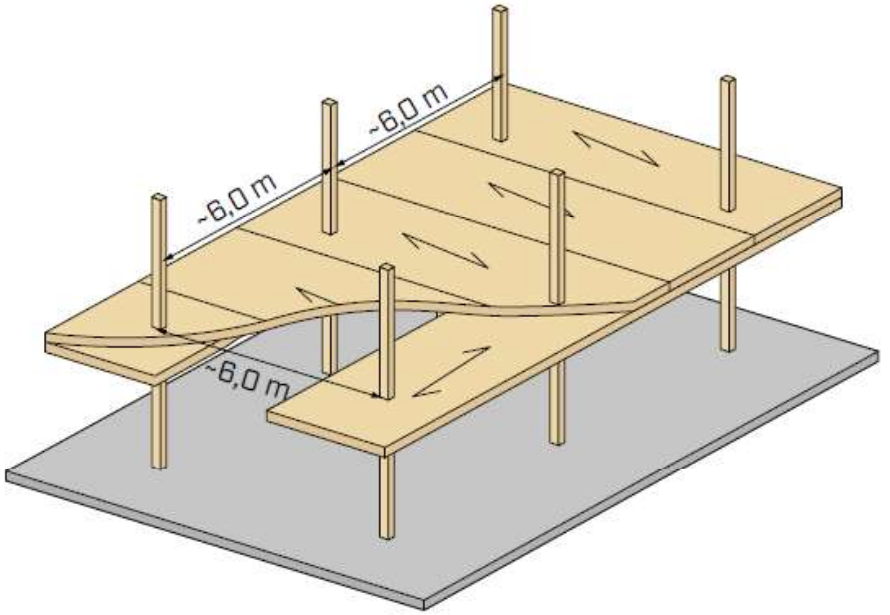
rothoblaas

universität innsbruck

SPIDER CONNECTOR

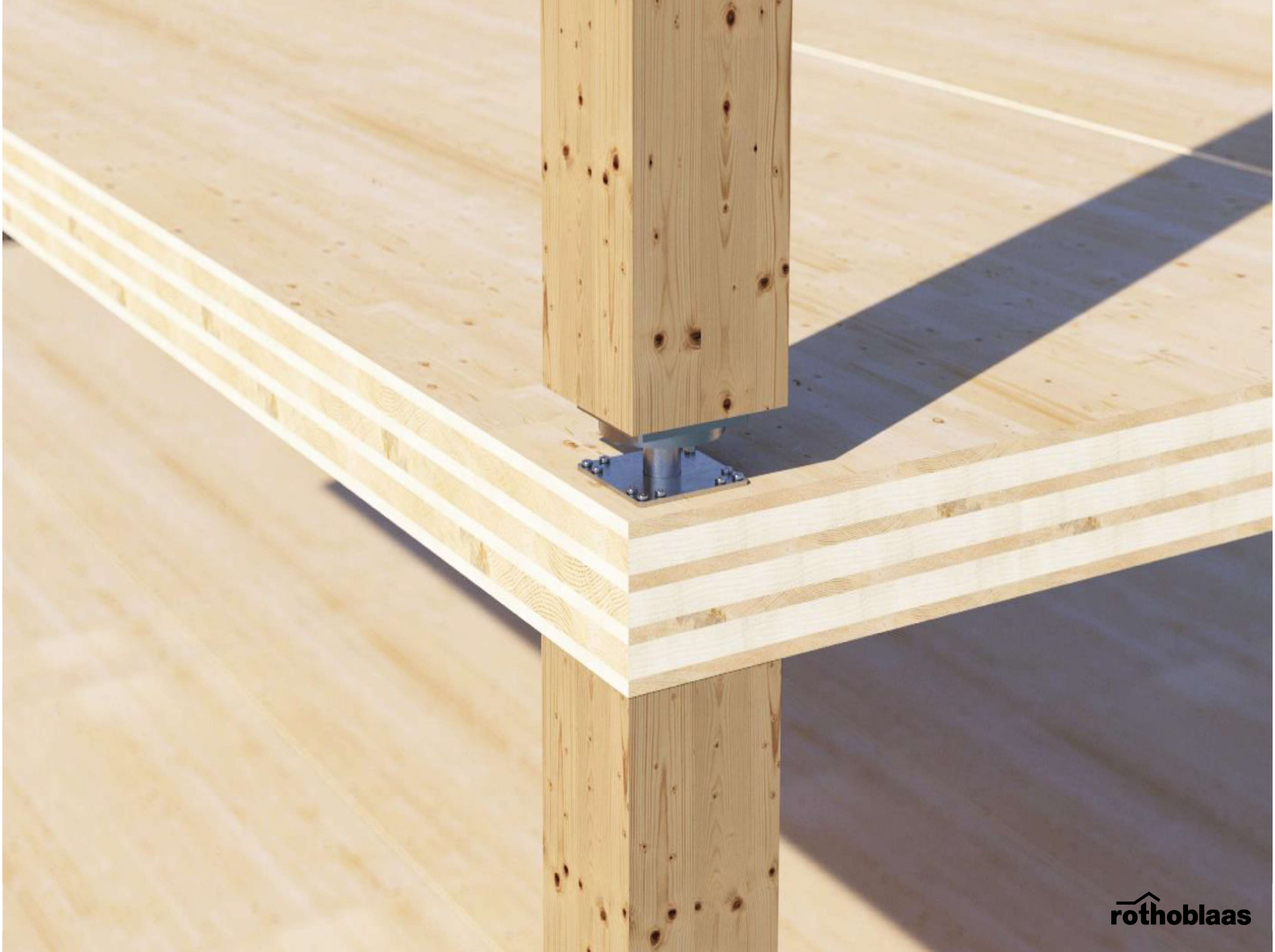


Flachdecke



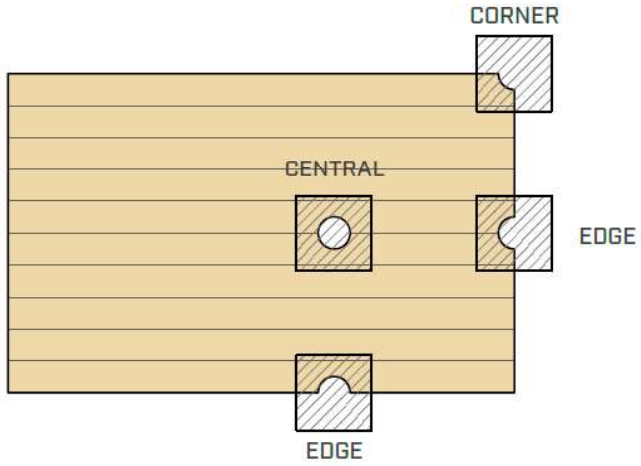
Kreuzweise Anordnung

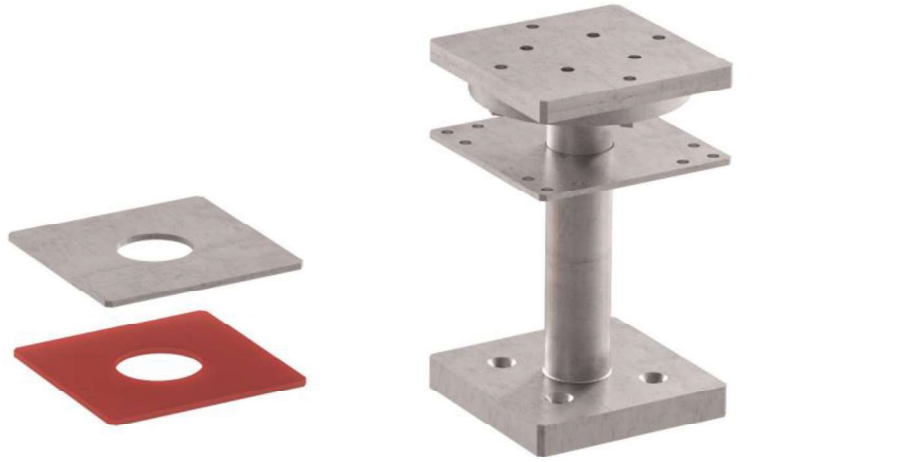

rothoblaas


rothoblaas

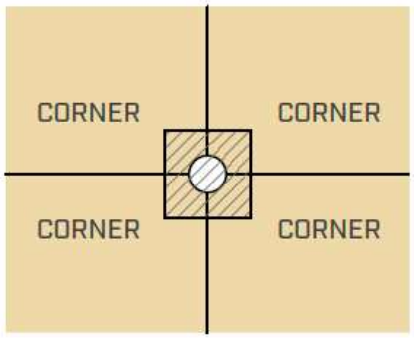
universität innsbruck

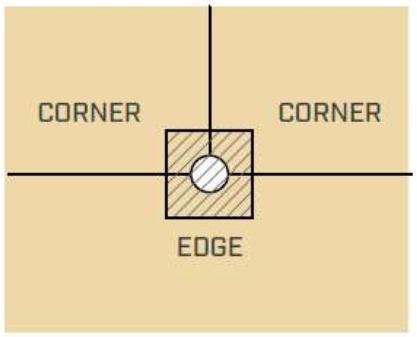
PILLAR CONNECTOR ETA-19/0700

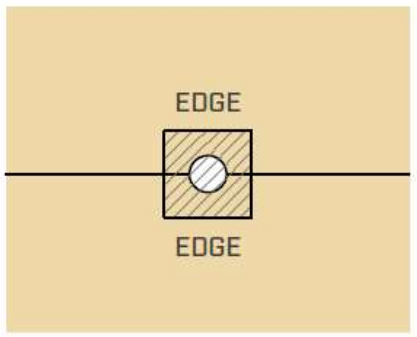




Auflagerkonfigurationen

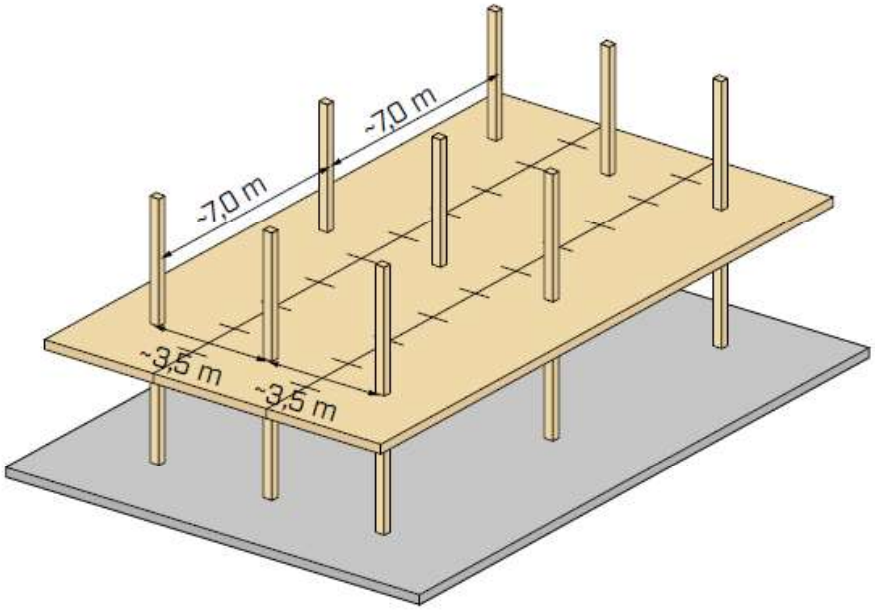




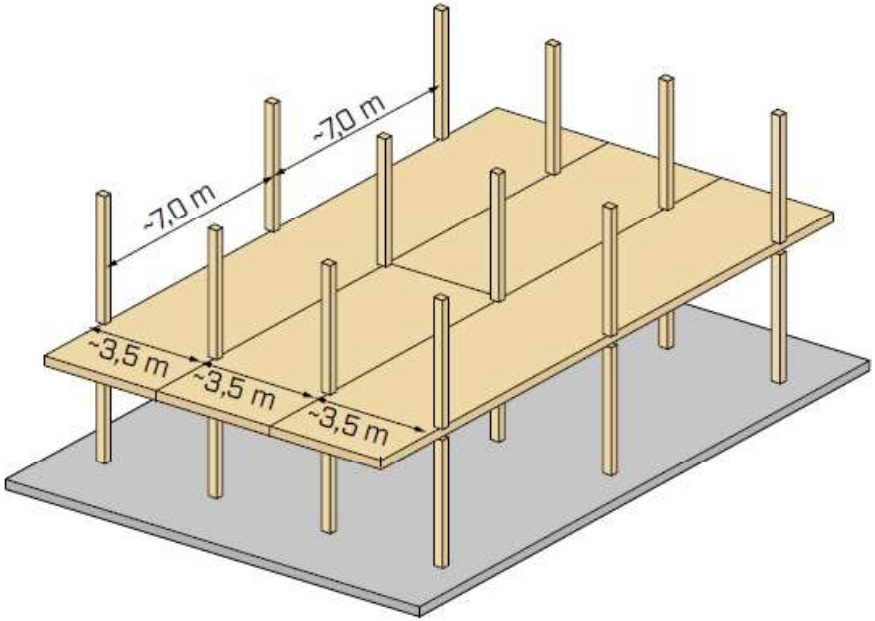


universität innsbruck

PILLAR CONNECTOR



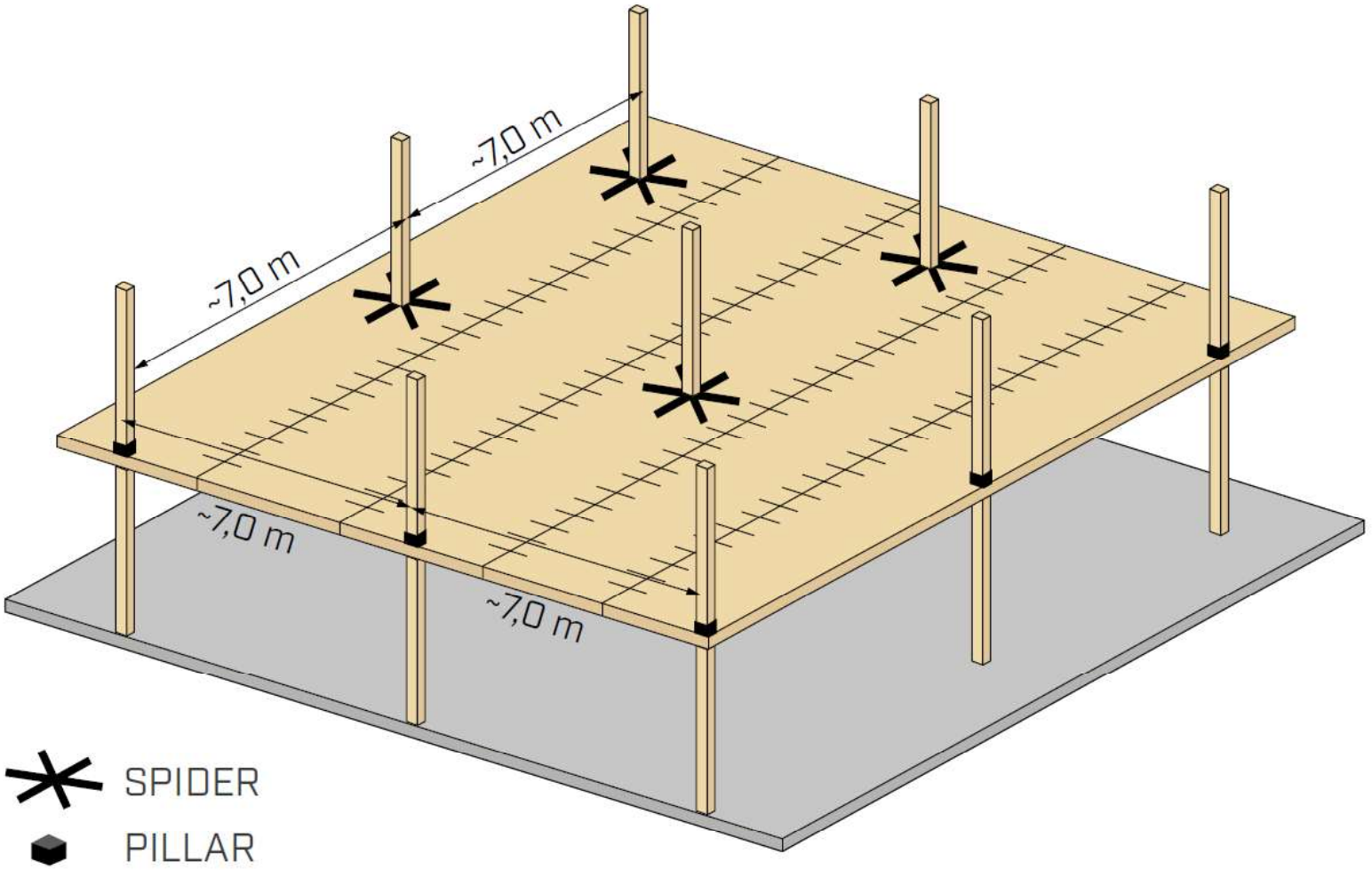
Zentrische Lagerung



Kanten/Ecken Lagerung

universität innsbruck

SPIDER CONNECTOR SYSTEM



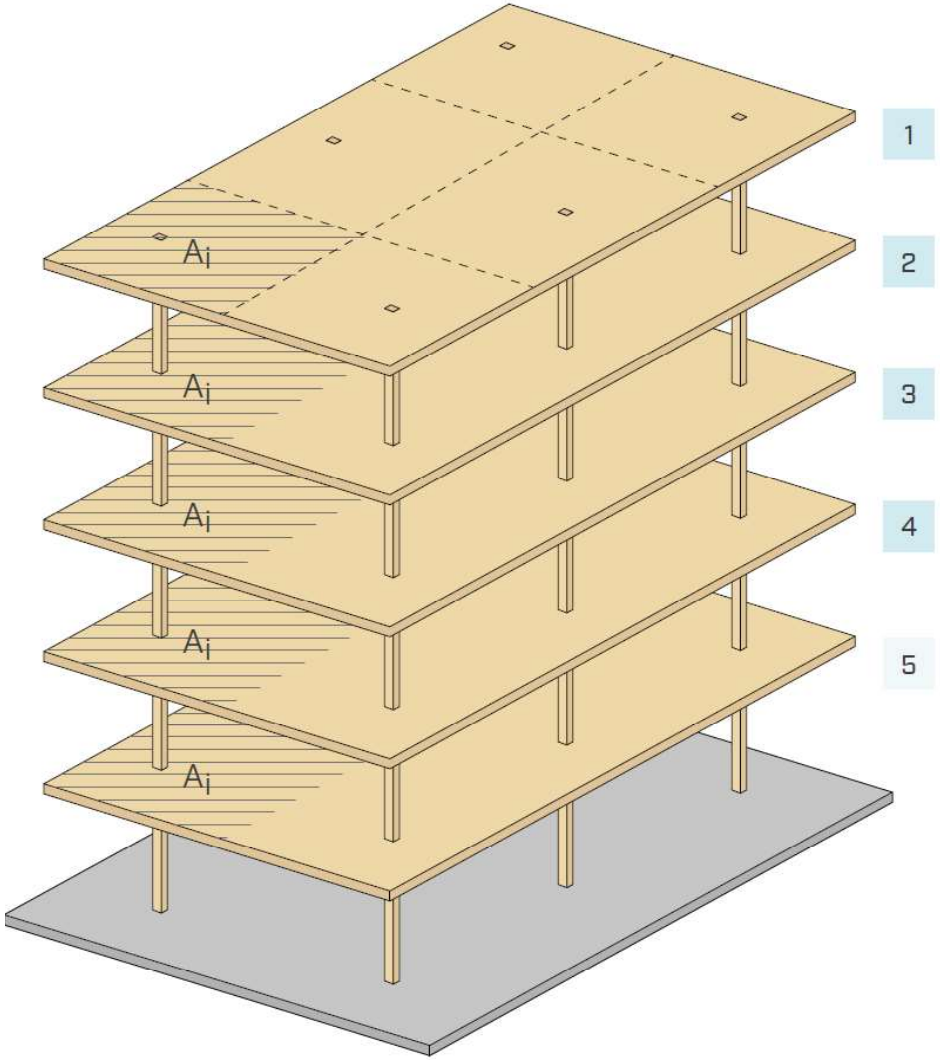
- Holzstützen, LVL
- Stahl
- Beton

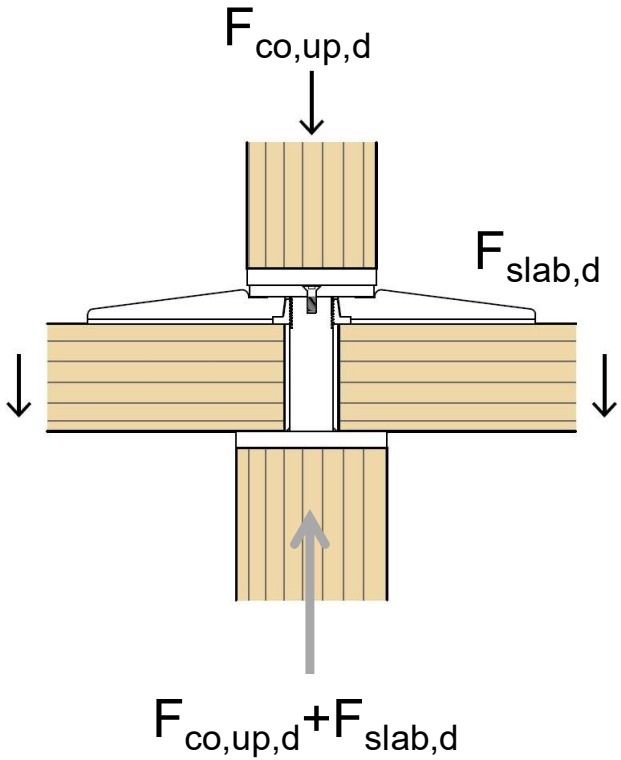
ETA-19/0700


rothoblaas

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG



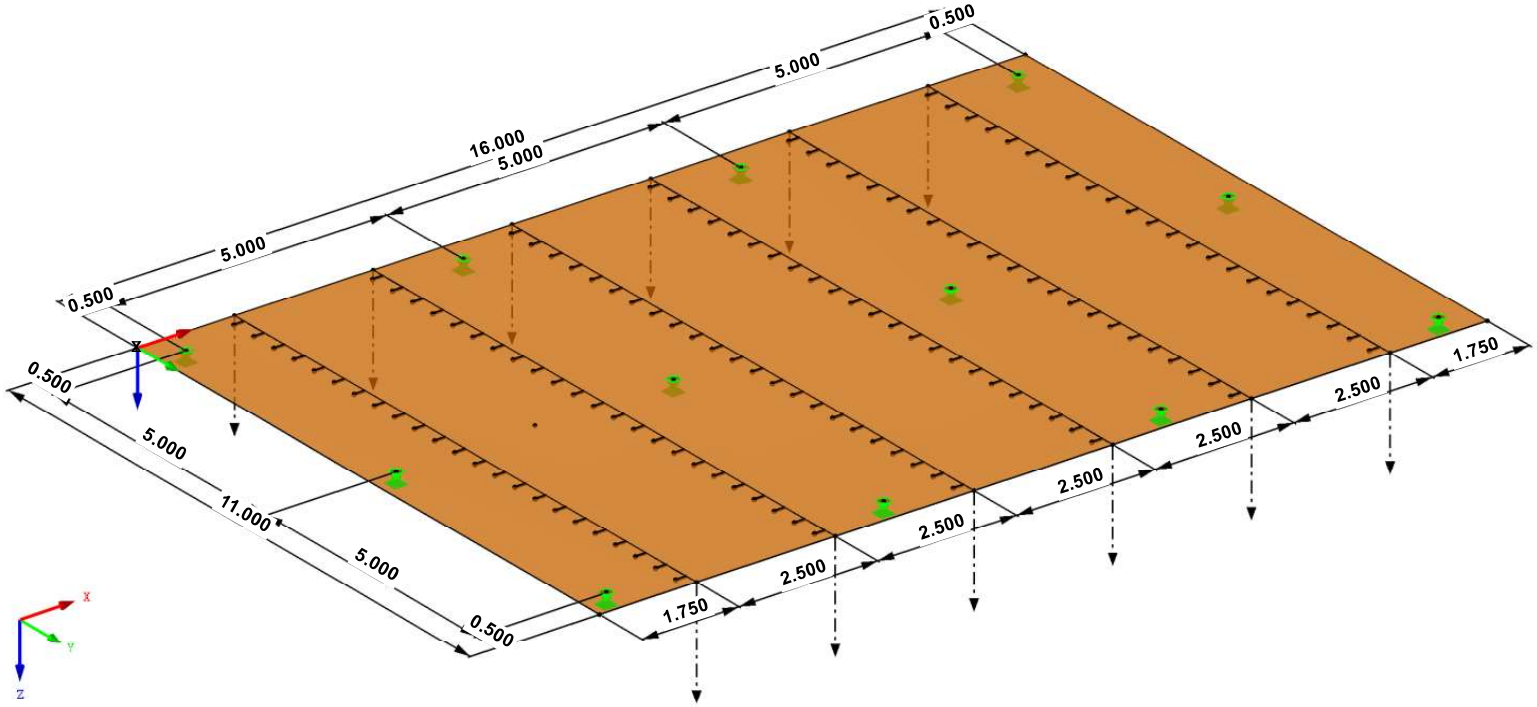


universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG

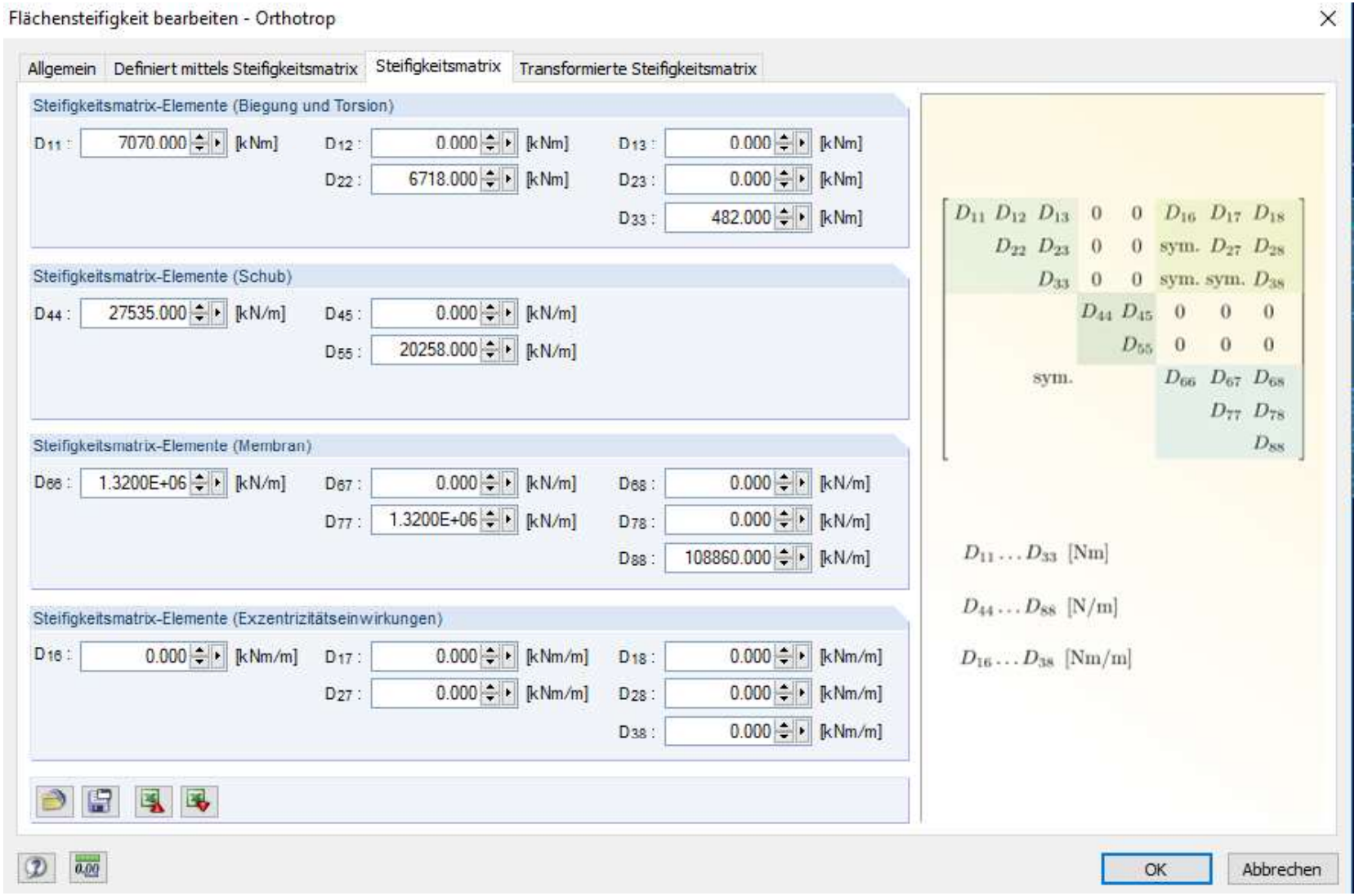
LF 3: Nutzlast

Isometrie



universität innsbruck

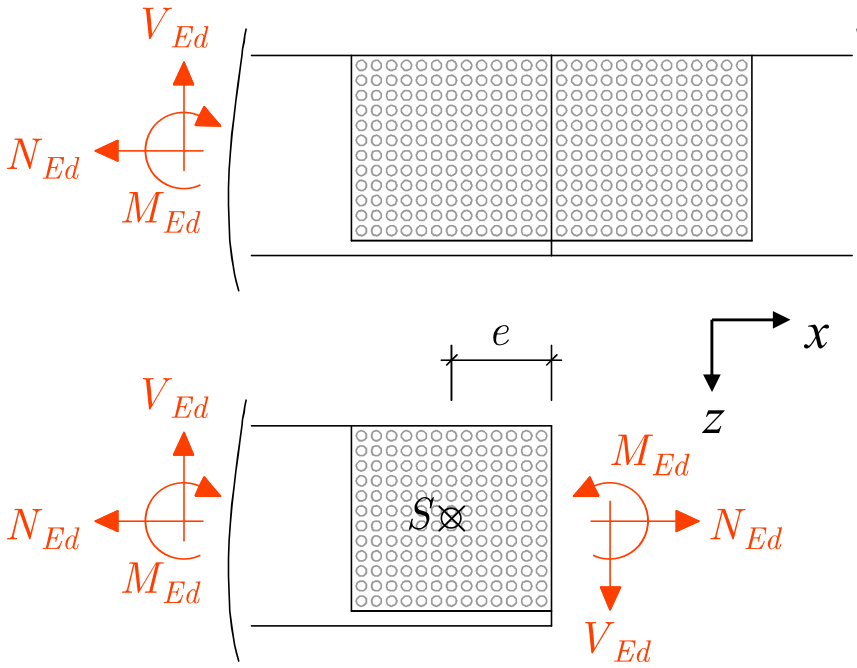
PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG



Quelle: DLUBAL Software GmbH; RFEM

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG



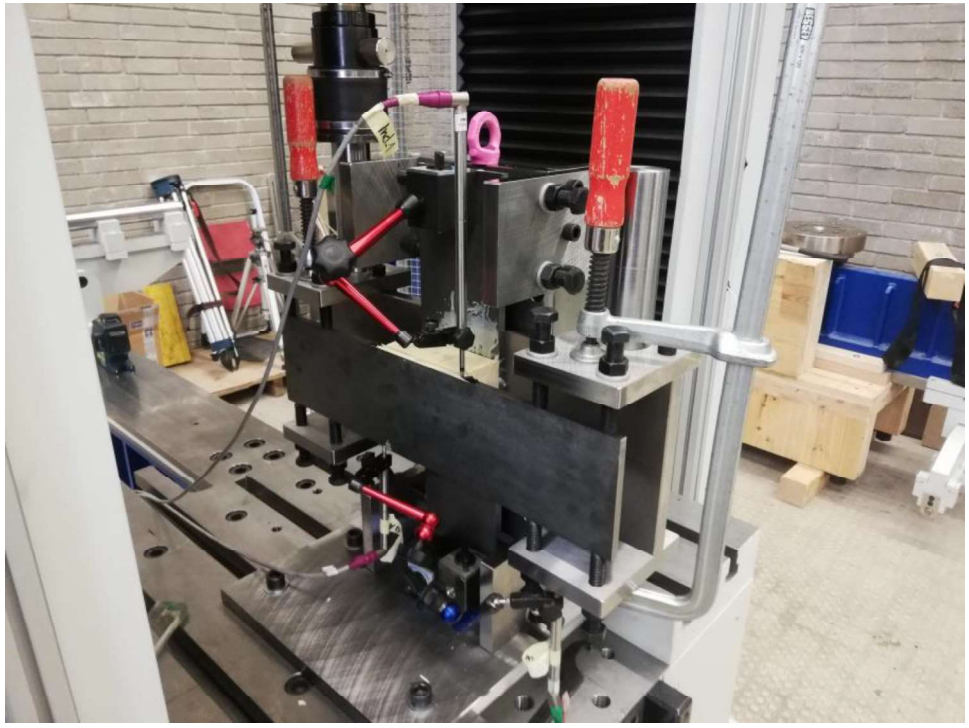
$$K_{ser.x} = z \times K_{ser,0}$$

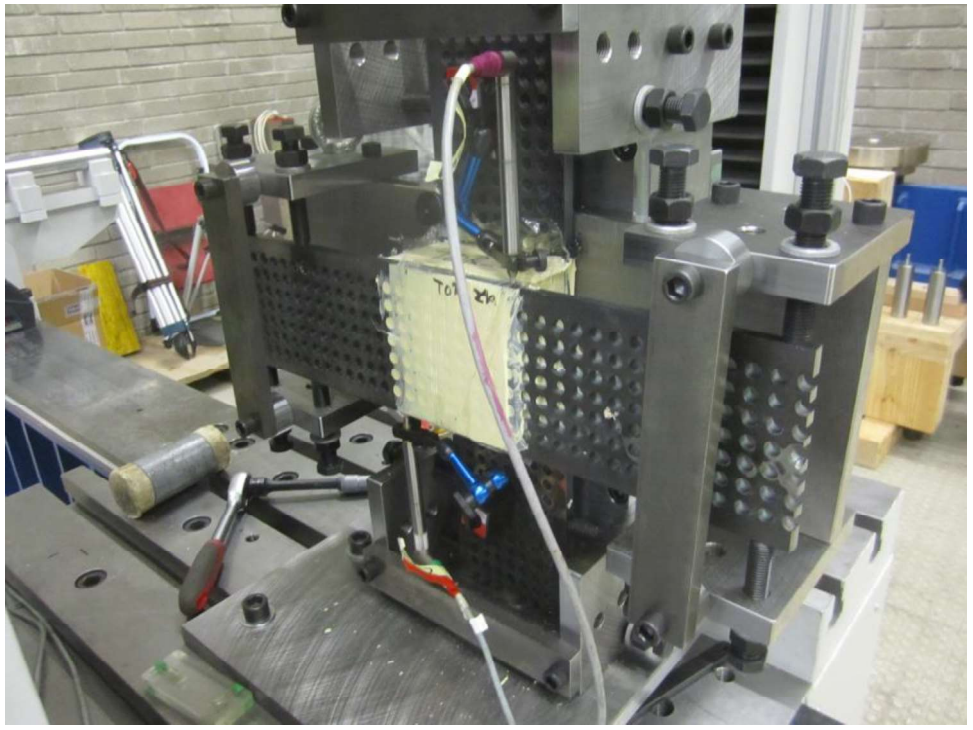
$$K_{ser,z} = x \times K_{ser,90}$$

$$K_{ser,p} = \text{å} \; z^2 \times K_{ser,0} + x^2 \times K_{ser,90}$$

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG



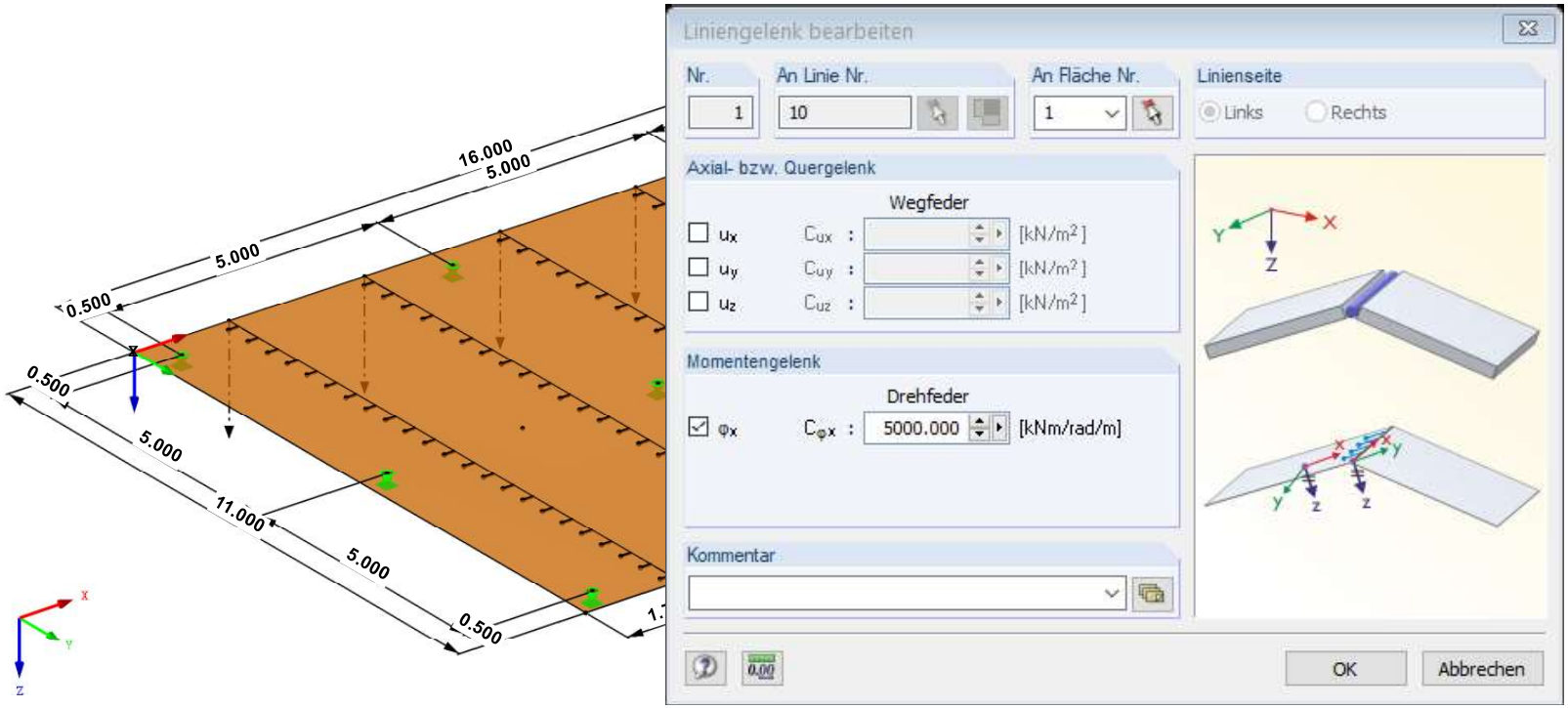


universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG

LF 3: Nutzlast

Isometrie

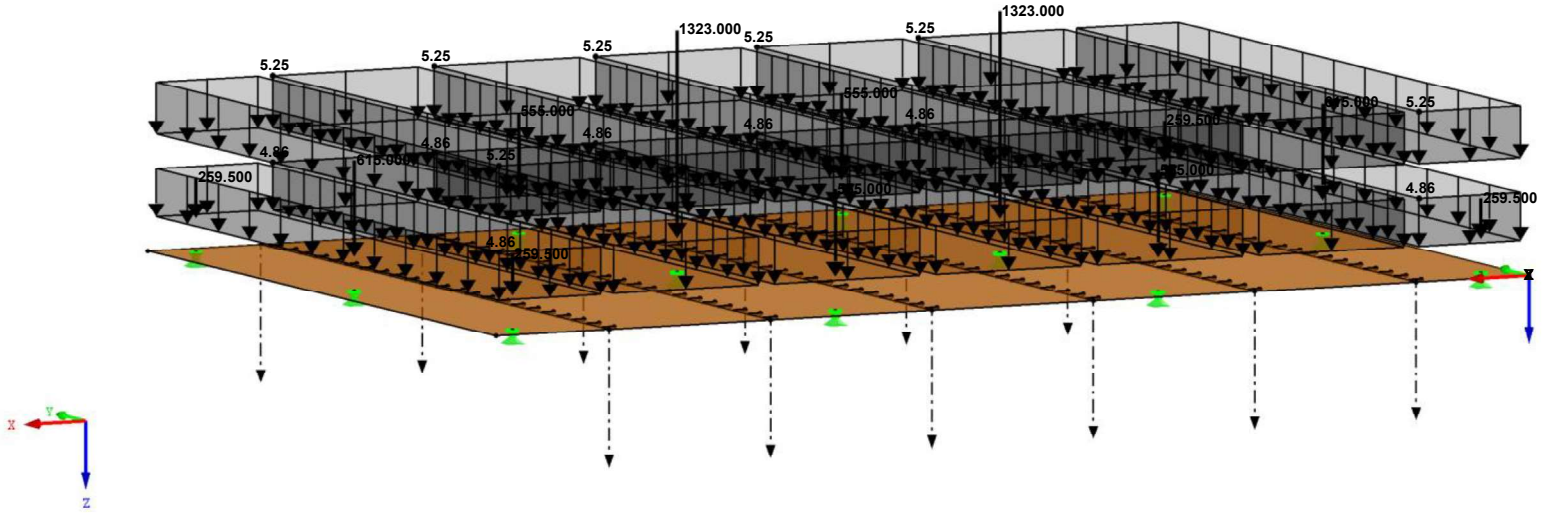


universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG

LK 3: ULS
Belastung [kN/m^2], [kN]

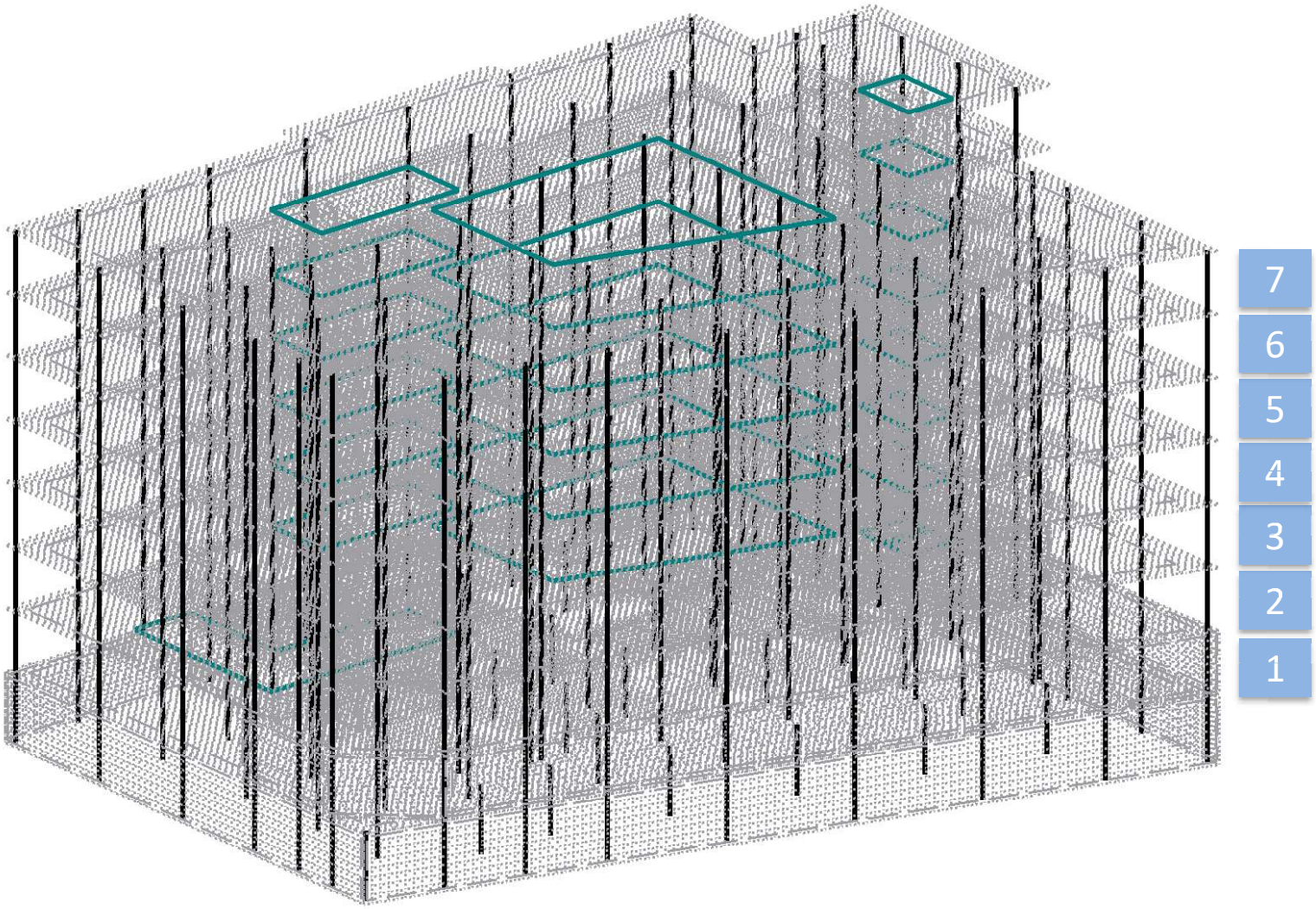
Isometrie



$g_{slab,k}$ = 4,80 kN/m²
$q_{slab,k}$ = 3,50 kN/m²
$F_{co,up,k}$= 1323 kN

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG



universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG

Modell	CLT- Platten Stärken [mm]							Stützen
	160 $F_{co,up,d} + F_{slab,d}$ [kN]	180 $F_{co,up,d} + F_{slab,d}$ [kN]	200 $F_{co,up,d} + F_{slab,d}$ [kN]	220 $F_{co,up,d} + F_{slab,d}$ [kN]	240 $F_{co,up,d} + F_{slab,d}$ [kN]	280 $F_{co,up,d} + F_{slab,d}$ [kN]	160+160 $F_{co,up,d} + F_{slab,d}$ [kN]	
SPI60S	345 + 296	290 + 349	240 + 401	185 + 454	135 + 506	135 + 506	245 + 394	GL 32h
SPI80S	630 + 296	575 + 349	525 + 401	470 + 454	420 + 506	420 + 506	530 + 394	
SPI80M	920 + 296	865 + 349	815 + 401	760 + 454	710 + 506	710 + 506	820 + 394	
SPI80L	1215 + 296	1185 + 349	1135 + 401	1080 + 454	1030 + 506	1030 + 506	1140 + 394	
SPI100S	1515 + 296	1515 + 349	1515 + 401	1515 + 454	1475 + 506	1475 + 506	1515 + 394	LVL Buche
SPI100M	1965 + 296	1930 + 349	1895 + 401	1855 + 454	1820 + 506	1820 + 506	2030 + 394	
SPI120S	1490 + 296	2440 + 349	2385 + 401	2335 + 454	2280 + 506	2280 + 506	2395 + 394	
SPI120M	1855 + 296	2855 + 349	2855 + 401	2855 + 454	2855 + 506	2855 + 506	2855 + 394	
SPI100L	3805 + 296	3805 + 349	3805 + 401	3805 + 454	3805 + 506	3805 + 506	3805 + 394	Stahl
SPI120L	4840 + 296	4840 + 349	4840 + 401	4840 + 454	4840 + 506	4840 + 506	4840 + 394	

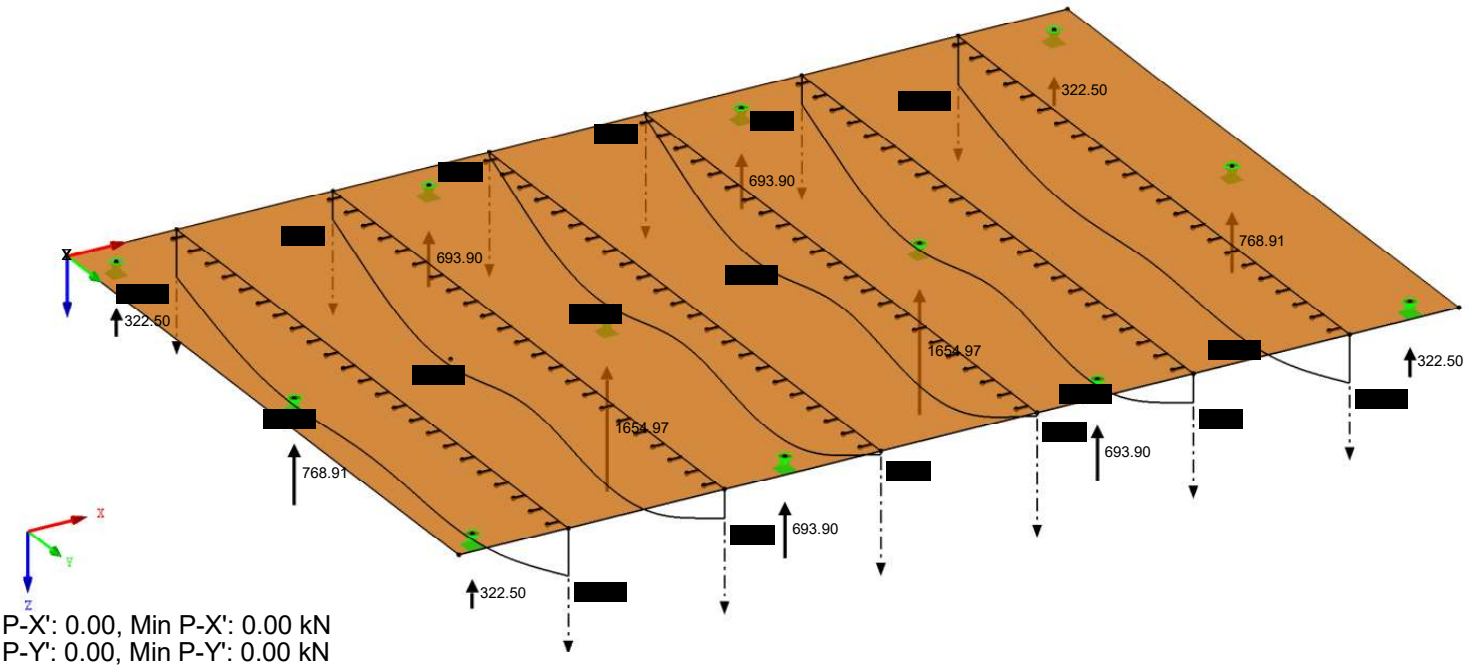
Quelle: Rothoblaas; Plates and Connectors for Timber
bzw. ETA-19/0700

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG

LK 3: ULS
Lagerreaktionen[kN]

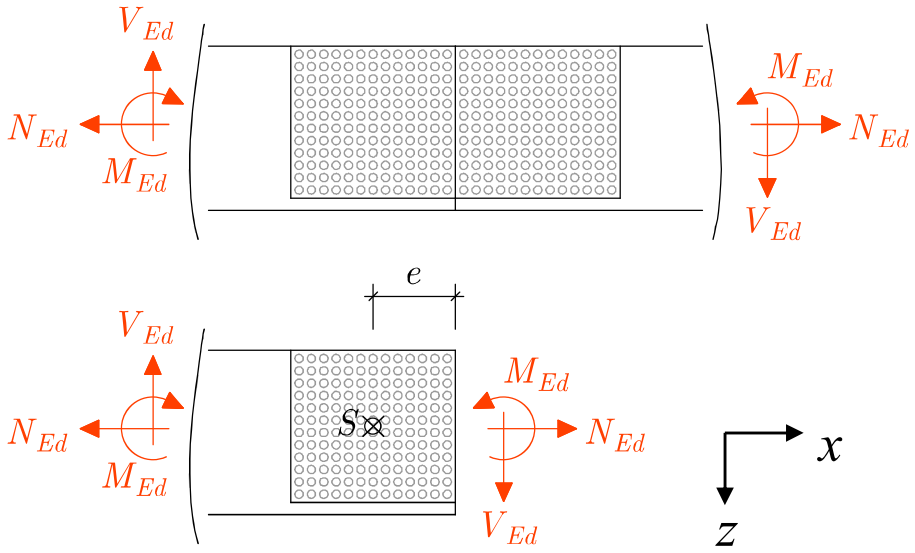
Isometrie

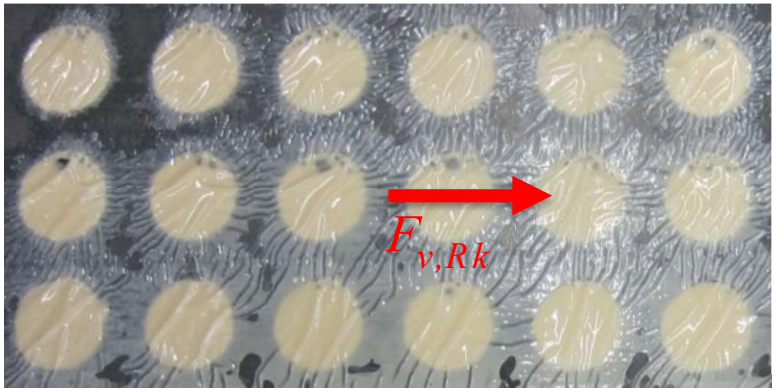


Max P-X': 0.00, Min P-X': 0.00 kN
Max P-Y': 0.00, Min P-Y': 0.00 kN
Max P-Z': 1654.97, Min P-Z': 322.50 kN

universität innsbruck

PUNKTGESTÜTZTE FLACHDECKEN | BEMESSUNG





$$M_{p,Ed} = M_{Ed} + e \times V_{Ed}$$

$$F_{x,Ed} = \frac{N_{Ed}}{n} + M_{p,Ed}\frac{K_{ser,x}}{K_{ser,p}}$$

$$F_{z,Ed} = \frac{V_{Ed}}{n} + M_{p,Ed}\frac{K_{ser,z}}{K_{ser,p}}$$

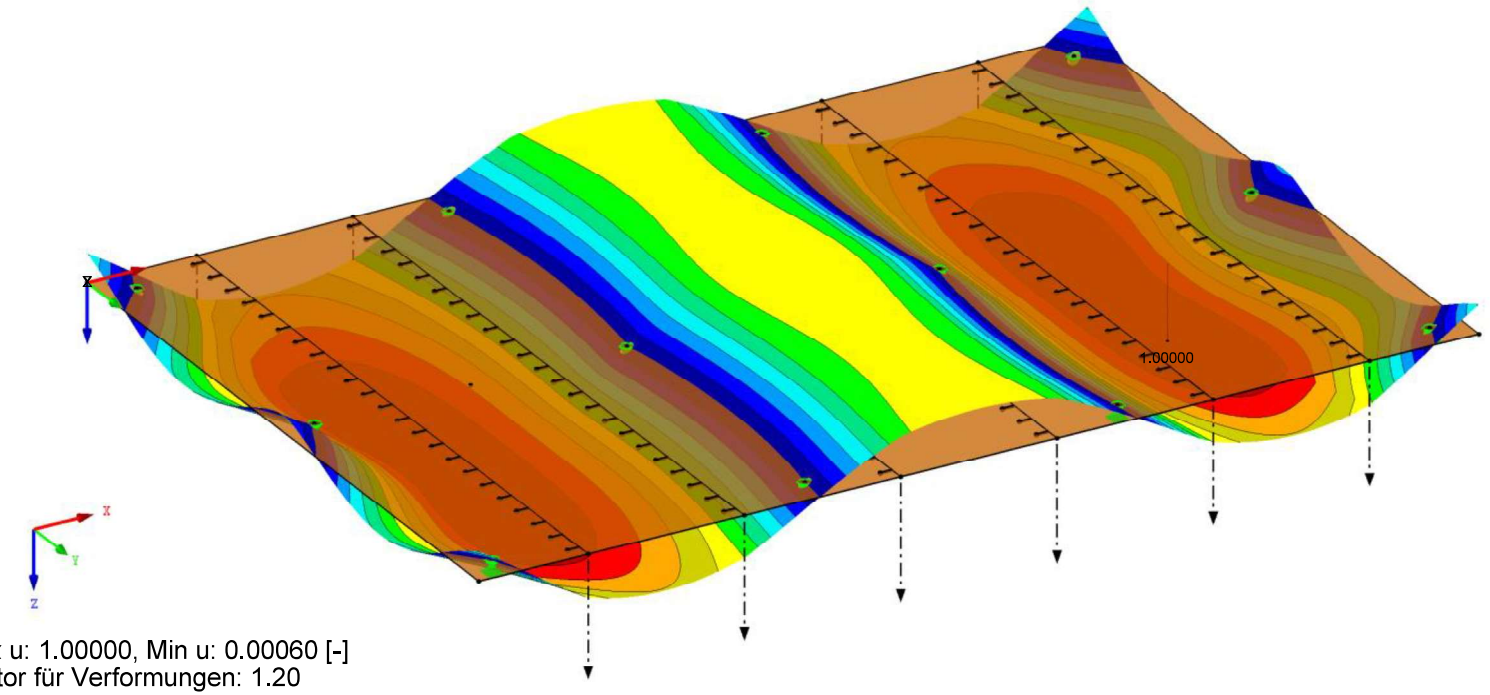
$$F_{v,Ed} = \sqrt{F_{x,Ed}^2 + F_{z,Ed}^2} \leq F_{v,Rd}$$

universität innsbruck

SCHWINGUNGSVERHALTEN GESAMTSYSTEM

RF-DYNAM Pro
Eigenschwingung u
Eigenform Nr. 1 - 10.890 Hz

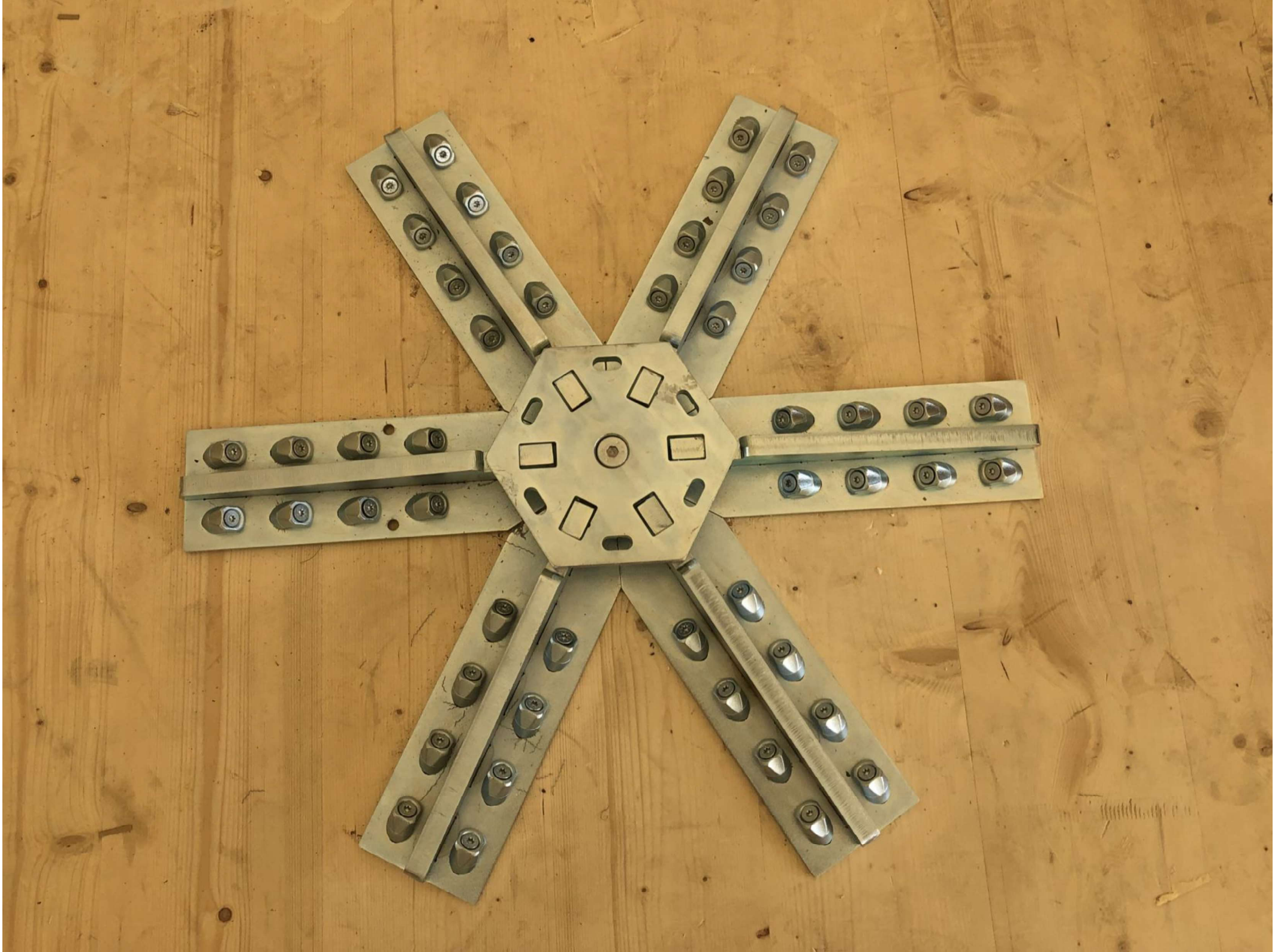
Isometrie



Max u: 1.00000, Min u: 0.00060 [-]
Faktor für Verformungen: 1.20


- 11 m -
- 5 m -
- 16 m -
MAN
HUTER
& SÖHNE


K F Z
abstellen
verboten.



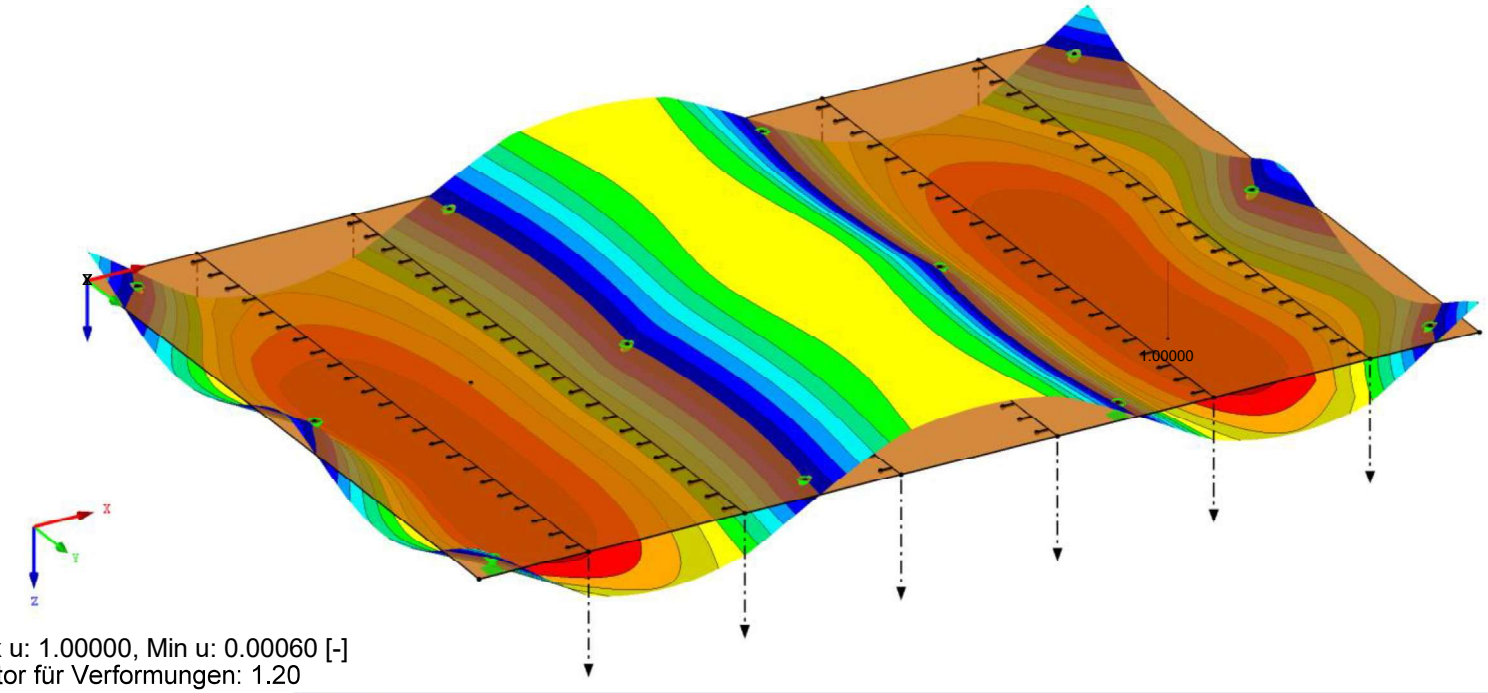

EIGENFREQUENZ
f=10,3 Hz

universität innsbruck

SCHWINGUNGSVERHALTEN GESAMTSYSTEM

RF-DYNAM Pro
Eigenschwingung u
Eigenform Nr. 1 - 10.890 Hz

Isometrie



Max u: 1.00000, Min u: 0.00060 [-]
Faktor für Verformungen: 1.20

5.1 Eigenfrequenzen

ESF1 | Eigenform 1 (f : 10.890 Hz)

Form Nr.	A Eigenwert λ [1/s²]	B Eigenkreisfrequenz ω [rad/s]	C Eigenfrequenz f [Hz]	D Eigenperiode T [s]	E
1	4681.998	68.425	10.890	0.092	
2	4959.937	70.427	11.209	0.089	
3	4980.107	70.570	11.232	0.089	
4	5212.171	72.195	11.490	0.087	

Eigenfrequenzen | Eigenformen knotenweise | Eigenformen flächenweise | Eigenformen netzpunktweise | Massen in Netzpunkten | Effektive Modalmassenfaktoren

GROSSFELD-VERSUCH

- Nutzlast: q_d = 12 kN/m²
- CLT 200 mm, Fichte Standardaufbau
- Stützenraster: a = 5 x 5 m
- f = 10 Hz

universität innsbruck

PROJEKTPARTNER

rothoblaas

FFG

storaenso

binderholz

tiptop timber

KLH®

HASSLACHER NORICA TIMBER

universität innsbruck

Roland Maderebner
roland.maderebner@uibk.ac.at

rothoblaas

Live & Online.
Aktuelles Bauwissen aus erster Hand.

bau information .com