# European Technical Assessment

# ETA-15/0876
of 22 October 2021

English translation prepared by DIBt - Original version in German language

**General Part**

| | |
|---|---|
| Technical Assessment Body issuing the European Technical Assessment: | Deutsches Institut für Bautechnik |
| Trade name of the construction product | Nailed Shear Connector X-HVB |
| Product family to which the construction product belongs | Nailed shear connector |
| Manufacturer | Hilti AG Feldkircherstraße 100 9494 Schaan FÜRSTENTUM LIECHTENSTEIN |
| Manufacturing plant | HILTI AG, Herstellwerke |
| This European Technical Assessment contains | 22 pages including 17 annexes which form an integral part of this assessment |
| This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of | EAD 200033-00-0602 |
| This version replaces | ETA-15/0876 issued on 3 June 2016 |

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**Specific part**

## 1 Technical description of the product

The nailed shear connector X-HVB is an L-shaped metal part that is mechanical attached with powder-actuated fasteners on steel beams of steel-to-concrete composite, as an alternate to welded headed studs, see annexes A1 and A2.

Aside of the use as shear connector for composite beams, nailed shear connectors are also used for the end anchorage of composite decks, see annex A1.

The nailed shear connectors X-HVB can be arranged with or without profiled composite decking, in one or more rows on steel beams of composite beams. Details of positioning of the nailed shear connectors X-HVB can be found in annexes B5 to B8.

The L-shaped sheet metal part is a 2 mm or 2.5 mm thick steel sheeting sheet steel with a fastening and an anchorage leg.

Depending on the thickness of the concrete slab or the height of the composite deck, a distinction is made between the following types of X-HVB fasteners with different lengths of the anchorage leg of the sheet metal part: X HVB 140, X-HVB 125, X-HVB 110, X-HVB 95, X-HVB 80, X-HVB 50 and X-HVB 40 (see annex A2).

The fastening leg of the L-shaped metal part is fastened by 2 powder-actuated fasteners X-ENP-21 HVB to the steel member. The fasteners X-ENP-21 HVB are made of zinc plated carbon steel and comprises of a pin with a shank diameter of 4.5 mm and two metal washers, see annex A2. The washers serve to guide the fastener while it is being driven into the base material and they contribute to the shear resistance. For the execution of the connection with powder-actuated fasteners, the manufacturer's information considering the information in the annexes B1 to B3.

## 2 Specification of the intended use in accordance with the applicable European Assessment Document

The intended use of the nailed shear connector X-HVB is the dowelling of composite beams and safeguarding of the composite effect of composite decks according to EN 1994-1-1. It can be used in new buildings or in existing buildings with the aim of reinforcing existing floor constructions.

The intended use of the nailed shear connectors comprises composite structures subject to static and quasi-static loading.

The performances given in Section 3 are only valid if the nailed shear connector is used in compliance with the specifications and conditions given in Annexes B1 to B8.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the nailed shear connector of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

## 3 Performance of the product and references to the methods used for its assessment

### 3.1 Mechanical resistance and stability (BWR 1)

| Essential characteristic | Performance |
|---|---|
| Characteristic resistance in solid concrete decks, shear connector orientation parallel to beam axis | See annex C1 |
| Characteristic resistance in solid concrete decks, shear connector orientation perpendicular to beam axis | No performance assessed |
| Characteristic resistance in composite decks - decking ribs perpendicular to beam axis - shear connector orientation parallel to beam axis | See annex C1 |
| Characteristic resistance in composite decks - decking ribs perpendicular to beam axis - shear connector orientation perpendicular to beam axis | See annex C1, C3 and C4 |
| Characteristic resistance in composite decks - decking ribs parallel to beam axis - shear connector orientation parallel to beam axis | See annex C2 |
| Characteristic resistance in composite decks - decking ribs parallel to beam axis - shear connector orientation perpendicular to beam axis | No performance assessed |
| Characteristic resistance of end anchorage of composite decks | See annex C4 |
| Characteristic resistance for use in seismic areas under seismic actions according to EN 1998-1 | See annex B1 |
| Characteristic resistance in solid concrete decks in renovation application with old metallic iron or steel material with an actual yield strength less than 235 MPa | See annex C3 |
| Application limit | See annex B3, pass |

### 3.2 Safety in case of fire (BWR 2)

| Essential characteristic | Performance |
|---|---|
| Reaction to fire | Class A1 according to EN 13501-1:2007+A1:2009 |
| Resistance to fire | See annex C5 |

**4        Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base**

In accordance with EAD No. 200033-00-0602, the applicable European legal act is: Decision 1998/214/EC.

The system to be applied is: 2+

**5        Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD**

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 22 October 2021 by Deutsches Institut für Bautechnik

Dr.-Ing. Ronald Schwuchow                                    *beglaubigt:*
Head of Section                                                          Bertram

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## Nailed shear connector X-HVB with powder-actuated fastener X-ENP-21 HVB



① Connector X-HVB

② Powder-actuated fasteners X-ENP-21 HVB
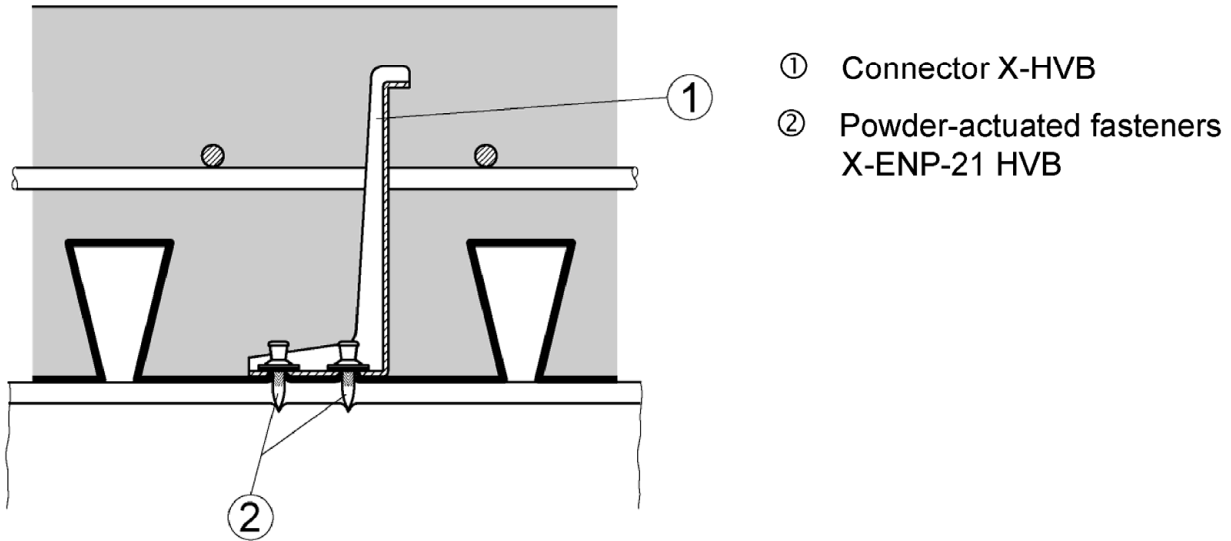
### Example of intended use: Nailed shear connection in composite beam
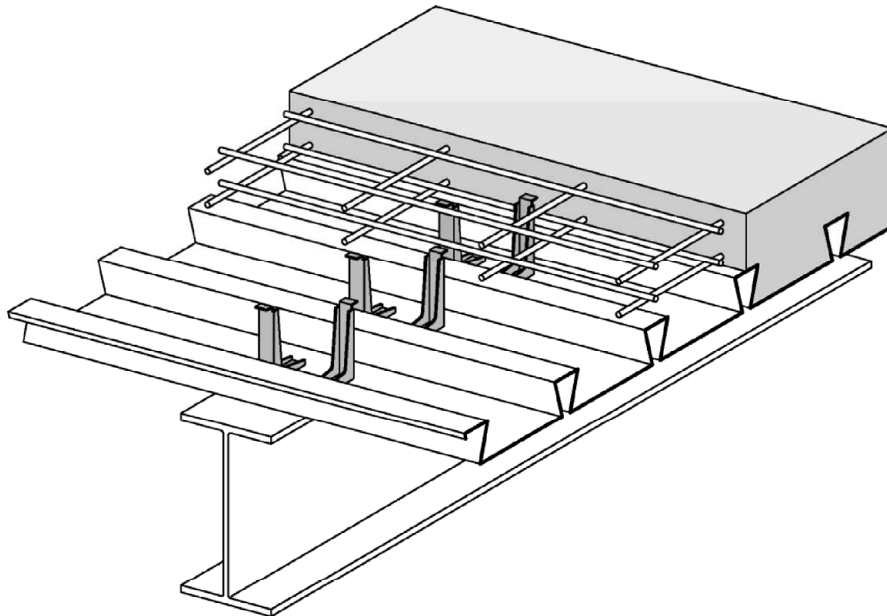


| Nailed shear connector X-HVB | |
|---|---|
| Product and intended use | Annex A1 |

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## Types of shear connector X-HVB

| X-HVB 140 | X-HVB 125 | X-HVB 110 | X-HVB 95 |
|---|---|---|---|

| X-HVB 80 | X-HVB 50 | X-HVB 40 |
|---|---|---|
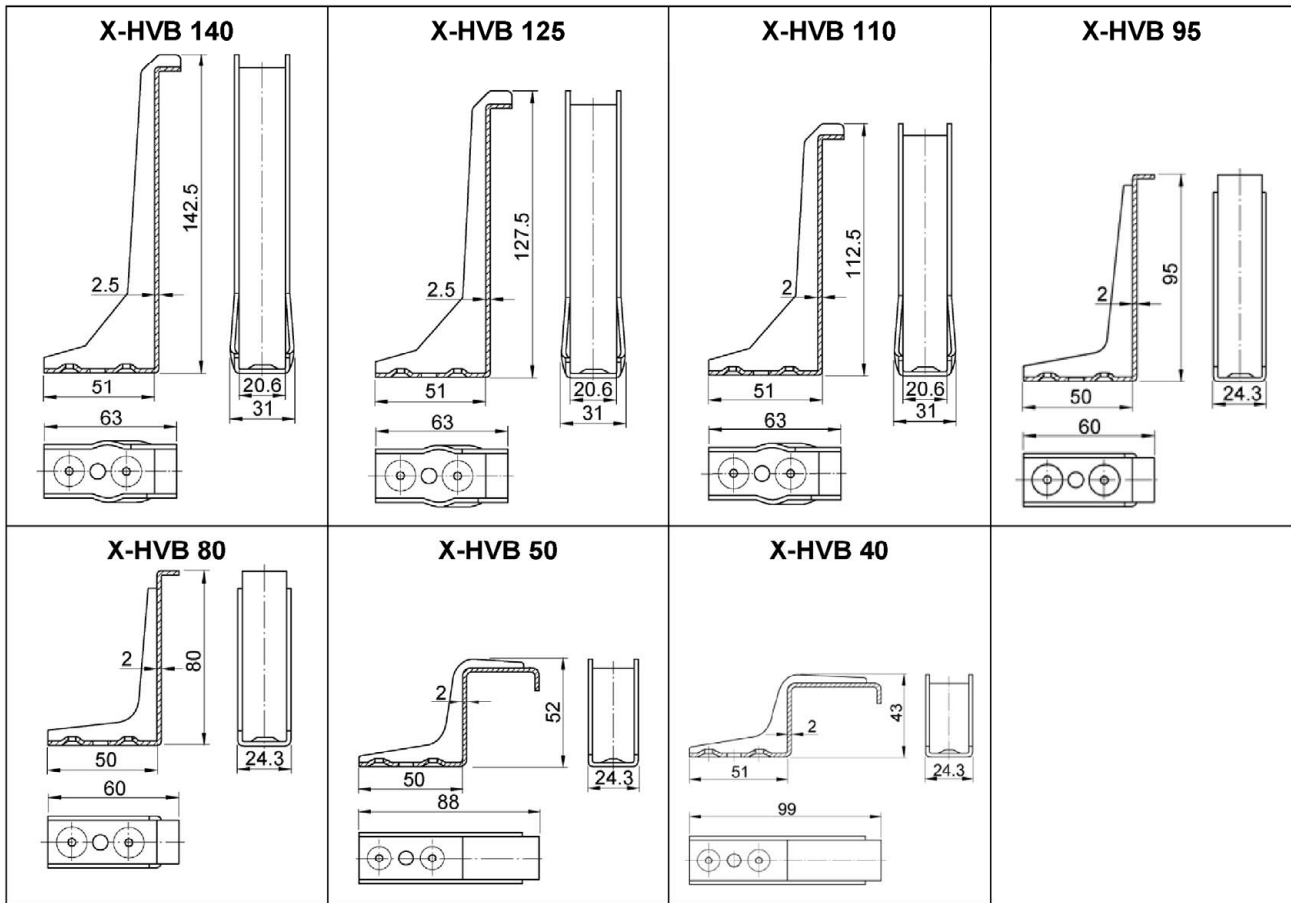
### Table 1: Materials

| Designation | Material |
|---|---|
| Shear connector X-HVB | Steel DC04 of a thickness of 2 or 2.5 mm according to EN 10130:2006, zinc plating ≥ 3 µm |
| Powder-actuated fastener X-ENP-21 HVB | Nail: Carbon steel C67S in keeping with EN 10132-4:2000/AC:2002, quenched, tempered and galvanized. Nominal hardness: 58 HRC, Zinc plating ≥ 8 µm<br>Washer: Steel DC01 according to EN 10139:2016/A1:2020, zinc plating ≥ 10 µm |

**Powder-actuated fastener X-ENP-21 HVB**

Nail

Washer

Ø7.4, Ø4.5, Ø15, 25.8
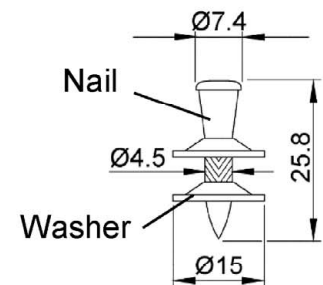
| **Nailed shear connector X-HVB** | Annex A2 |
|---|---|
| Dimensions and materials | |

# Specification of intended use

The nailed shear connector X-HVB is intended to be used as connection device between steel and concrete in composite beams and composite decks according to EN 1994-1-1:2004/AC:2009. The nailed shear connector can either be used in new buildings or for the renovation of existing buildings with the aim to increase the bearing capacity of aged floor constructions.

**Shear connections of composite structures subject to:**

· Static and quasi-static loading.

· As the X-HVB is a ductile shear connector according to EN 1994-1-1:2004/AC:2009, section 6.6, seismic loading is covered if the X-HVB is used as shear connector in composite beams used as secondary seismic members in dissipative as well as non-dissipative structures according to EN 1998-1:2004/A1:2013.

**Base materials:**

· Structural steel S235, S275 and S355 in qualities JR, J0, J2, K2 according to EN 10025-2:2019, thickness see Annex B3.

· Old steels which cannot be classified accordingly are still applicable provided these are made of unalloyed carbon steel with minimum yield strength $f_y$ of 170 N/mm².

**Concrete:**

· Normal weight concrete C20/25 – C50/60 according to EN 206:2013/A2:2021, minimum slab thickness see Annex B4.

· Light weight concrete LC 20/22 – LC 50/55 according to EN 206:2013/A2:2021 with a raw density $\rho \geq 1750$ kg/m³, minimum slab thickness see Annex B4.

**Composite decking:**

· Steel for profiled sheeting follows EN 1993-1-3:2006/AC:2009 and the material codes given there.

**Design:**

· Design of the composite beams with X-HVB shear connectors is made according to EN 1994-1-1:2004/AC:2009.

· The X-HVB shear connectors are ductile shear connectors according to EN 1994-1-1:2004/AC:2009, section 6.6.

· The recommended partial factor of $\gamma_V = 1.25$ is used provided no other values are given in national regulations of the member states. For fire design the recommended partial factor $\gamma_{M,fi,V} = 1.0$ is used provided no other value is given in national regulations of the member states.

**Installation:**

· The installation is only carried out according to the manufacturer's instructions. The powder-actuated fastening tools Hilti DX 76 or Hilti DX 76 PTR as shown in Annex B2 are used to install the X-ENP-21 HVB together with the X-HVB shear connector.

· In combination with composite decking the steel sheeting is in direct contact with the steel base material in the area of the connection. The beams may be hot-dipped galvanized, paint coated or coated with a primer with a coating thickness up to approximately 160 $\mu$m. The contact surface of the beam may not be covered with intumescent reactive fire coating.

· Cartridge selection and tool energy settings in order to match the application limit diagram are taken into account, see Annex B3.

· Installation tests are carried out (e.g. check of nail head standoff $h_{NVS}$), provided the fitness of the recommended cartridge cannot be checked otherwise. Fine regulation of the driving energy by using the wheel on the fastening tool is acceptable in order to meet the nail head standoff $h_{NVS}$.

· The shear connector X-HVB is properly set if the connector – if applicable together with the profiled metal sheet – is tightened against the steel surface and the nail head standoff $h_{NVS}$ is in accordance with the requirements given in Annex B3. A piston mark on the top washer is clearly visible, see Annex B3.

| Nailed shear connector X-HVB | Annex B1 |
|---|---|
| Specification of intended use | |

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## Powder-actuated fastening tools and cartridge 6.8/18M

The driving force of the fastening tools Hilti DX 76 and Hilti DX 76 PTR is provided by the power load of the cartridge. The application limit of the powder-actuated fastening system depends on the strength and thickness of the base material. The fastening tools (incl. cartridges) are an integral part of this assessment with regard to the capacity of the nailed shear connector X-HVB and the application of the respective system.



Powder-actuated fastening tool
**DX 76 HVB**



Powder-actuated fastening tool
**DX 76 PTR HVB**



Fastener guide
**X-76-F-HVB**



Fastener guide
**X-76-F-HVB-PTR**



Piston
**X-76-P-HVB**

Buffer: X-76-PS



Piston
**X-76-P-HVB-PTR**

Buffer: X-76-PS



Detail of wheel on tool allowing continuous regulation of the driving energy within one cartridge colour:
Setting 1: Minimum energy
Setting 4: Maximum energy
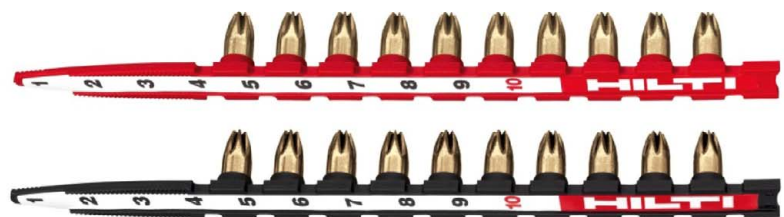


**Cartridges 6.8/18 M**

**Red:** Medium high load (energy scale 6)
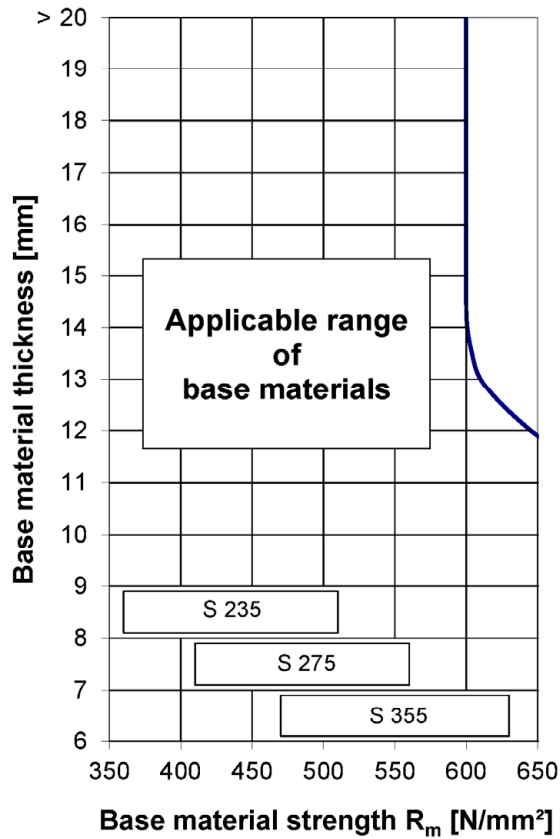**Black:** Extra high load (energy scale 7)

Blue: Medium load (energy scale 5), see Annex B3
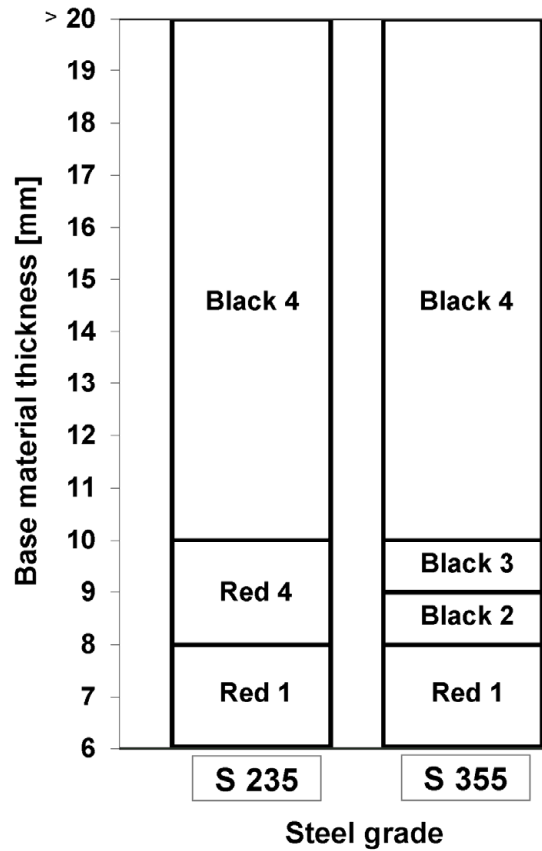
| **Nailed shear connector X-HVB** | |
|---|---|
| Powder-actuated fastening tool and components | Annex B2 |

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## Application limit and tool energy setting

Base material thickness [mm]

Applicable range
of
base materials

S 235

S 275

S 355

**Base material strength $R_m$ [N/mm²]**

Note:
Minimum section covered: IPE 100 (see Annex C5)

Base material thickness [mm]

Black 4 — Black 4

Red 4 — Black 3 / Black 2

Red 1 — Red 1

S 235 — S 355

**Steel grade**

Notes:
In case of thin base materials, the blue cartridge is possible to be used. Blue 3 corresponds to Red 1.
Fine adjustment on the energy based on job site trials.

## Fastener inspection

$h_{NVS}$

X-HVB
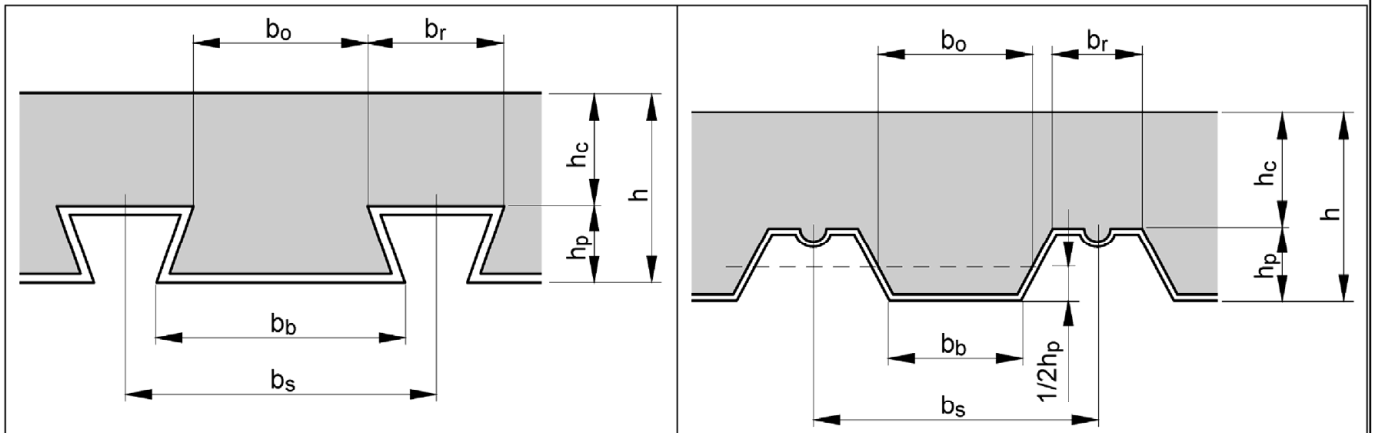Metal decking
Structural steel
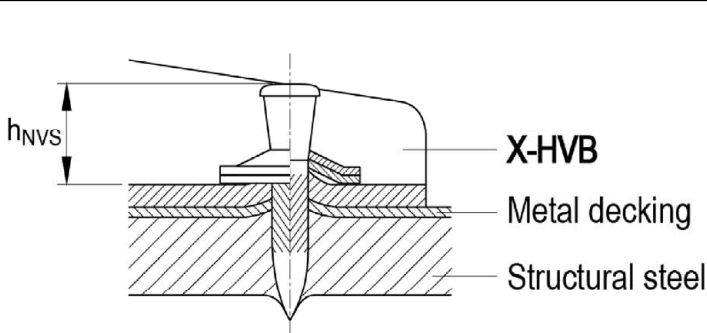
Clearly visible piston mark on top washer

**8.2 mm ≤ $h_{NVS}$ ≤ 9.8 mm**

**Nailed shear connector X-HVB**

Application limit, cartridge selection and fastener inspection
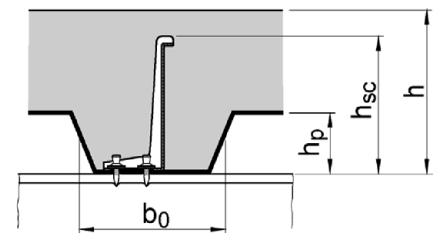
**Annex B3**

## Composite decking geometry



Maximum total thickness of fixed sheeting $t_{fix}$
   2.0 mm for X-HVB 80, X-HVB 95 and X-HVB 110
   1.5 mm for X-HVB 125 and X-HVB 140

### Minimum slab thickness

| X-HVB | Minimum slab thickness h [mm] | |
|---|---|---|
| | Without effect of corrosion | With effect of corrosion |
| 40 | 50 | 60 |
| 50 | 60 | 70 |
| 80 | 80 | 100 |
| 95 | 95 | 115 |
| 110 | 110 | 130 |
| 125 | 125 | 145 |
| 140 | 140 | 160 |



### Maximum decking height $h_p$ dependent on decking geometry – general rules

| X-HVB | Maximum height of composite decking $h_p$ [mm] | | |
|---|---|---|---|
| | $\dfrac{b_0}{h_p} \geq 1.8$ | $1.0 < \dfrac{b_0}{h_p} < 1.8$ | $\dfrac{b_0}{h_p} \leq 1.0$ [x)] |
| 80 | 45 | 45 | 30 |
| 95 | 60 | 57 | 45 |
| 110 | 75 | 66 | 60 |
| 125 | 80 | 75 | 73 |
| 140 | 80 | 80 | 80 |

[x)]   $b_0/h_p \geq 1$ for composite decking perpendicular to beam combined with X-HVB orientation parallel with beam

| | |
|---|---|
| **Nailed shear connector X-HVB** | |
| Geometric parameters | Annex B4 |

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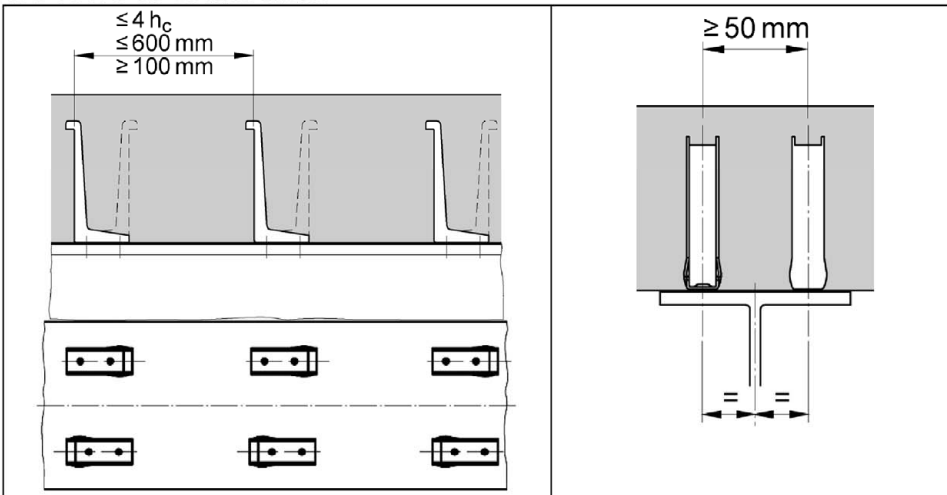## Positioning of X-HVB connectors in solid concrete slabs, X-HVB are to be positioned parallel with beam

### One row of connectors



Centric

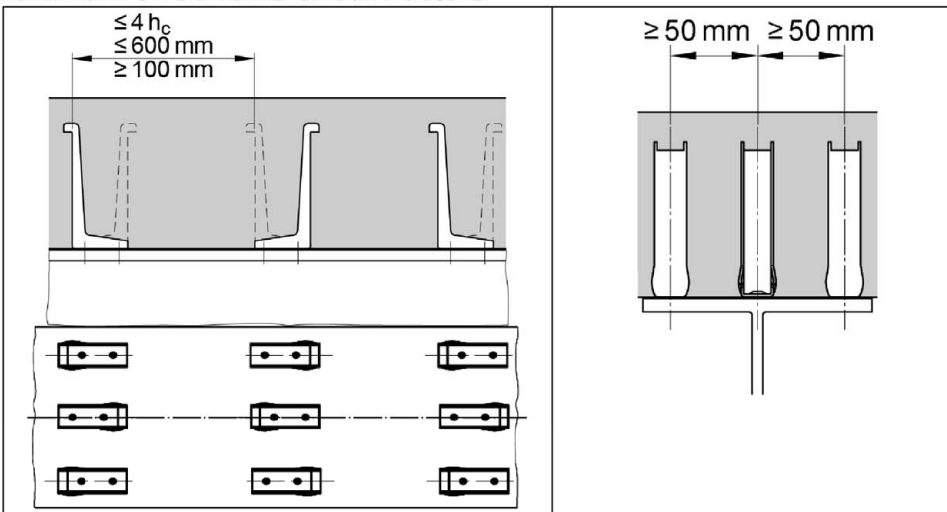Alternating vs. web

$\leq 4\ h_c$
$\leq 600$ mm
$\geq 100$ mm

$h_c$
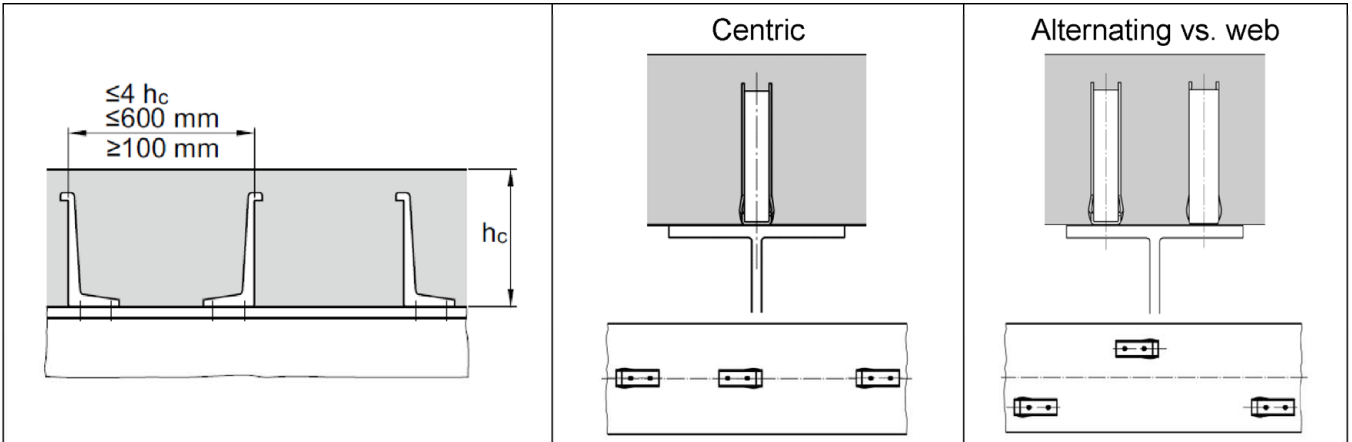
### Two rows of connectors

$\leq 4\ h_c$
$\leq 600$ mm
$\geq 100$ mm

$\geq 50$ mm

**Remark:**

When using thin solid concrete slabs in combination with small I-profiles the „duckwalk" positioning according to Annex C5 applies.

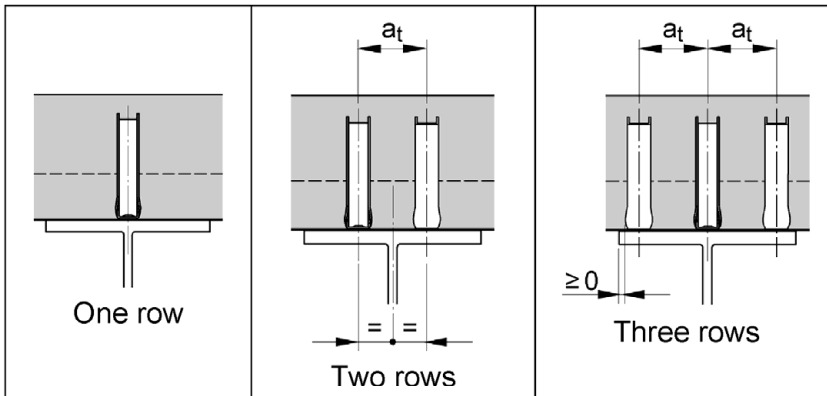### Maximum three rows of connectors

$\leq 4\ h_c$
$\leq 600$ mm
$\geq 100$ mm

$\geq 50$ mm  $\geq 50$ mm

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**Nailed shear connector X-HVB**

Positioning in composite beams with solid concrete slabs

Annex B5

## Spacing and positioning within cross section
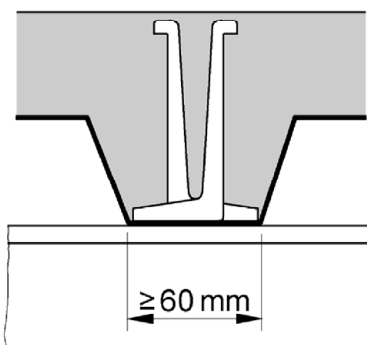


One row

Two rows

Three rows

$a_t \geq$ 50 mm for compact profiled decking with $b_0/h_p \geq$ 1.8

$a_t \geq$ 100 mm for other decking

## Minimum rib width and spacing to decking in case of single row positioning



≥ 90 mm

≥ 40 mm

for rib width < 105 mm

≥ 40 mm

For rib width ≥ 105 mm

≥ 105 mm
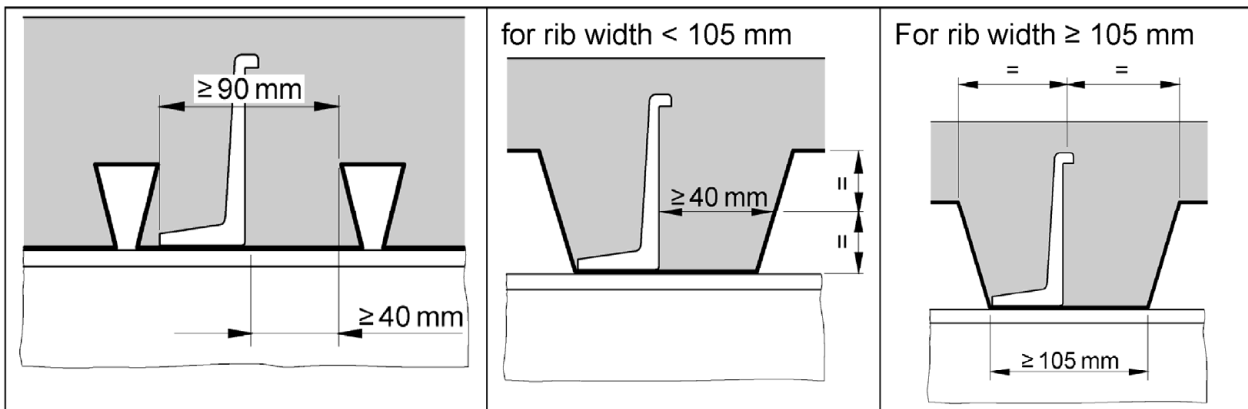
## Minimum rib width in case of multiple row positioning
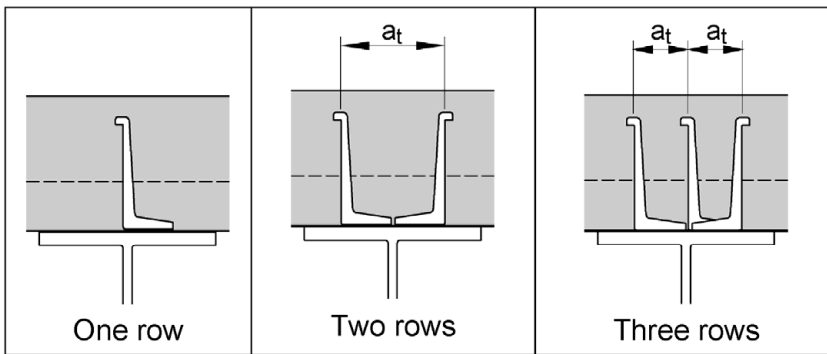


≥ 60 mm

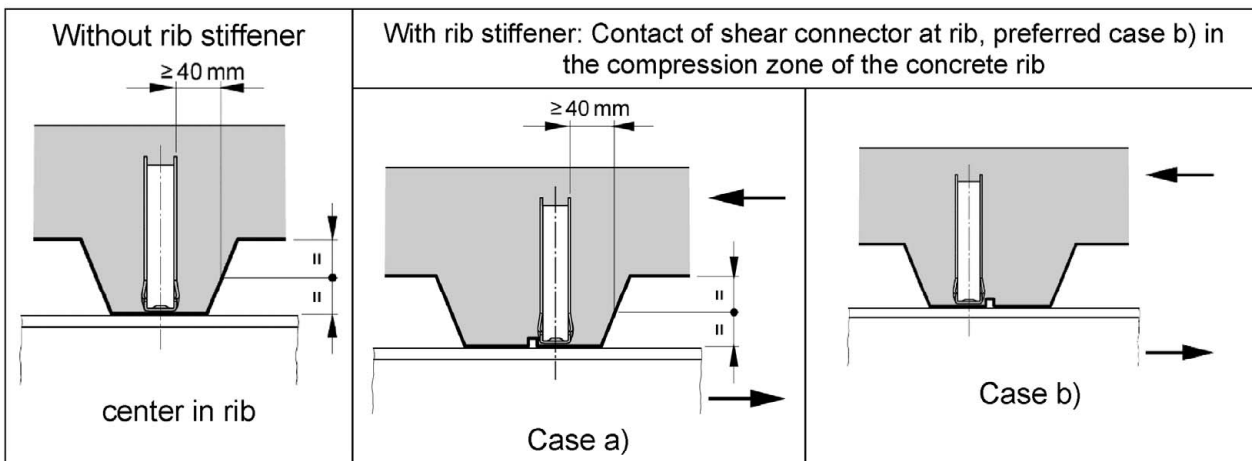| **Nailed shear connector X-HVB** | |
|---|---|
| Positioning in composite beams with composite decking transverse and X-HVB positioning parallel with beam axis | Annex B6 |

## Spacing and positioning within cross section



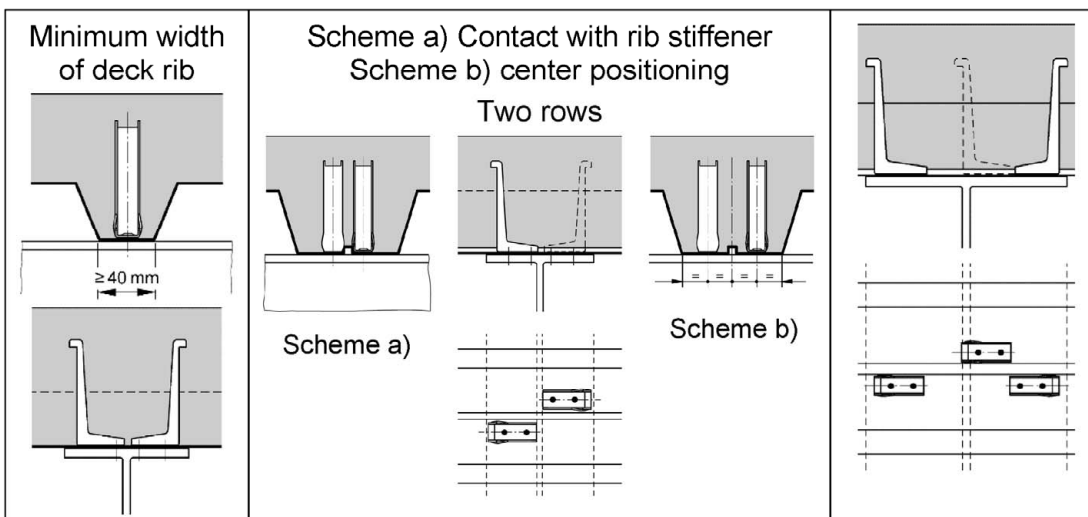One row | Two rows | Three rows

Two rows:

$a_t \geq 100$ mm for all types decking

Three rows:

$a_t \geq 50$ mm for compact profiled decking with $b_0/h_p \geq 1.8$

$a_t \geq 100$ mm for other decking

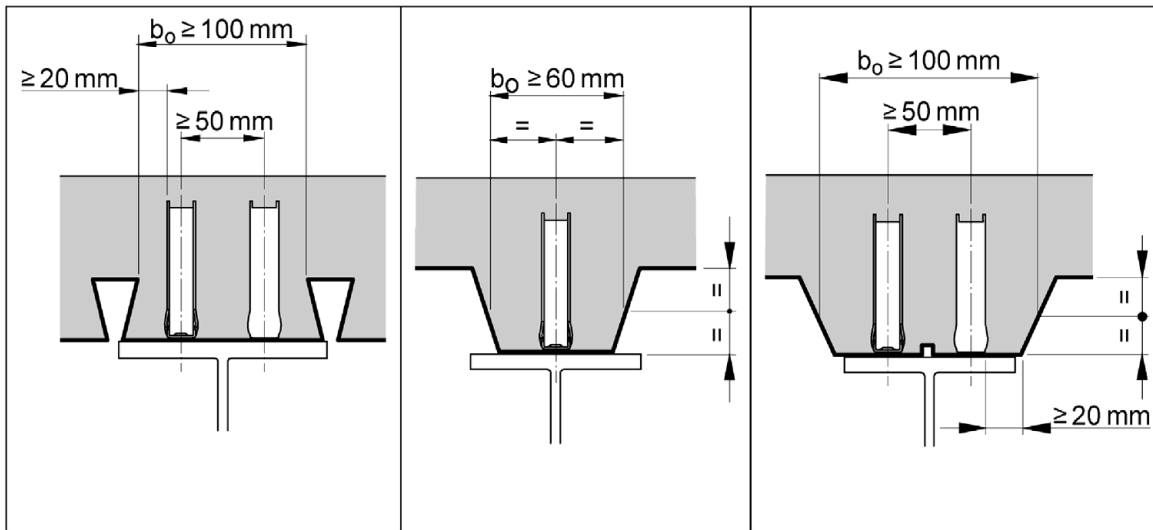## Positioning in one row with composite deck with or without rib stiffener

Without rib stiffener

≥40 mm

center in rib

With rib stiffener: Contact of shear connector at rib, preferred case b) in the compression zone of the concrete rib

≥40 mm

Case a)

Case b)



## Positioning in two or three rows

Minimum width of deck rib

≥40 mm

Scheme a) Contact with rib stiffener
Scheme b) center positioning

Two rows

Scheme a)

Scheme b)



Specific deck geometries deviating from these general rules are addressed in Annex C3 and Annex C4.

| **Nailed shear connector X-HVB** | |
|---|---|
| Positioning in composite beams with composite decking transverse and X-HVB positioning transverse with beam axis | Annex B7 |

## Spacing and positioning within cross section, X-HVB are to be positioned parallel with beam

If a centric positioning within the concrete rib is not possible due to the shape of the composite decking, the decking needs to be split:
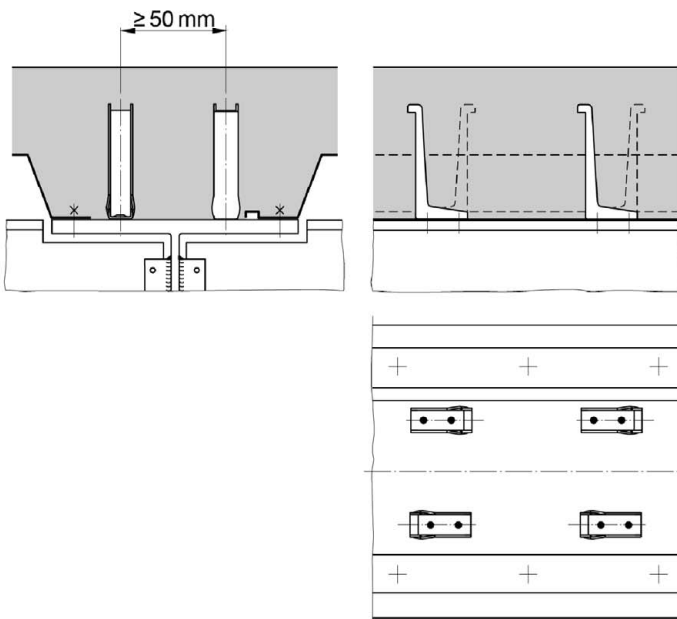
**Nailed shear connector X-HVB**

Positioning in composite beams with composite decking
parallel with beam axis

Annex B8

**Table 3: Characteristic and design[1] resistance in composite beams with solid slabs**

| Shear Connector | Characteristic Resistance $P_{Rk}$ [kN] | Minimum base material thickness [mm] | X-HVB positioning[3] | Ductility assessment |
|---|---|---|---|---|
| X-HVB 40 | 29.0 | 6 | "duckwalk" | Ductile according to EN 1994-1-1: 2004/AC:2009 |
| X-HVB 50 | 29.0 | 6 | | |
| X-HVB 80 | 32.5 | 8 [2] | parallel with beam | |
| X-HVB 95 | 35.0 | | | |
| X-HVB 110 | 35.0 | | | |
| X-HVB 125 | 37.5 | | | |
| X-HVB 140 | 37.5 | | | |

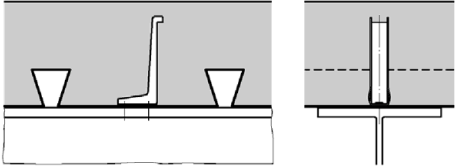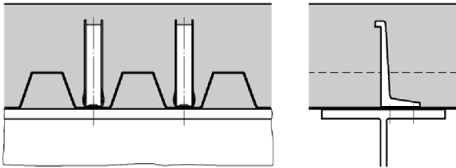[1] In the absence of other national regulations a recommended partial factor $\gamma_V = 1.25$ can be used
[2] Reduction to 6 mm minimum base material thickness possible, see Annex C5
[3] "Duckwalk" positioning according to Annex C5, positioning "parallel with beam" according to Annex B5

Conditions:
- Normal weight concrete C20/25 to C50/60
- Light weight concrete LC20/22 to LC50/55 with a minimum density $\rho = 1750$ kg/m³
- Observation of positioning rules according to Annex B5 and Annex C5

**Table 4:  Characteristic and design[1] resistance in composite beams with decking ribs transverse to beam axis**

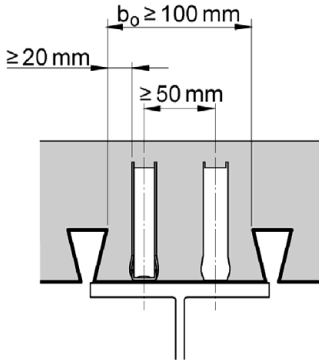| X-HVB positioning | Characteristic Resistance $P_{Rk,t}$ | Ductility assessment |
|---|---|---|
|  X-HVB positioning longitudinal with the beam | $$P_{Rk,t,l} = k_{t,l} \cdot P_{Rk}$$ $$k_{t,l} = \frac{0.66}{\sqrt{n_r}} \cdot \frac{b_0}{h_p} \cdot \left(\frac{h_{SC}}{h_p} - 1\right) \leq 1.0$$ | Ductile according to EN 1994-1-1: 2004/AC:2009 |
|  X-HVB positioning transverse with the beam | $$P_{Rk,t,t} = 0.89 \cdot k_{t,t} \cdot P_{Rk}$$ $$k_{t,t} = \frac{1.18}{\sqrt{n_r}} \cdot \frac{b_0}{h_p} \cdot \left(\frac{h_{SC}}{h_p} - 1\right) \leq 1.0$$ | |

[1] In the absence of other national regulations a recommended partial factor $\gamma_V = 1.25$ can be used

Conditions:
- Characteristic resistance $P_{Rk}$ for solid concrete slabs according to Table 3
- Normal weight concrete C20/25 to C50/60
- Light weight concrete LC20/22 to LC50/55 with a minimum raw density $\rho = 1750$ kg/m³
- Geometric parameters $b_0$, $h_p$ and $h_{SC}$ according to Annex B4, $n_r$ corresponds to the number of X-HVBs per rib
- Observation of positioning rules according to Annex B6 and Annex B7
- Applicable for X-HVB 80, X-HVB 95, X-HVB 110, X-HVB 125, X-HVB 140

| Nailed shear connector X-HVB | Annex C1 |
|---|---|
| Characteristic and design values of resistance: Solid concrete slabs and composite slabs with decking transverse to beam | |

**Table 5: Characteristic and design[1] resistance in composite beams with decking ribs parallel to beam axis**

| X-HVB positioning | Characteristic Resistance $P_{Rk,l}$ | Ductility assessment |
|---|---|---|
|  X-HVB positioning longitudinal with the beam | $$P_{Rk,l} = k_l \cdot P_{Rk}$$ $$k_l = 0.6 \cdot \frac{b_0}{h_p} \cdot \left(\frac{h_{SC}}{h_p} - 1\right) \le 1.0$$ | Ductile according to EN 1994-1-1: 2004/AC:2009 |

[1]  In the absence of other national regulations a recommended partial factor $\gamma_V = 1.25$ can be used

Conditions:
- Characteristic resistance $P_{Rk}$ for solid concrete slabs according to Annex C1, Table 3
- X-HVB are to be positioned parallel with beam
- Normal weight concrete C20/25 to C50/60
- Light weight concrete LC20/22 to LC50/55 with a minimum density $\rho = 1750$ kg/m³
- Geometric parameters $b_0$, $h_p$ and $h_{SC}$ according to Annex B4
- Observation of positioning rules according to Annex B8
- Applicable for X-HVB 80, X-HVB 95, X-HVB 110, X-HVB 125, X-HVB 140

**Nailed shear connector X-HVB**

Characteristic and design values of resistance:
Composite slabs with decking parallel to beam

Annex C2

## Characteristic and design resistance for decking with narrow ribs on narrow beams and X-HVB transverse to beam axis
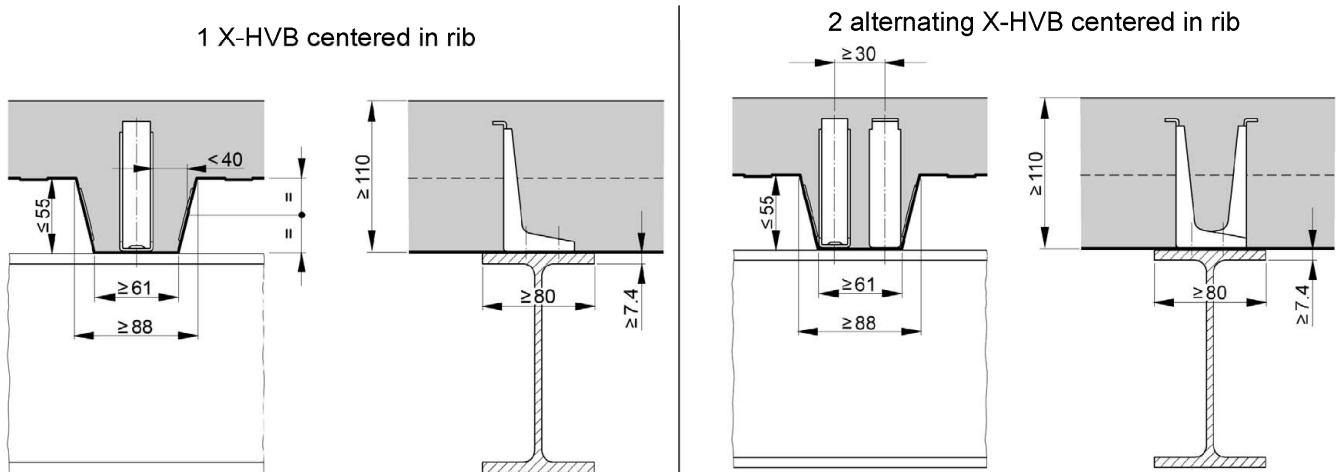
**Table 6: Characteristic and design[1] resistance**

| Shear Connector | Number of X-HVB within rib | Type of concrete | Ductility assessment [2] | Characteristic Resistance $P_{Rk,t,t}$ [kN] |
|---|---|---|---|---|
| X-HVB 95 X-HVB 110 X-HVB 125 X-HVB 140 | 1 | C20/25 – C50/60 | Non-ductile | 22.7 |
| | | | Ductile | 17.2 |
| | | LC20/22 | Ductile | 16.5 |
| | | LC25/28 – LC50/55 | | 17.7 |
| | 2 | C20/25 – C50/60 | Ductile | 14.5 |
| | | LC20/22 | | 12.4 |
| | | LC25/28 – LC50/55 | | 13.3 |

[1]   In the absence of other national regulations a recommended partial factor $\gamma_V = 1.25$ can be used
[2]   according to EN 1994-1-1:2004/AC:2009, section 6.6.1.1

Conditions:
- Normal weight concrete C20/25 to C50/60
- Light weight concrete LC20/22 to LC50/55 with a minimum density $\rho = 1750$ kg/m³
- Minimum base material thickness $t_{II} = 7.4$ mm
- Observation of the following positioning rules and geometric limitations

1 X-HVB centered in rib

2 alternating X-HVB centered in rib



**Nailed shear connector X-HVB**

Characteristic and design values of resistance: Specific provisions for composite slabs with decking transverse to beam with narrow ribs and narrow beams

Annex C3

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## Characteristic and design resistance for X-HVB 140 for 80 mm deep decking with 15 mm deep re-entrant stiffener

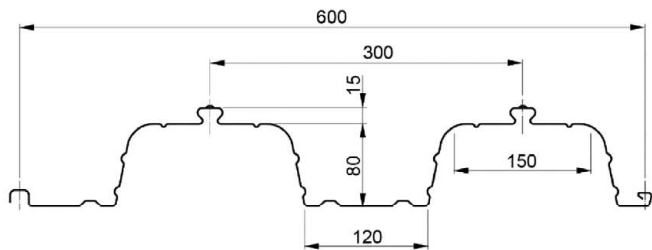**Table 7: Characteristic and design[1] resistance**

| Shear Connector | Number of X-HVB within rib | Characteristic Resistance $P_{Rk,t,t}$ [kN] | X-HVB positioning | Ductility assessment |
|---|---|---|---|---|
| X-HVB 140 | 1 | 26.5 | transverse to the beam | Ductile according to EN 1994-1-1: 2004/AC:2009 |
| | 2 | 26.5 | | |
| | 3 | 24.0 | | |
| | 4 | 22.0 | | |

[1] In the absence of other national regulations a recommended partial factor $\gamma_V = 1.25$ can be used
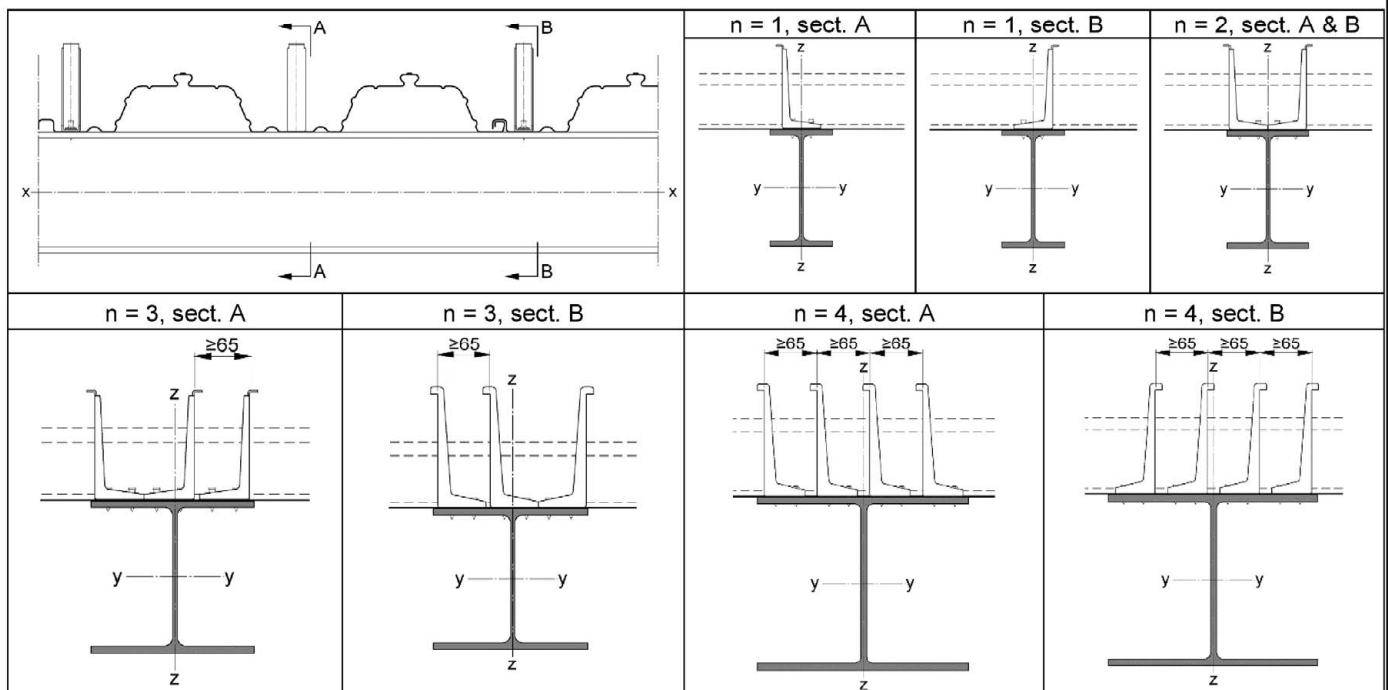
Conditions:
- Normal weight concrete C20/25 to C50/60
- Light weight concrete LC20/22 to LC50/55 with a minimum density $\rho = 1750$ kg/m³
- Minimum base material thickness $t_{||} = 8$ mm
- Observation of the following positioning rules and geometric limitations

Deck geometry:



## Spacing and positioning within cross section



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**Nailed shear connector X-HVB**

Characteristic and design values of resistance of X-HVB 140: Specific provisions for composite slabs with 80 mm deep decking with stiffeners, deck transverse to beam

Annex C4

## Characteristic resistance:
## Effect of reduced base material thickness for X-HVB 80 to X-HVB 140

Reduction of characteristic resistance $P_{Rk}$ with the factor ($t_{II,act}$ / 8) is required in case the actual base material thickness is less than 8 mm.

$$P_{Rk,red} = \frac{t_{II,act}}{8} \cdot P_{Rk}$$

with:

$P_{Rk,red}$ ....    reduced characteristic resistance of X-HVB 80 to X-HVB 140 for actual base material thickness $t_{II,act}$ < 8 mm and a minimum thickness of 6 mm

$P_{Rk}$ .......    Characteristic resistances in solid and composite slabs for X-HVB 80 to X-HVB 140 according to Annex C1 (Table 3 and 4) and Annex C2

For solid concrete slabs $P_{Rk,red} \geq 29.0\ kN$ applies.

Notes:   Corresponding values can also be applied in new construction.
No extrapolation of above formula for base material thickness $t_{II}$ > 8 mm

## Characteristic resistance: Effect of reduced base material strength

Reduction of characteristic resistance $P_{Rk}$ with the factor $\alpha_{BM,red}$ is required in case the actual base material $f_u$ strength of the old construction steel is less than 360 N/mm².

Minimum ultimate strength $f_{u,min}$ = 300 N/mm² (with a minimum yield strength $f_y$ = 170 N/mm²).

$$P_{Rk,red} = \alpha_{BM,red} \cdot P_{Rk}$$

$$\alpha_{BM,red} = 0.95$$

with:

$P_{Rk,red}$ ....   reduced characteristic strength of X-HVB for base material strength between 300 and 360 N/mm²

$P_{Rk}$ .......   characteristic resistances of X-HVB according to Annex C1 to Annex C4

$\alpha_{BM,red}$....   base material strength reduction factor

## "Duckwalk" positioning of X-HVB 40 and 50 in combination with thin solid slabs:



| Profile I 80 | Profile I 100 | Profile IAO 100 | Profile IPE 100 |
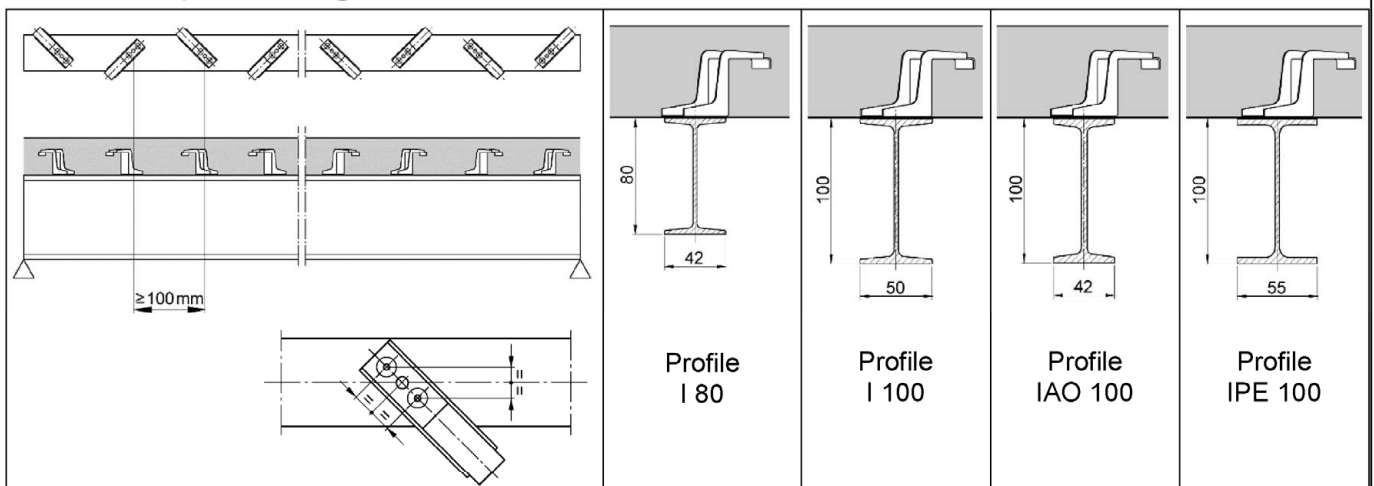
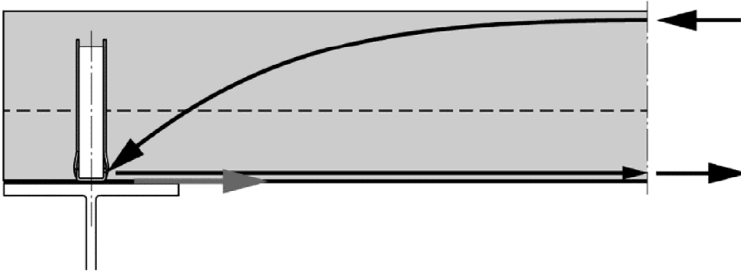Minimum section width = 40 mm (e.g. old section IAO 100)
Minimum center distance of steel sections = 400 mm

| **Nailed shear connector X-HVB** | |
|---|---|
| Use in renovation construction: characteristic resistance and "duckwalk" positioning | Annex C5 |

# End anchorage in composite slabs



## Characteristic and design[1] resistance

$$V_{Rk,EA} = 50 \cdot t \cdot f_{u,k}$$

[1] In the absence of other national regulations a recommended partial factor $\gamma_V = 1.25$ can be used

with:

$V_{Rk,EA}$  ….  characteristic strength of X-HVB 80 to X-HVB 140 for end anchorage of composite decking.

$t$ …….  design core thickness of composite sheet

$f_{u,k}$ ….  characteristic strength of steel composite decking. Independent on the applied steel grade, $f_{u,k}$ used in the formula shall not exceed 360 N/mm²

**Nailed shear connector X-HVB**

Characteristic and design values of end anchorage of composite slabs

Annex C6

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**Table 8: Temperature dependent strength reduction factor**

| Temperature of top flange $\Theta_{X\text{-}HVB}$ [°C] | $k_{u,\Theta,X\text{-}HVB}$ |
|:---:|:---:|
| 20 | 1.00 |
| 100 | 1.00 |
| 200 | 0.95 |
| 300 | 0.77 |
| 400 | 0.42 |
| 500 | 0.24 |
| 600 | 0.12 |
| ≥ 700 | 0 |

The design of the X-HVB shear connector in case of a fire is done according to EN 1994-1-2:2005/A1:2014. The reduction factor $k_{u,\Theta,X\text{-}HVB}$ shall be determined with the temperature of the steel top flange to which the X-HVB is connected.

The characteristic resistance of the X-HVB nailed shear connector at elevated temperature is calculated:

In case of solid concrete slabs:

$$P_{fi,Rk} = k_{u,\theta,X-HVB} \cdot P_{Rk}$$

with:

$P_{fi,Rk}$ .... characteristic resistance of X-HVB shear connector at elevated temperature
$P_{Rk}$ .... characteristic resistance of X-HVB shear connector according to Annex C1, Table 3

In case of composite beams with decking ribs transverse to the beam:

$$P_{fi,Rk} = k_{u,\theta,X-HVB} \cdot k_{t,l} \cdot P_{Rk} \quad \text{or} \quad P_{fi,Rk} = 0.89 \cdot k_{u,\theta,X-HVB} \cdot k_{t,t} \cdot P_{Rk}$$

with:

$P_{fi,Rk}$ .... characteristic resistance of X-HVB shear connector at elevated temperature
$P_{Rk}$ .... characteristic resistance of X-HVB shear connector according to Annex C1, Table 3
$k_{t,l}$ or $k_{t,t}$ .. reduction factor according to Annex C1, Table 4

Provision for deck types covered by Annex C3 and Annex C4: $P_{fi,Rk} = k_{u,\theta,X-HVB} \cdot P_{Rk}$

In case of composite beams with decking ribs parallel to the beam:

$$P_{fi,Rk} = k_{u,\theta,X-HVB} \cdot k_l \cdot P_{Rk}$$

with:

$P_{fi,Rk}$ .... characteristic resistance of X-HVB shear connector at elevated temperature
$P_{Rk}$ .... characteristic resistance of X-HVB shear connector according to Annex C1, Table 3
$k_l$ ... reduction factor according to Annex C2, Table 5

$k_{u,\Theta,X\text{-}HVB}$ temperature dependent reduction factor according to Table 8

[1] In the absence of other national regulations a recommended partial factor $\gamma_{M,fi,V} = 1.0$ can be used

**Nailed shear connector X-HVB**

Characteristic and design resistance to fire

Annex C7