European Technical Assessment

ETA-15/0876 of 3 June 2016

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	Plant 1 Plant 2
This European Technical Assessment contains	20 pages including 15 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	European Assessment Document (EAD) 200033-00-0602

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Specific part

1 Technical description of the product

The nailed shear connector X-HVB is a mechanically attached shear connector for use in steel-to-concrete composite beams and in composite decks with profiled sheeting as an alternate to welded headed studs.

The nailed shear connector consists of an L-shaped cold-formed cantilever metal connector made from steel sheeting with a thickness of 2 mm or 2.5 mm. The cantilever metal part consists of a fastening leg and an anchorage leg. The fastening leg of the connector is fastened by 2 powder-actuated fasteners X-ENP-21 HVB to the steel member, whereas the anchorage leg embeds in the concrete deck of the composite beam. The nailed shear connector can be used for composite beams with and without profiled composite decking.

The height of the anchorage leg varies in order to take the different thicknesses of the concrete slab as well as the different heights of composite deck into account.

The different models of the X-HVB are:

X-HVB 140, X-HVB 125, X-HVB 110, X-HVB 95, X-HVB 80, X-HVB 50 and X-HVB 40.

The number in the product designation refers to the height of the X-HVB connector.

The powder-actuated fasteners X-ENP-21 HVB are made of zinc plated carbon steel. The fasteners comprise of a pin with a shank diameter of 4.5 mm and they are assembled with two metal washers. The washers serve to guide the fastener while it is being driven into the base material and they contribute to the shear resistance. The powder-actuated fastening tools Hilti DX 76 or Hilti DX 76 PTR are used in order to install the X-ENP-21 HVB together with the X-HVB shear connector. The driving force of the fastening tool 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.

The nailed shear connectors can be placed in one or more rows along the length of the composite beams. Aside of the use as shear connector for composite beams, nailed shear connectors may also be used for the end anchorage of composite decks, see Annex A1.

The shear connectors X-HVB and the powder-actuated fastener X-ENP-21 HVB are detailed in Annexes A1 and A2.

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

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. 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, 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.

The intended use is also specified in Annex A1 and B1 to B4.

Positioning of the connectors follows Annexes B5 to B8.

The installation is only carried out according to the manufacturer's instructions.

In combination with composite decking the steel sheeting is in direct contact with the steel base material in the area of the connection.

Cartridge selection and tool energy settings in order to match the application limit diagram are taken into account.

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.

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 or perpendicular to beam axis	See Annex C1
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

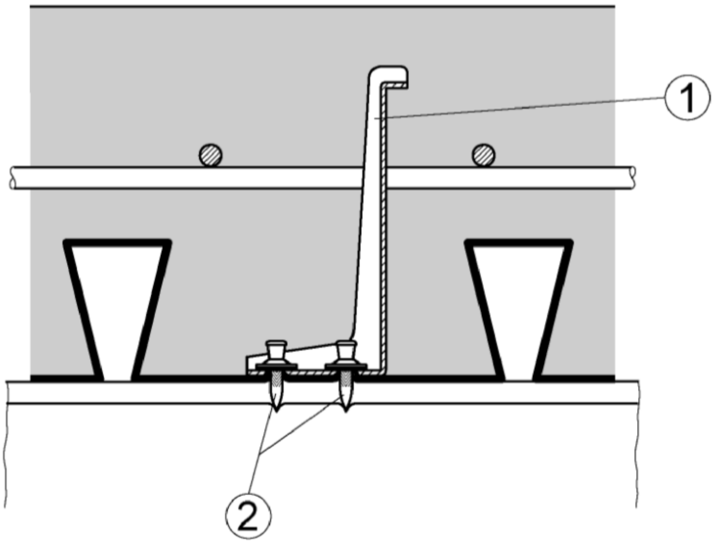
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 3 June 2016 by Deutsches Institut für Bautechnik

Uwe Bender
Head of Department

beglaubigt:
Stöhr

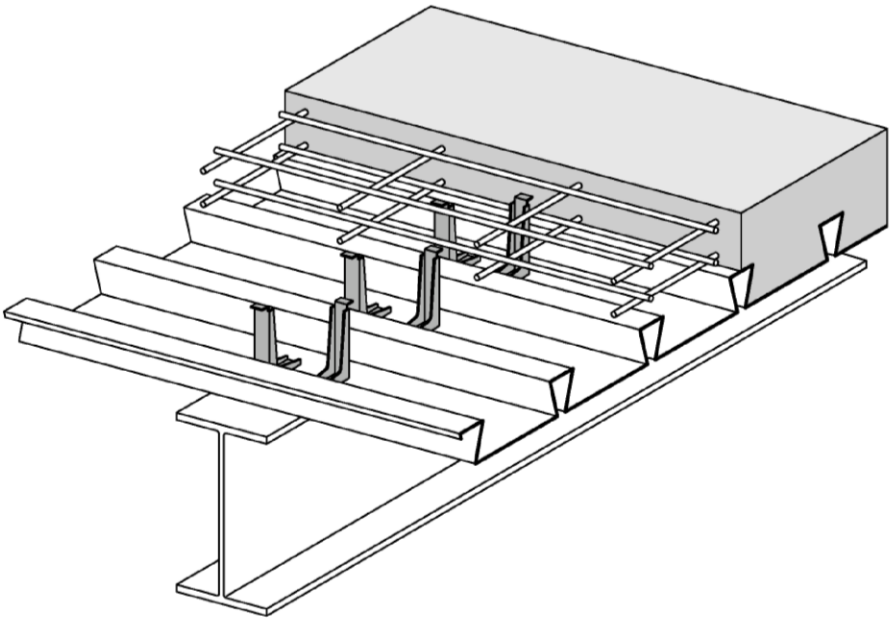
Nailed shear connector X-HVB with powder-actuated fastener X-ENP-21 HVB



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	Annex A1
Product and intended use	

Types of shear connector X-HVB

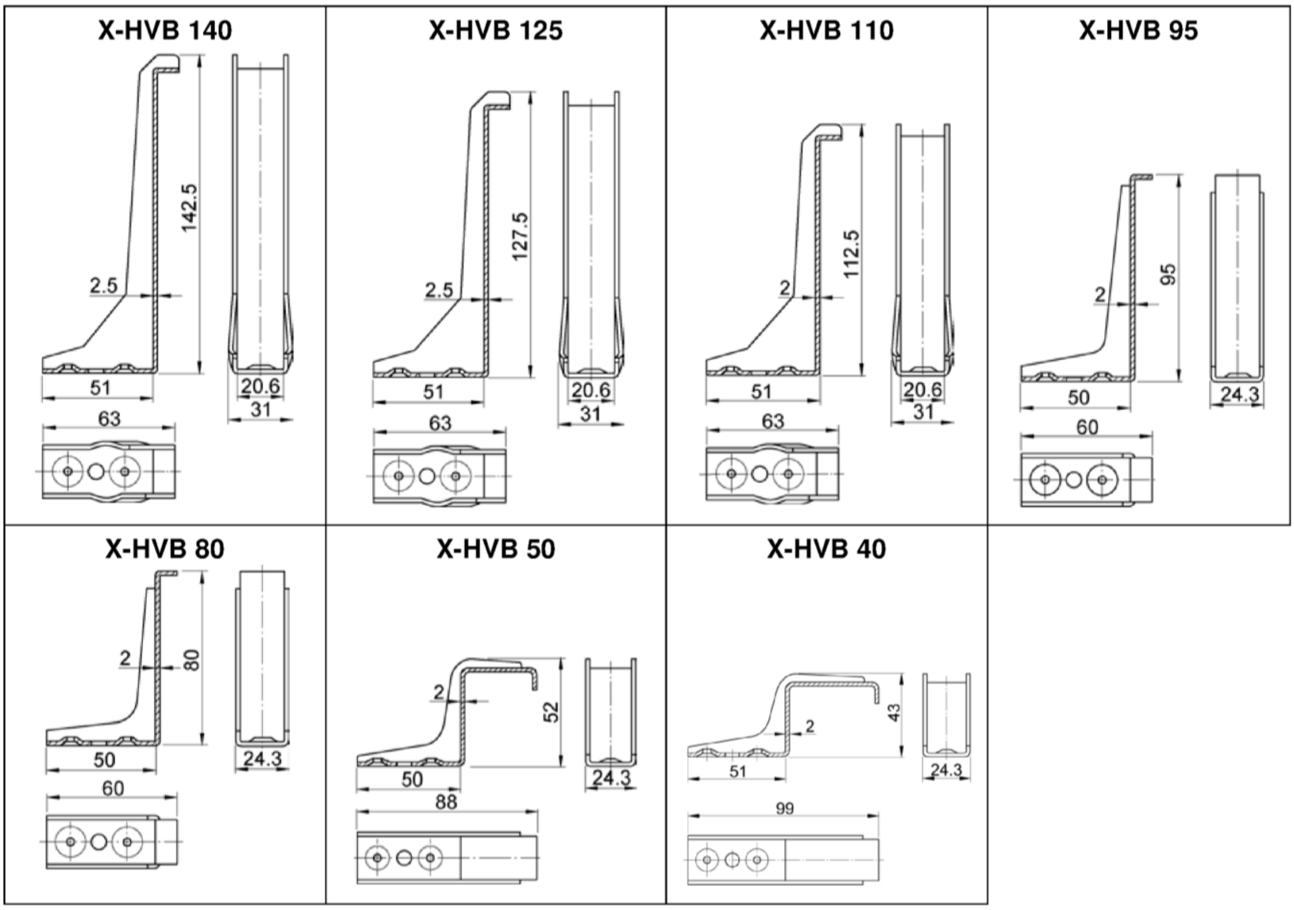
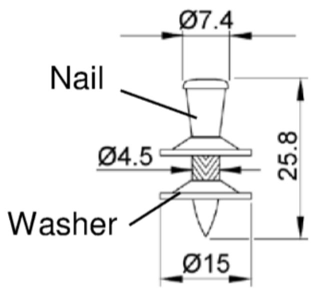


Table 1: Materials

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

Powder-actuated fastener X-ENP-21 HVB



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. 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, 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.

Base materials:

- Structural steel S235, S275 and S355 in qualities JR, JO, J2, K2 according to EN 10025-2, 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, minimum slab thickness see Annex B4.
- Light weight concrete LC 20/22 – LC 50/55 according to EN 206 with a raw density $\rho \geq 1750$ kg/m^3, minimum slab thickness see Annex B4.

Composite decking:

- Steel for profiled sheeting follows EN 1993-1-3 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.
- The X-HVB shear connectors are ductile shear connectors according to EN 1994-1-1, section 6.6.
- The partial safety factor of $\gamma_V = 1.25$ is used provided no other values are given in national regulations of the member states.

Installation:

- The installation is only carried out according to the manufacturer's instructions.
- In combination with composite decking the steel sheeting is in direct contact with the steel base material in the area of the connection.
- 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.

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Powder-actuated fastening tools and cartridge 6.8/18M

Powder-actuated fastening tool
DX 76 HVB

Powder-actuated fastening tool
DX 76 PTR HVB

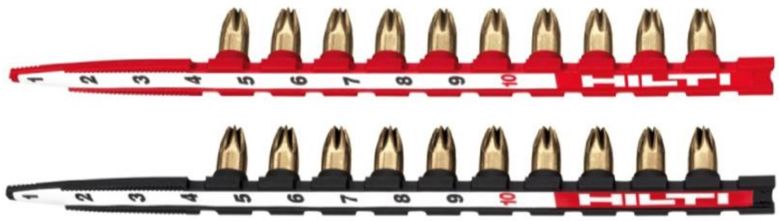
Fastener guide
X-76-F-HVB

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



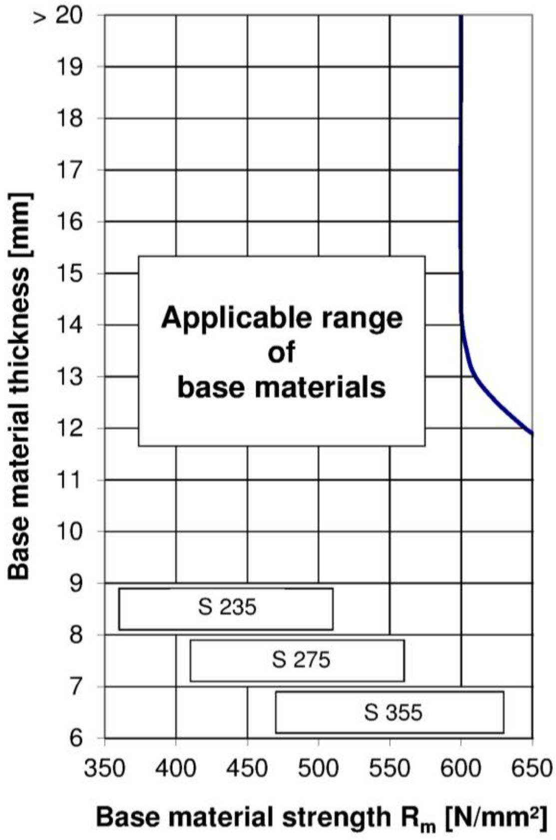
Cartridges 6.8/18 M

Red: Medium high load (level 6)
Black: Extra high load (level 7)

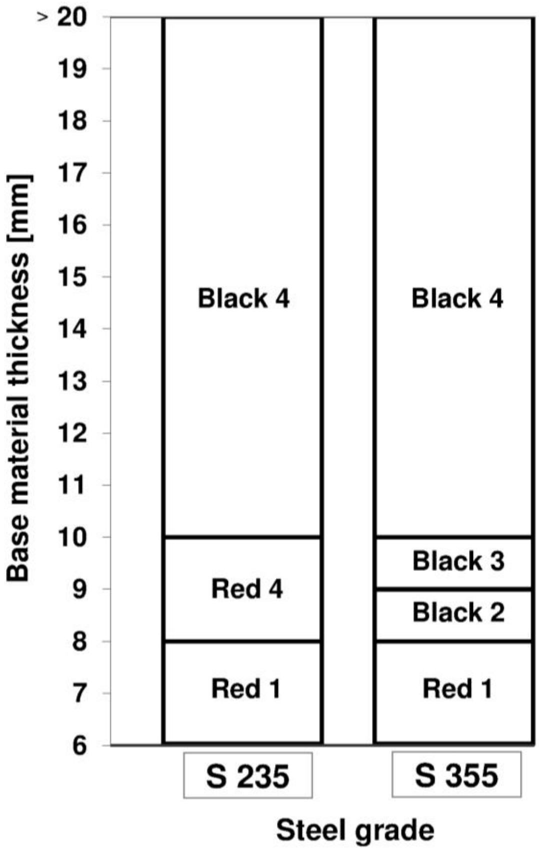
Blue: Medium load (level 5), see Annex B3

Nailed shear connector X-HVB	Annex B2
Powder-actuated fastening tool and components	

Application limit and tool energy setting

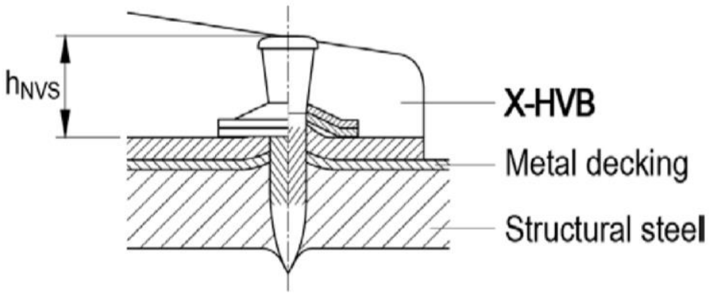


Notes:
Minimum section covered: IPE 100 (see annex C3)
Minimum base material thickness for beams with composite decking: 8 mm



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

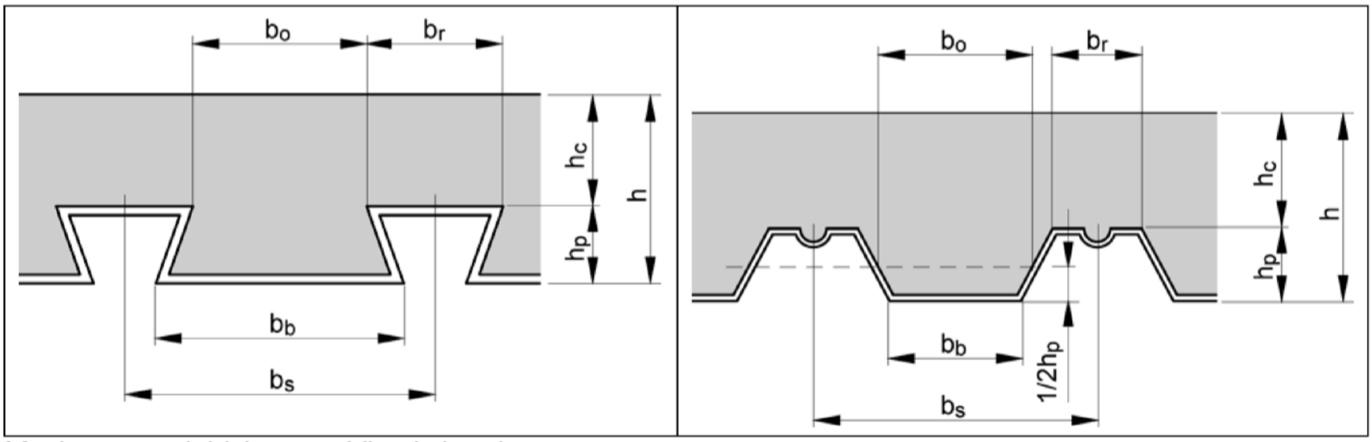


Clearly visible piston mark on top washer

8.2 mm ≤ h_{NVS} ≤ 9.8 mm

Nailed shear connector X-HVB	Annex B3
Application limit, cartridge selection and fastener inspection	

Composite decking geometry



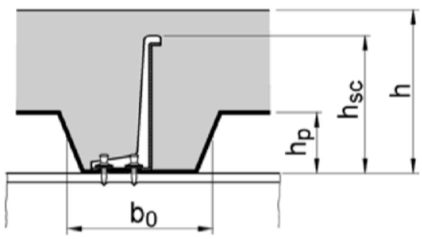
Maximum total thickness of fixed sheeting t_{fix}

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

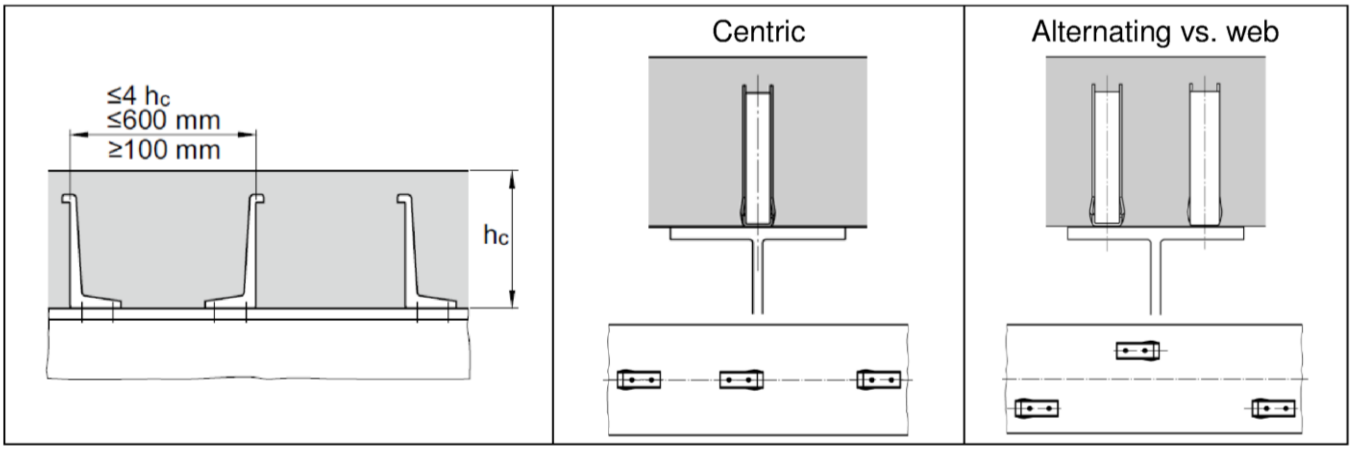
X-HVB	Maximum height of composite decking h_p [mm]		
	$\frac{b_0}{h_p} \geq 1.8$	$1.0 < \frac{b_0}{h_p} < 1.8$	$\frac{b_0}{h_p} \leq 1.0$ x)
80	45	45	30
95	60	57	45
110	75	66	60
125	80	75	73
140	80	80	80

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

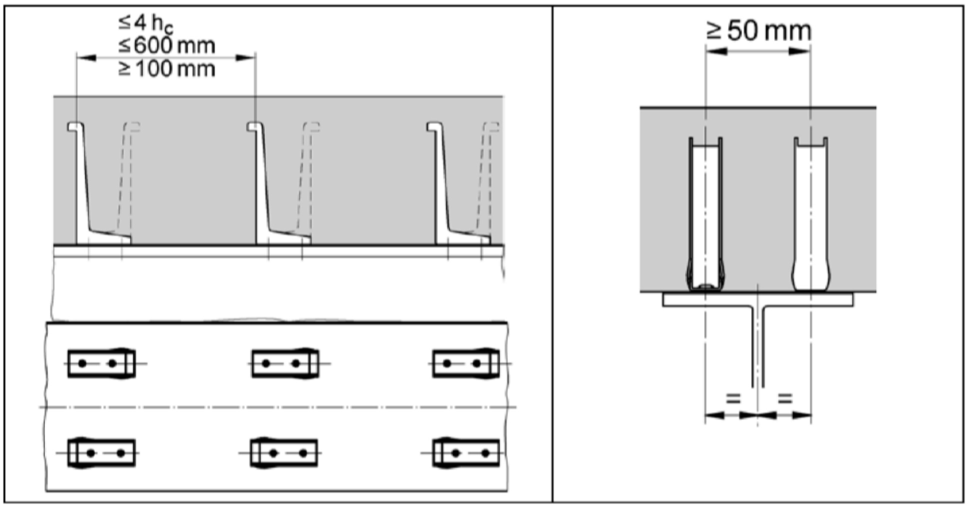
Nailed shear connector X-HVB	Annex B4
Geometric parameters	

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

One row of connectors



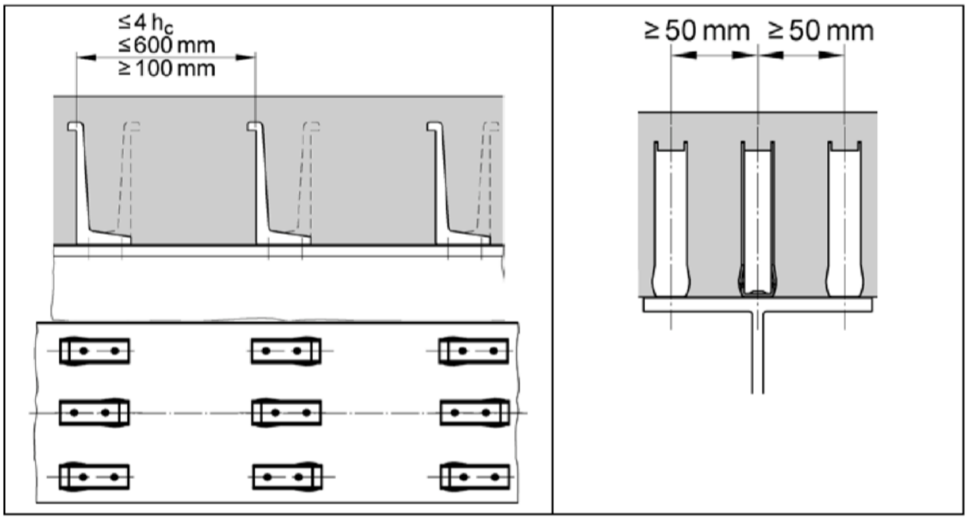
Two rows of connectors



Remark:

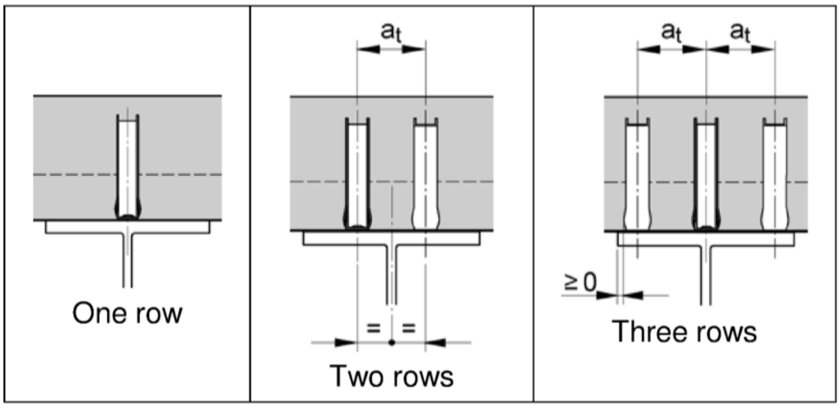
When using thin solid concrete slabs in combination with small I-profiles the „duckwalk“ positioning according to Annex C3 applies.

Maximum three rows of connectors



Nailed shear connector X-HVB	Annex B5
Positioning in composite beams with solid concrete slabs	

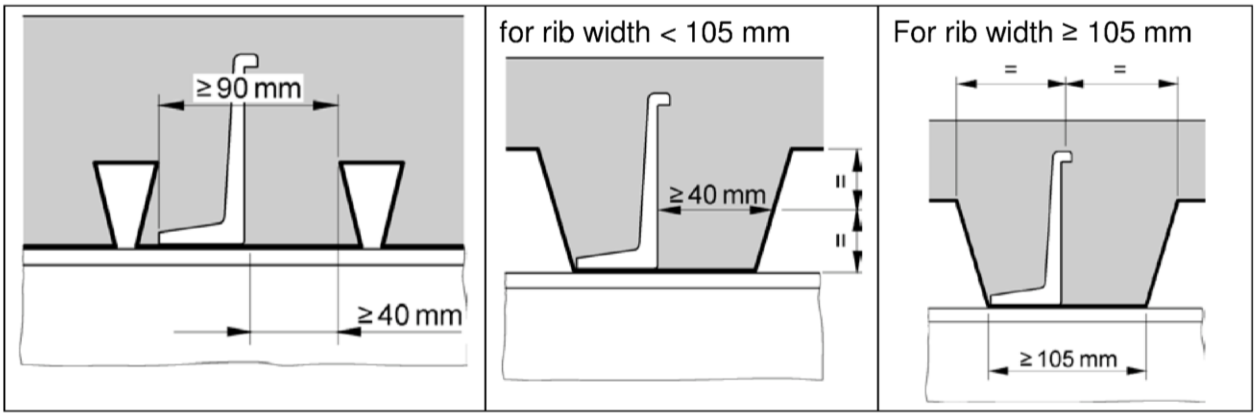
Spacing and positioning within cross section



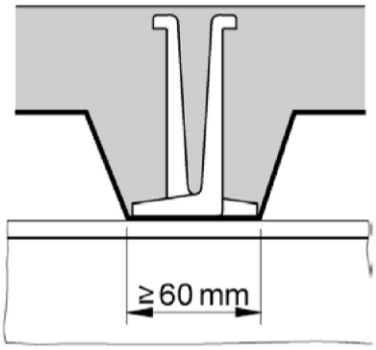
$a_t \geq$ 50 mm for compact profiled decking with $b_0/h_p \geq 1.8$

$a_t \geq$ 100 mm for other decking

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

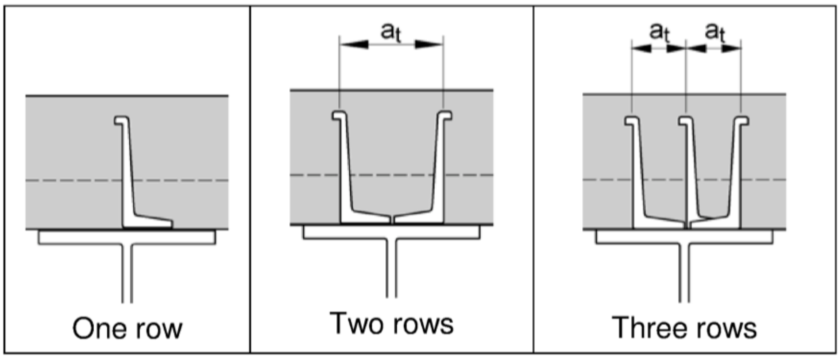


Minimum rib width in case of multiple row positioning



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

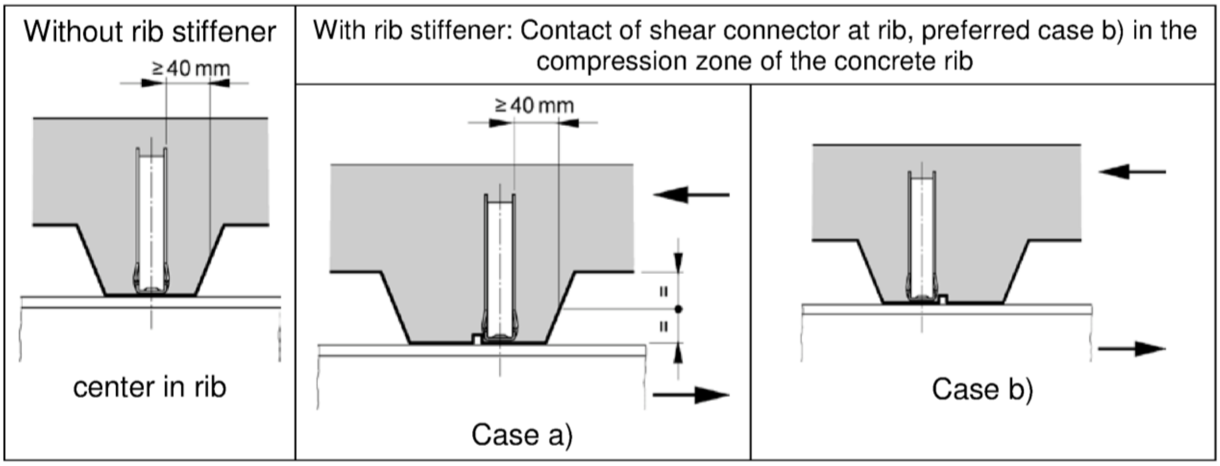
Spacing and positioning within cross section



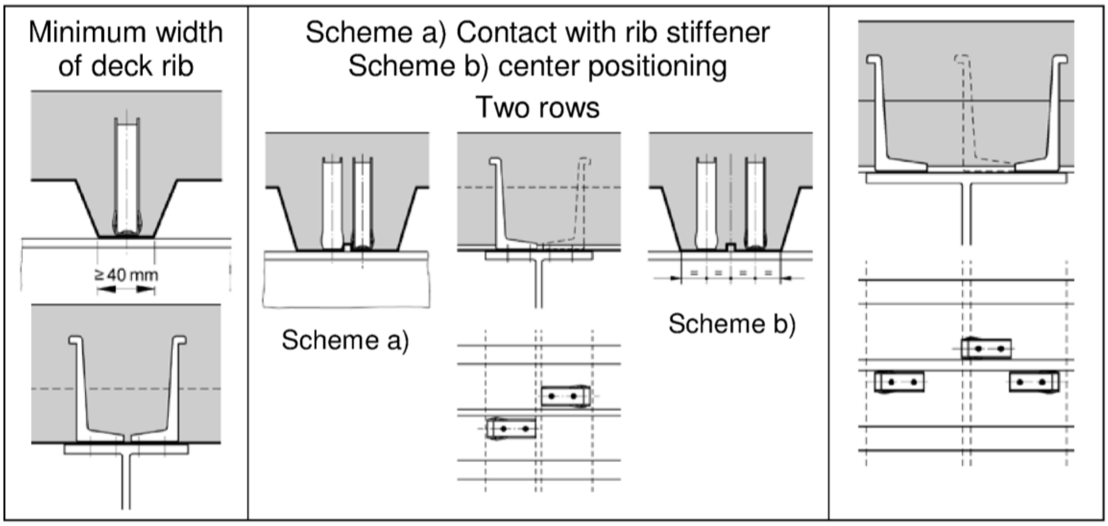
Two rows:
$a_t \geq 100$ mm for all types decking

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

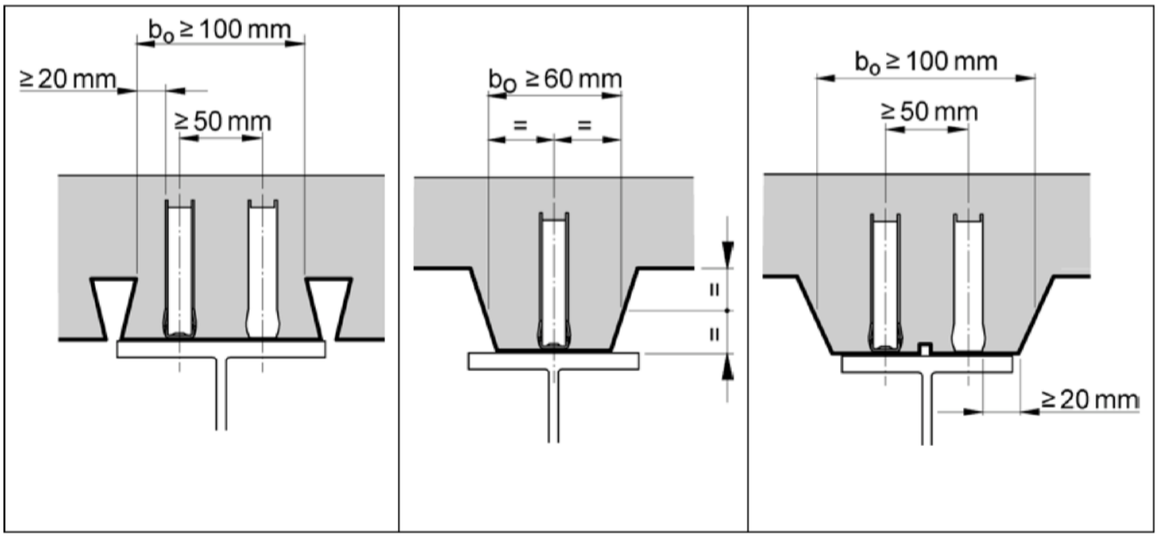


Positioning in two or three rows

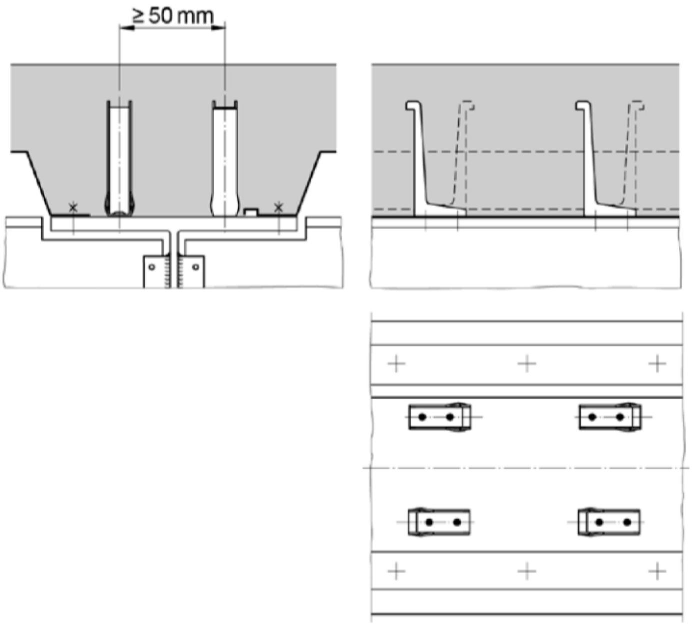


Nailed shear connector X-HVB	Annex B7
Positioning in composite beams with composite decking transverse and X-HVB positioning transverse with beam axis	

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	Annex B8
Positioning in composite beams with composite decking parallel with beam axis	

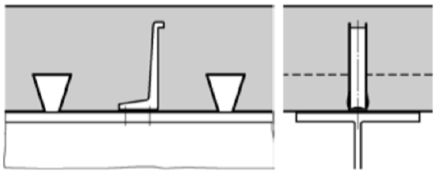
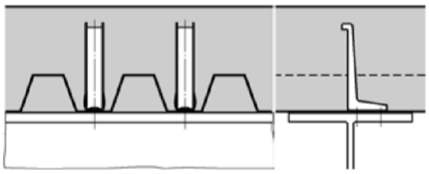
Table 3: Characteristic and design resistance in composite beams with solid slabs[1)]

Shear Connector	Characteristic Resistance P_{Rk} [kN]	Design Resistance P_{Rd} [kN]	Minimum base material thickness [mm]	X-HVB positioning[3)]	Ductility assessment
X-HVB 40	29	23	6	"duckwalk"	Ductile according to EN 1994-1-1
X-HVB 50	29	23	6		
X-HVB 80	32.5	26	8 [2)]	parallel with beam	
X-HVB 95	35	28			
X-HVB 110	35	28			
X-HVB 125	37.5	30			
X-HVB 140	37.5	30			

1) In the absence of other national regulations a partial safety factor $\gamma_V = 1.25$ applies
2) Reduction to 6 mm minimum base material thickness possible, see Annex C3
3) "Duckwalk" positioning according to Annex C3, 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 C3

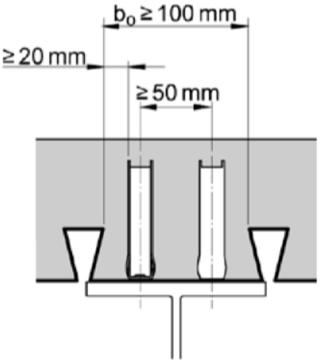
Table 4: Design resistance in composite beams with decking ribs transverse to beam axis

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

Conditions:
- Design resistance P_{Rd} 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: Design resistance in composite beams with decking ribs parallel to beam axis

X-HVB positioning	Design Resistance $P_{Rd,l}$	Ductility assessment
 X-HVB positioning longitudinal with the beam	$P_{Rd,l} = k_l \cdot P_{Rd}$ $k_l = 0.6 \cdot \frac{b_0}{h_p} \cdot \left(\frac{h_{SC}}{h_p} - 1\right) \leq 1.0$	Ductile according to EN 1994-1-1

Conditions:
- Design resistance P_{Rd} 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

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

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

$$P_{Rd,red} = \frac{t_{II,act}}{8} \cdot P_{Rd} \geq 23.0\ kN$$

with:

$P_{Rd,red}$ .... reduced design resistance of X-HVB 80 to X-HVB 140 in solid concrete slab for actual base material thickness $t_{II,act} < 8$ mm and a minimum thickness of 6 mm.

P_{Rd} .... design resistance in solid concrete slab of X-HVB 80 to X-HVB 140 according to Annex C1, Table 3

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

Design resistance: Effect of reduced base material strength

Reduction of design resistance P_{Rd} 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)

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

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

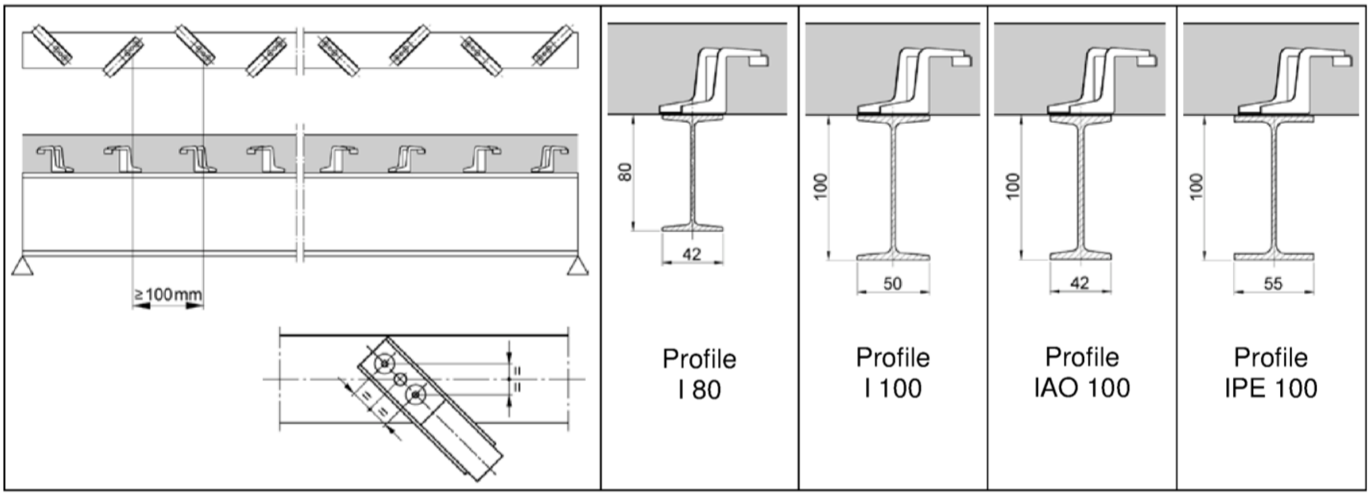
with:

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

P_{Rd} .... design resistance of X-HVB according to Annex C1, Table 3 and Table 4

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

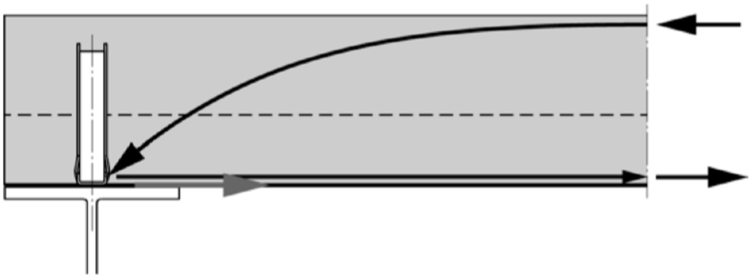
"Duckwalk" positioning of X-HVB 40 and 50 in combination with thin solid slabs:



Minimum section width = 40 mm (e.g. old section IAO 100),
Minimum center distance of steel sections = 400 mm

Nailed shear connector X-HVB	Annex C3
Use in renovation construction: design resistance and "duckwalk" positioning	

End anchorage in composite slabs



Design resistance:

$$V_{Rd,EA} = 50 \cdot t \cdot f_{u,k} \frac{1}{\gamma_V}$$

with:

$V_{Rd,EA}$ .... design 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.

γ_V .... partial safety factor, in the absence of national regulations γ_V = 1.25 applies

Table 6: 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. 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

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 6.

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

$$P_{fi,Rd} = \frac{1}{\gamma_{M,fi,V}} \cdot P_{fi,Rk}$$

with

$\gamma_{M,fi,V}$ …. partial safety factor in case of a fire, in the absence of national regulations $\gamma_{M,fi,V}$ = 1.0 applies

Nailed shear connector X-HVB	Annex C5
Characteristic and design resistance to fire	