X-HVB
Nailed Shear Connector

Design according to AS/NZS 2327:2017

Content:

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   Nailed shear connector X-HVB

September 12, 2019

Hilti X-HVB Nailed Shear Connector Design according to AS/NZS 2327:2017

SUMMARY

The purpose of this document is to summarize technical information on the use of Hilti X-HVB nailed shear connector in accordance with the new Australian/New Zealand composite construction standard AS/NZS 2327:2017 [1].

The design capacities of the X-HVB as provided in the European Technical Assessment ETA-15/0876 [2] can be also used in the Australian and New Zealand market. The corresponding assessment was made by HERA – Heavy Engineering Research Association (HERA Report SSTR-066 [3]).

The Hilti X-HVB shear connectors (X-HVB 80, X-HVB 95, X-HVB 110, X-HVB 125 and X-HVB 140) are also included within the "HERA Composite Beam and Slab Software". This document further summarizes the design capacities of the X-HVB used in that software, which are dependent on the different composite deck geometries. Furthermore, X-HVB positioning schemes for these composite decks are specified. Specifically, positioning drawings are provided in Appendix 2 for the ComFlor composite decking types (ComFlor 60, ComFlor 80 and ComFlor SR).

Important note: The user of the "HERA Composite Beam and Slab Software" needs to check separately if the placement of the required number of X-HVB´s is possible in the available ribs considering the positioning provisions within the rib.

CONTENT

1 GENERAL DESIGN PROVISIONS

The design resistance P_{Rd} of the Hilti nailed shear connector X-HVB is given in the European Technical Assessment ETA-15/0876 [2]. The data within ETA-15/0876 [2] allows design of composite beams in strict compliance with Eurocode 4, EN 1994-1-1 [4].

HERA – Heavy Engineering Research Association – assessed the suitability of using the X-HVB design data of ETA-15/0876 [2] in accordance with the new Australian/New Zealand Standard AS/NZS 2327:2017 [1]. The performance of the X-HVB in the context of AS/NZS 2327:2017 [1] is described in detail in the HERA Report SSTR-066 [3].

The key conclusions for the design of Hilti X-HVB nailed shear connectors related with AS/NZ 2327:2017 [1] are:

- The design resistance P_{Rd} as given in Annex C1 and Annex C2 of ETA-15/0876 [2] can be equivalently applied as design shear capacity P_{Rd} per AS/NZS 2327:2017 [1].
- The same level of safety on the resistance is applied. ETA-15/0876 [2] uses the partial factor γ_V = 1.25 from EN 1994-1-1 [4], whereas AS/NZS 2327 [1] applies a capacity factor ϕ = 0.8. Therefore, the characteristic resistance P_{Rk} as given in Annex C1 of ETA-15/0876 [2] for solid concrete slab can be equivalently applied as nominal shear capacity P_{Rk} per AS/NZS 2327:2017 [1].
- The design data of ETA-15/0876 [2] can be equivalently applied for steel base materials with nominal yield strength f_y of 235 to 355 N/mm².
- The design data of ETA-15/0876 [2] can be equivalently applied for characteristic concrete strength f_c' = 20 to 50 N/mm².

Table 1-1 summarizes the calculation of the design shear capacity of the X-HVB nailed shear connector per AS/NZS 2327:2017 [1] and compares it with the nomenclature of EN 1994-1-1 [4].

Table 1-1 Design capacity of X-HVB per AS/NZS 2327:2017 [1]

<table>
<tr><th>Parameter</th><th>AS/NZS 2327:2017 [1]</th><th>EN 1994-1-1 [4]</th></tr>
<tr><td rowspan="3">Design data</td><td>$P_{Rd} = \phi P_{Rk}$
P_{Rd} ... Design shear capacity
P_{Rk} ... Nominal shear capacity
ϕ … capacity factor (ϕ = 0.8)</td><td>$P_{Rd} = \frac{P_{Rk}}{\gamma_V}$
P_{Rd} ... Design resistance
P_{Rk} ... Characteristic resistance
γ_V … Partial factor (γ_V = 1.25)</td></tr>
<tr><td>The X-HVB is considered as ductile shear connector.</td><td>The X-HVB is considered as ductile shear connector.</td></tr>
<tr><td colspan="2">The values P_{Rk} and P_{Rd} apply per ETA-15/0876 [2].
The presence of composite decking is considered by application of the reduction factors $k_{t,l}$, $k_{t,t}$ or k_l.</td></tr>
<tr><td>Steel grades[1]</td><td>Construction steel with nominal yield strength f_y = 235 to 355 N/mm²</td><td>Steel grades S235, S275 and S355 in qualities JR, J0, J2 and K2 (EN 10025-2)</td></tr>
<tr><td>Concrete strength</td><td>f_c' = 20 to 50 N/mm²</td><td>C20/25 to C50/60</td></tr>
<tr><td>Conditions per ETA-15/0876 [1]</td><td colspan="2">• Observation of tool energy setting recommendation per Annex B3[2]
• Observation of application limit[3] and fastener stand-off provisions per Annex B3
• Observation of geometric parameters per Annex B4
• Observation of X-HVB positioning rules per Annex B5, B6, B7 and B8</td></tr>
</table>

1 Thermomechanically rolled steel beams are not covered by the application limit given in Annex B3 of ETA-15/0876 [1], inquire at Hilti.

2 For base material thickness ≥ 10 mm: Black cartridge 6.8/18M
For base material thickness 8 to 10 mm: Black or Red cartridge 6.8/18M
For base material thickness 6 to 8 mm: Red cartridge 6.8/18M

3 Note: Thermomechanilly rolled fine grained steel not covered, inquire at Hilti.

2 DESIGN SHEAR CAPACITIES USED IN HERA SOFTWARE

2.1 STEEL DECKING AND SELECTION PARAMETERS

The Hilti X-HVB shear connectors (X-HVB 80, X-HVB 95, X-HVB 110, X-HVB 125 and X-HVB 140) are also included within the "HERA Composite Beam and Slab Software". This software uses the design method provided in the new Australian/NZ composite construction standard AS/NZS 2327:2017 [1].

The "HERA Composite Beam and Slab Software" includes a set of composite decking used in the Australian and New Zealand market as summarized in Table 2-1.

Table 2-1 Steel decking covered by the "HERA Composite Beam and Slab Software"

Steel decking covered by the Software						
Designation	**Shape**	**Height h_p [mm]**	**Overall depth t_p [mm]**	**Rib width b_0 [mm]**	**(b_0/h_p) or (b_0/t_p) [-] (1)**	**Bottom rib (centre) stiffener**
Formsteel Unifloor, Flatdeck, Tray-deck 300	Rectangular	54, 57, 58	54, 57, 58	na.	na.	No
Formsteel, Svelte 60	Trapezoidal	60	63	147,5	2,46	Yes
Formsteel, Svelte 80	Trapezoidal	80	83	147,5	1,84	Yes
Hibond 80	Trapezoidal	80	95	179,0	1,88	No
Hibond 55	Trapezoidal	55	55	154,5	2,81	Yes
Tray-dec 60	Trapezoidal	60	60.75	136,7	2,28	Yes
Tray-dec 80	Trapezoidal	80	81	149,1	1,86	Yes
ComFlor 60	Trapezoidal	60	75	144,6	1,93	No
ComFlor 80	Trapezoidal	80	95	135,0	1,42	No
ComFlor SR	Re-entrant	55	55	161,0	2,93	No

(1) for decking with top crest stiffener of 15 mm height (Hibond 80, ComFlor 60 and ComFlor 80), the ratio (b_0/t_p) is calculated.

Sketches of the geometry of all decking are provided Appendix 1.

Important note:

The user of the "HERA Composite Beam and Slab Software" needs to check separately if the placement of the required number of X-HVB´s is possible in the available ribs considering the positioning provisions within the rib.

The "HERA Composite Beam and Slab Software" does not check the geometric requirements related with the positioning of the X-HVBs in the decking rib.

Therefore, a pre-selection of the X-HVB´s was prepared by Hilti per decking type.

This pre-selection includes:

- Minimum X-HVB height
- Orientation of the X-HVB in the rib in case of decking transverse to be beam:
  - Parallel to the beam
  - Transverse to the beam
- Minimum number of X-HVB per rib
- Design capacity in composite beams with solid concrete slab (default X-HVB orientation: longitudinal to the beam)
- Design capacity in composite beams with composite slabs (with decking transverse or parallel with the beam)
  - For 1, 2 and 3 X-HVB´s per rib (general case)
  - For 1, 2, 3 and 4 X-HVB´s per rib (in the specific case of the use of X-HVB 140 in combination with ComFlor 80 composite decking)

The following sections summarize the X-HVB design capacities and provide information on their calculation. They correspond with the values used by the software. They already consider a potential reduction with the respective reduction factor k:

- $k_{t,l}$ …. decking transverse to the beam and X-HVB longitudinal to the beam
- $k_{t,t}$ …. decking transverse to the beam and X-HVB transverse to the beam
- k_l ..... decking parallel with beam (default X-HVB orientation: longitudinal to the beam)

2.2 SOLID CONCRETE SLAB

The same values as given in the ETA-15/0876 [2] apply, those are also summarized in Table 2-2 and in Table 2-3 for reference. The X-HVBs are to be positioning longitudinal with the beam and the geometric provisions as given in ETA-15/0876, Annex B5 [2] are to be observed.

2.3 DECKING TRANSVERSE WITH BEAM

Table 2-2 summarizes the conditions and design capacities P_{Rd} for composite decking transverse with the beam. With the exception of the test based data for the ComFlor 80 decking, all design capacities are calculated per ETA-15/0876 [2] applying the reduction formula from Table 4 in Annex C1 of the ETA-15/0876 [2]. For specific calculation notes see the end of this section.

Table 2-2 Design Data for HERA Software: Solid concrete slab and decking transverse with beam

Composite beam with solid slab or composite decking transverse to beam									Design resistance P_{Rd} [kN]				
Designation	Shape	Height h_p [mm]	Overall depth t_p [mm]	Positioning X-HVB vs. Beam	Minimum height	Positiong scheme	Minimum number of X-HVB per rib	Number of X-HVB per rib	X-HVB 80	X-HVB 95	X-HVB 110	X-HVB 125	X-HVB 140
Solid Slab	*	*	*	Longitudinal	X-HVB 80	A	n.a.	n.a.	26,00	28,00	28,00	30,00	30,00
Formsteel Unifloor, Flatdeck, Tray-deck 300	Rectangular	54, 57, 58	54, 57, 58	Longitudinal	X-HVB 80	A	1	1	26,00	28,00	28,00	30,00	30,00
								2					
								3					
Formsteel Svelte 60	Trapezoidal	60	63	Transverse	X-HVB 95	B	2	2	*	24,73	24,92	26,70	26,70
								3	*	20,19	24,92	26,70	26,70
Formsteel Svelte 80	Trapezoidal	80	83	Transverse	X-HVB 140	B	2	2	*	*	*	*	26,70
								3	*	*	*	*	22,20
Hibond 80	Trapezoidal	80	95	Transverse	X-HVB 140	C	1	1	*	*	*	*	26,70
								2	*	*	*	*	19,88
								3	*	*	*	*	16,23
Hibond 55	Trapezoidal	55	55	Transverse	X-HVB 95	B	2	2	*	24,92	24,92	26,70	26,70
								3	*	24,92	24,92	26,70	26,70
Tray-dec 60	Trapezoidal	60	60	Transverse	X-HVB 95	B	2	2	*	24,92	24,92	26,70	26,70
								3	*	21,54	24,92	26,70	26,70
Tray-dec 80	Trapezoidal	80	80	Transverse	X-HVB 125	B	2	2	*	*	*	22,28	26,70
								3	*	*	*	18,19	24,39
ComFlor 60	Trapezoidal	60	75	Transverse	X-HVB 110	C	1	1	*	*	24,92	26,70	26,70
								2	*	*	18.71	26,70	26,70
								3	*	*	15,28	23,39	26,70
ComFlor 80	Trapezoidal	80	95	Transverse	X-HVB 140	D	1	1	*	*	*	*	21,22
								2	*	*	*	*	21,22
								3	*	*	*	*	19,20
								4	*	*	*	*	17,60
ComFlor SR	Re-entrant	55	55	Longitudinal	X-HVB 95	A	1	1	*	28,00	28,00	30,00	30,00
								2	*	27,80			
								3	*	22,70			

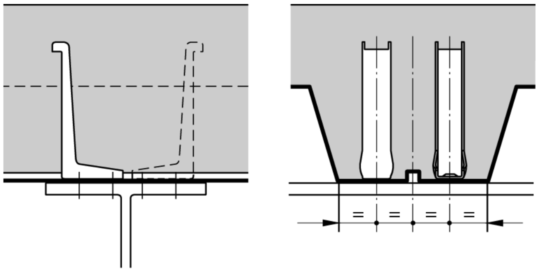
Positioning scheme (A)

The scheme corresponds with the positioning in solid concrete slabs per Annex B5 of ETA-15/0876 [2].

With regards to the design capacity, flat decks are considered as solid concrete slabs according to AS/NZS 2327: 2017, Clause 3.6.2.4.2. [1]. However, due to the presence of bottom rib stiffeners, the minimum longitudinal spacing – given as 100 mm for solid slabs – might be slightly adjusted, as well as the way of alternating the X-HVB connectors in case of one row of X-HVB connectors.

Positioning scheme (B)

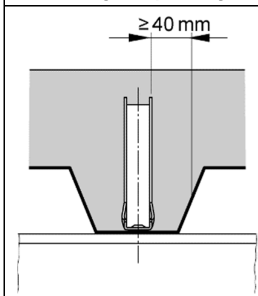
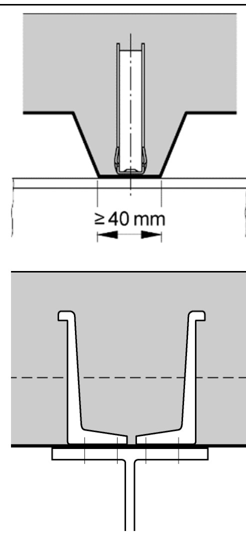
This scheme is recommended for decks with a center bottom rib stiffener as shown in Annex B7 of ETA-15/0876 [2] for 2 or 3 X-HVBs per rib. Sub-scheme b) is recommended:



Scheme b) with X-HVB in the center of half of the rib

Positioning scheme (C)

The scheme covers deck without a central rib stiffener as the ComFlor 60 or the HiBond 80. Therefore, the X-HVBs can be placed in transverse orientation in the center of the rib, see Annex B7 of ETA-15/0876 [2] and the relevant extract below. Also, the use of just one X-HVB per rib is possible as the deck mid-height to X-HVB distance exceeds 40 mm.

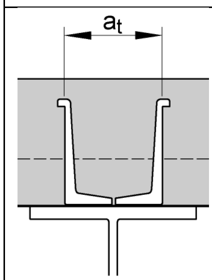
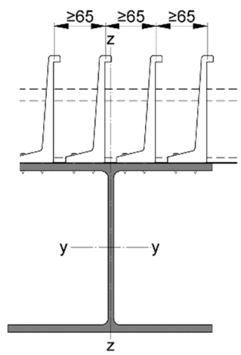
One X-HVB per rib: Mid-height spacing of 40 mm is met.	2 or 3 X-HVB´s per rib: Minimum bottom rib width of 40 mm is met.
	

X-HVB positioning drawings in all 3 ComFlor decking (ComFlor 60, ComFlor 80 und ComFlor SR) are provided in Appendix 2.

Spacing

Except for ComFlor 80 decking, all decking has a compact geometry as the ratio (b_0/h_p) or (b_0/t_p) exceeds the value of 1.8 (see Table 2-1). Therefore, the spacing provisions for compact decking geometries as given in Annex B6 and B7 of ETA-15/0876 [2] apply.

Based on the tests with ComFlor 80 [3], the specific spacing provision for X-HVB 140 and ComFlor 80 are as follows:

2 X-HVB 140	3 to 4 X-HVB 140	
 $a_t \geq 100$ mm	 $a_t \geq 65$ mm	Note: alignment of all X-HVB´s in one line with minimum leg spacing of 65 mm is allowed (as shown left). Alternating positioning of X-HVB legs is also acceptable provided the beam flange is wide enough and the minimum spacing of 65 mm is observed.

Calculation notes

Decking with small top rib stiffeners (Svelte 60 and Svelte 80) or slight deviation from nominal height (Tray-dec 60 and 80)

- Svelte 60 and Svelte 80:
  - For Svelte 60 the very small stiffeners are considered negligible (see also section 3.6.2.4.2 (c) of [1]) related with the selection of the smallest X-HVB (→ X-HVB 95 for Svelte 60).
  - The stiffeners are conservatively considered in the calculation of the reduction factor $k_{t,t}$ and the calculation is done with the overall depth t_p.
- Tray-dec 60 and Tray-dec 80:
  - The very small height deviation (60.75 mm vs. nominal 60 mm / 81 mm vs. 80 mm) is considered negligible related with the selection of the smallest X-HVB (→ X-HVB 95 and → X-HVB 125, respectively).
  - The actual height of 60,75 mm or 81 mm is considered in the calculation of the reduction factor $k_{t,t}$.

Decking with top crest stiffener of 15 mm height

- Hi-Bond 80:
  - The minimum X-HVB height was selected with 140.
  - The stiffeners are conservatively considered in the calculation of the reduction factor $k_{t,t}$ and the calculation is done with the overall depth t_p of 95 mm.
- ComFlor 60:
  - The minimum X-HVB height was selected with 110.
  - The stiffeners are conservatively considered in the calculation of the reduction factor $k_{t,t}$ and the calculation is done with the overall depth t_p of 75 mm.
- ComFlor 80: New testing is available per HERA SST-066 [3]. Therefore, the test-based design resistances are directly used for n = 1, 2, 3 and 4.

Decking with rectangular shape (Formsteel Unifloor, Flatdeck, Tray-dec 300)

- The reduction factor $k_{t,l}$ = 1.0 is applied as given in section 3.6.2.4.2 of [1] for clipped pan profiles.

2.4 DECKING PARALLEL WITH BEAM

Table 2-3 summarizes the conditions and design capacities P_{Rd} for composite decking parallel with the beam. All design capacities are calculated per ETA-15/0876 [2] applying the reduction formula from Table 5 in Annex C2 of the ETA-15/0876 [2].

Table 2-3 Design Data for HERA Software: Solid concrete slab and decking parallel with beam

Composite beam with solid slab or composite decking parallel with beam						Design resistance P_{Rd} [kN]				
Designation	Shape	Height h_p [mm]	Overall depth t_p [mm]	Positioning X-HVB vs. Beam	Minimum height	X-HVB 80	X-HVB 95	X-HVB 110	X-HVB 125	X-HVB 140
Solid Slab	*	*	*	Longitudinal	X-HVB 80	26,00	28,00	28,00	30,00	30,00
Formsteel Unifloor, Flatdeck, Tray-deck 300	Rectangular	54, 57, 58	54, 57, 58	Longitudinal	X-HVB 80	26,00	28,00	28,00	30,00	30,00
Formsteel, Svelte 60	Trapezoidal	60	63	Longitudinal	X-HVB 95	*	19,98	28,00	30,00	30,00
Formsteel, Svelte 80	Trapezoidal	80	83	Longitudinal	X-HVB 140	*	*	*	*	21,97
Hibond 80	Trapezoidal	80	95	Longitudinal	X-HVB 140	*	*	*	*	16,07
Hibond 55	Trapezoidal	55	55	Longitudinal	X-HVB 95	*	28,00	28,00	30,00	30,00
Tray-dec 60	Trapezoidal	60	60	Longitudinal	X-HVB 95	*	21,32	28,00	30,00	30,00
Tray-dec 80	Trapezoidal	80	80	Longitudinal	X-HVB 125	*	*	*	18,00	24,14
ComFlor 60	Trapezoidal	60	75	Longitudinal	X-HVB 110	*	*	15,12	23,14	30,00
ComFlor 80	Trapezoidal	80	95	Longitudinal	X-HVB 140	*	*	*	*	12,12
ComFlor SR	Re-entrant	55	55	Longitudinal	X-HVB 95	*	28,00	28,00	30,00	30,00

Spacing:

The spacing provisions as given in Annex B8 of ETA-15/0876 [2] apply.

2.5 FIRE RESISTANCE

Table 6 of Annex C5 of ETA-15/0876 [2] provides temperature dependent strength reduction factors $k_{u,\Theta,X\text{-}HVB}$ for calculation of the X-HVB design resistance in case of a fire. The same reduction factors have been implemented within the "HERA Composite Beam and Slab Software".

3 LITERATURE AND APPENDICES

3.1 LITERATURE

[1] AS/NZ 2327:2017 *Composite structures – composite steel-concrete construction in buildings.* Standard Australia International/Standards New Zealand, Sydney/Wellington

[2] ETA-15/0876: *Design rules for Hilti Nailed Shear Connector X-HVB,* HERA Report SSTR-066, Heavy Engineering Research Association, HERA ISBN 0112-1758, 12/12/2018

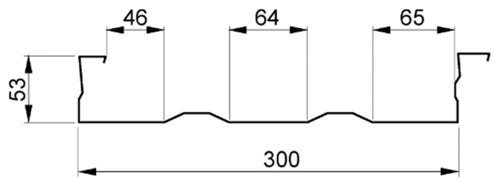
[3] Hicks, S., Cao, J. (2019): *Design rules for Hilti Nailed Shear Connector X-HVB,* HERA Report SSTR-066, Heavy Engineering Research Association, HERA ISBN 0112-1758, 12/12/2018

[4] EN 1994-1-1:2004 *Eurocode 4: Design of composite steel and concrete structures – Part 1.1.: General rules and rules for buildings,* European Committee for Standardization, Brussels

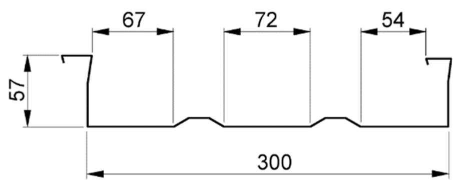
3.2 APPENDICES

Geometry of Steel decking covered by the "HERA Composite Beam and Slab Software"

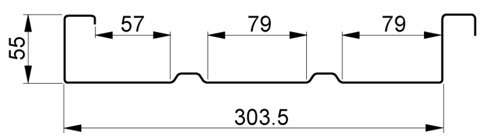
Formsteel Unifloor



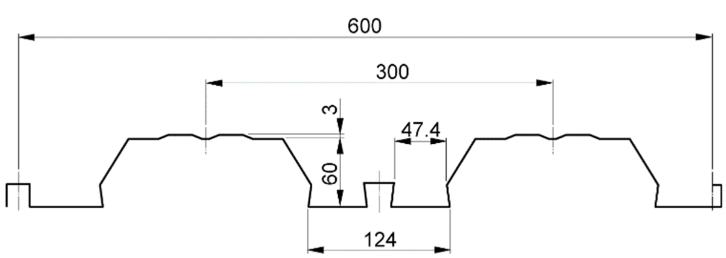
Flatdeck



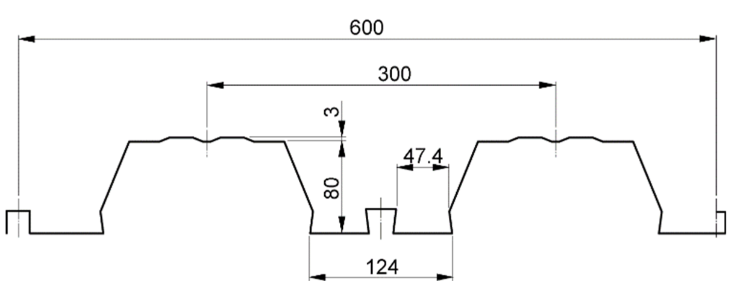
Tray-dec 300



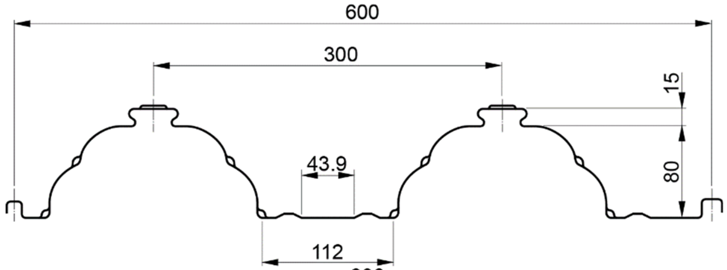
Svelte 60

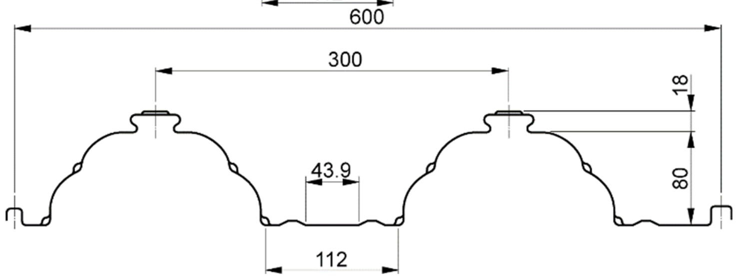


Svelte 80

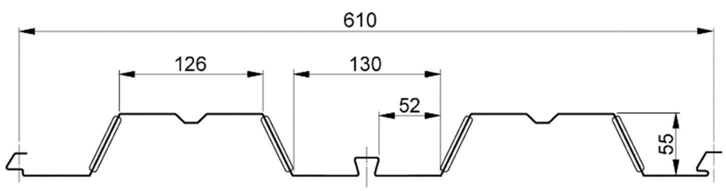


Hibond 80

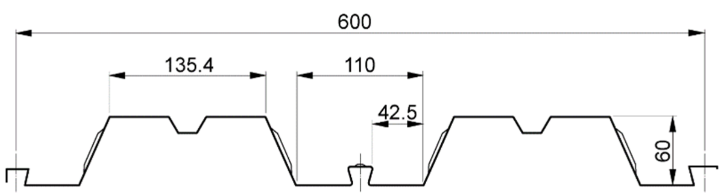




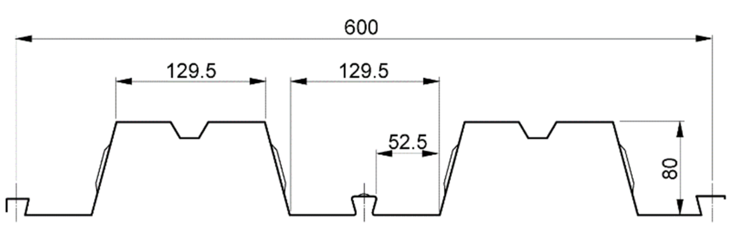
Hibond 55



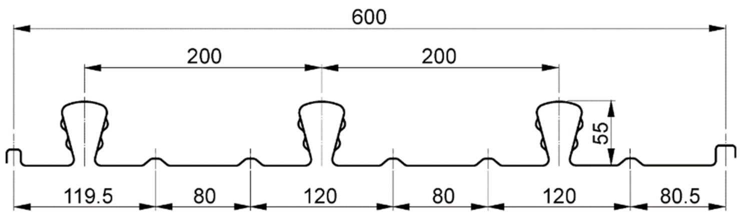
Tray-dec 60



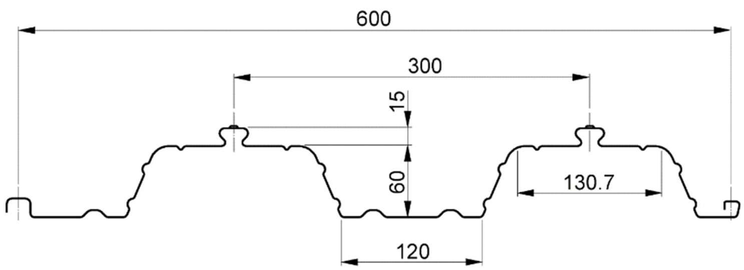
Tray-dec 80



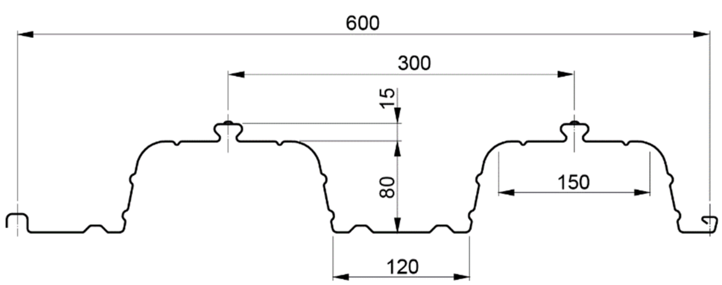
ComFlor SR



ComFlor 60-600

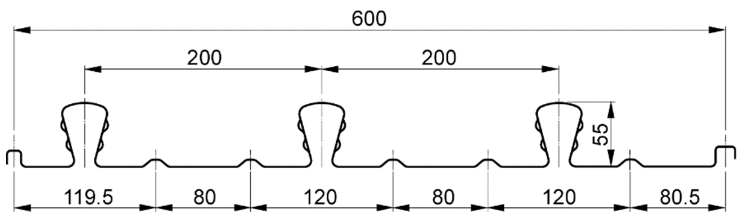


ComFlor 80-600

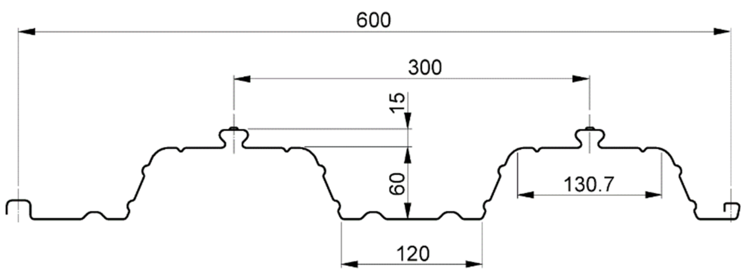


X-HVB positioning drawings in ComFlor composite decking

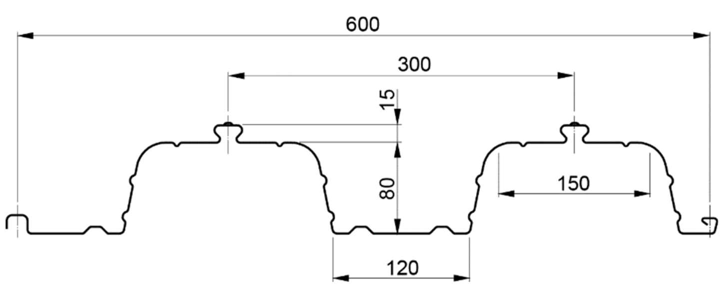
ComFlor SR



ComFlor 60-600

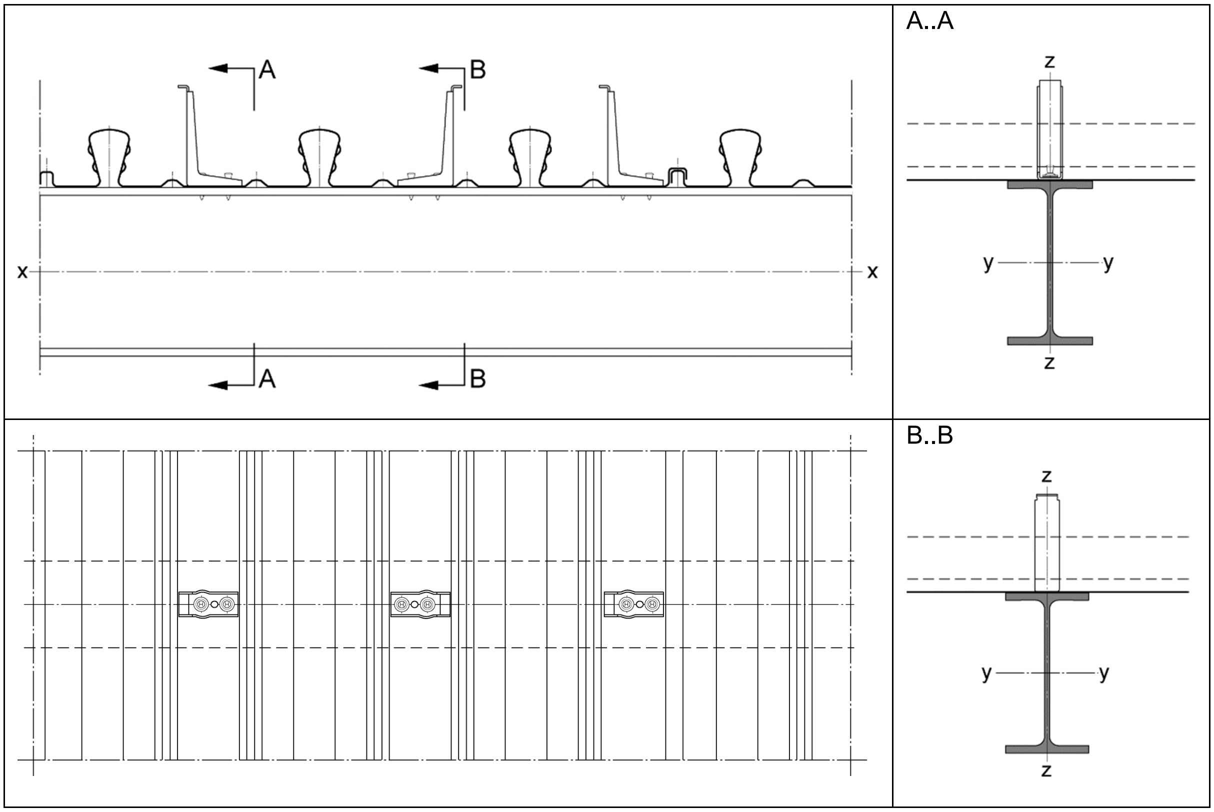


ComFlor 80-600

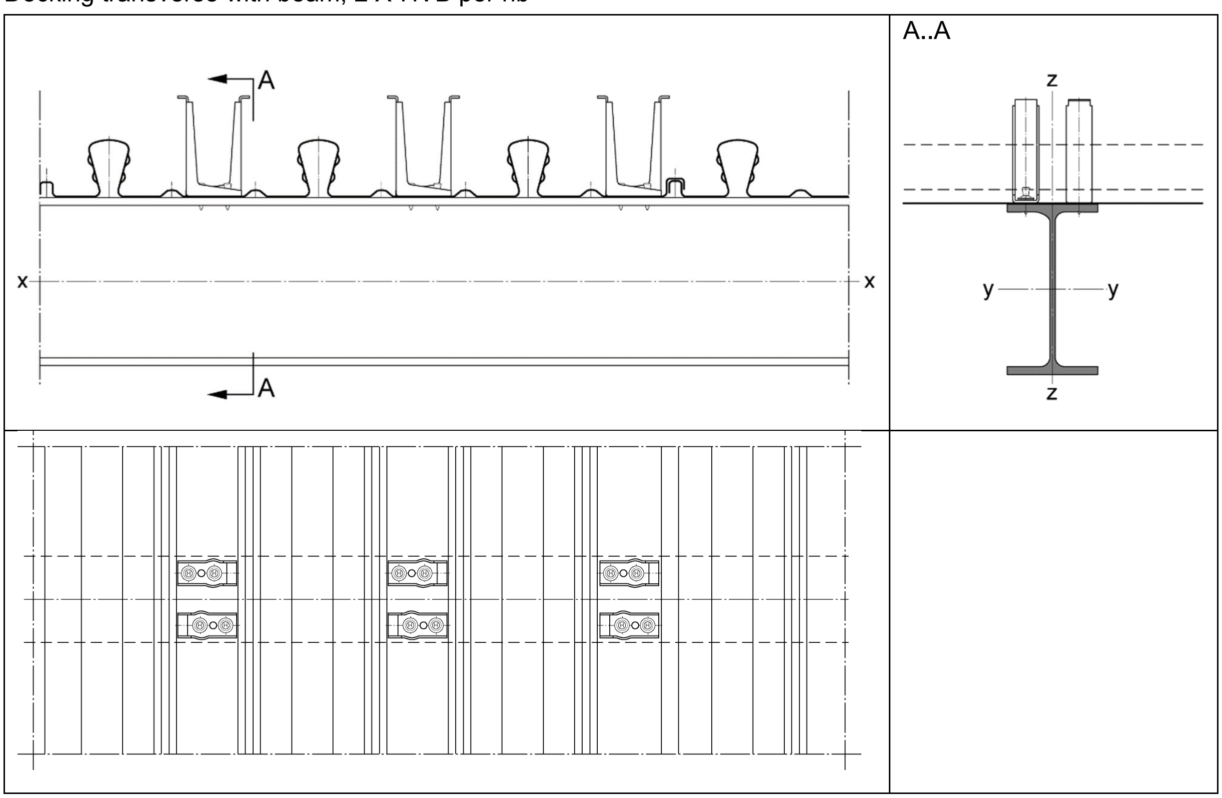


X-HVB positioned in Comflor-SR − Orientation: Longitudinal with the beam

Decking transverse with beam, 1 X-HVB per rib

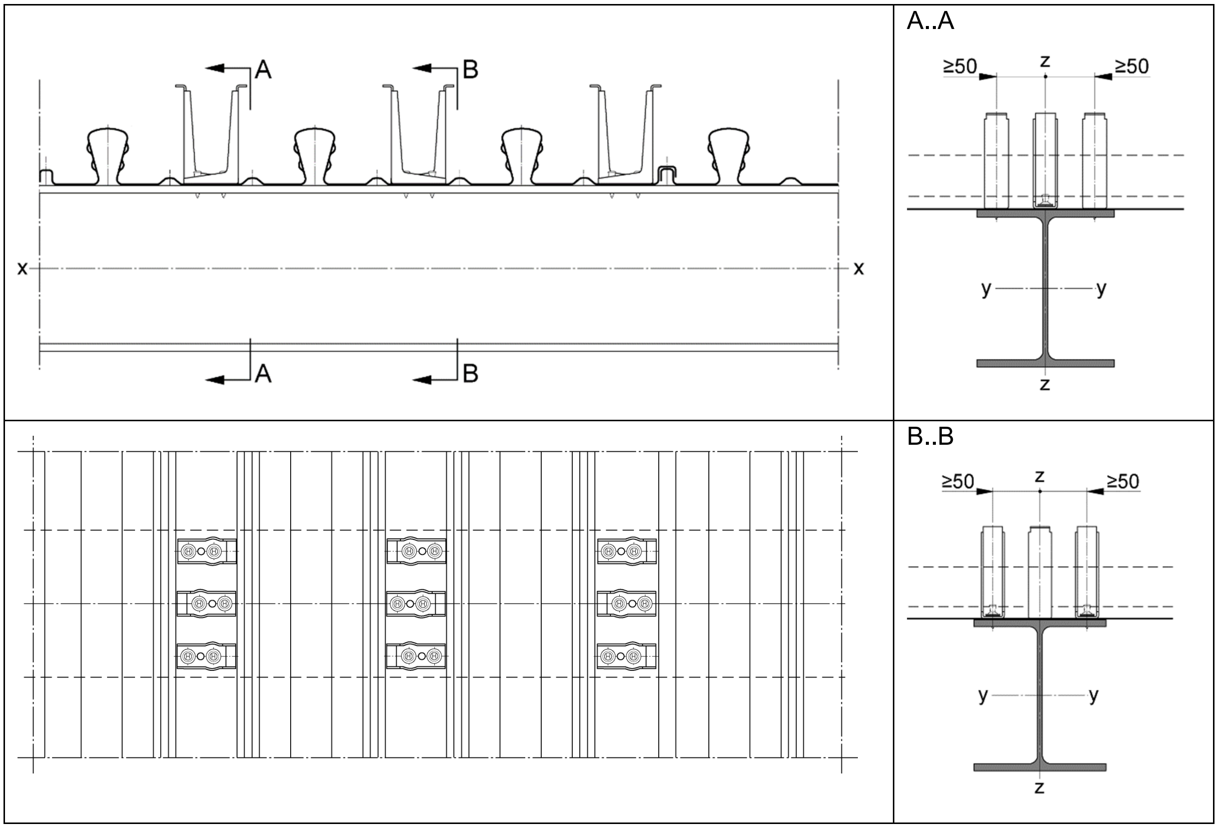


Decking transverse with beam, 2 X-HVB per rib



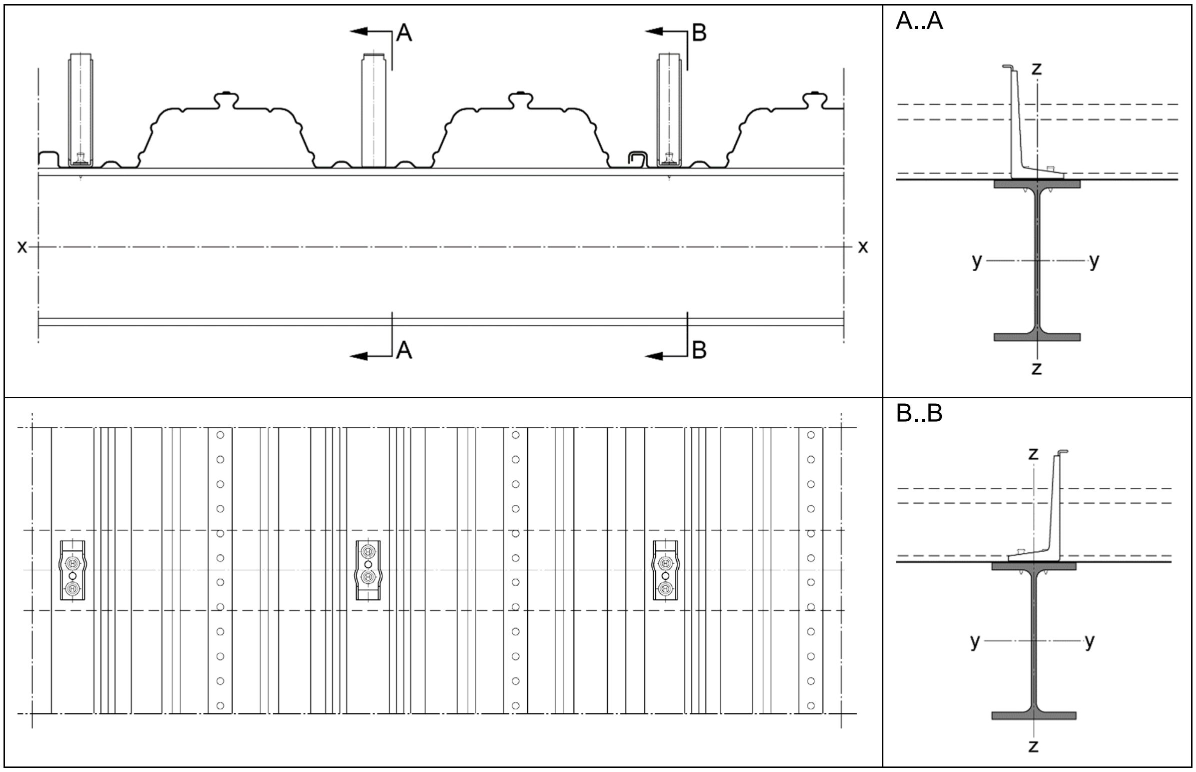
X-HVB positioned in Comflor-SR − Orientation: Longitudinal with the beam

Decking transverse with beam, 3 X-HVB per rib

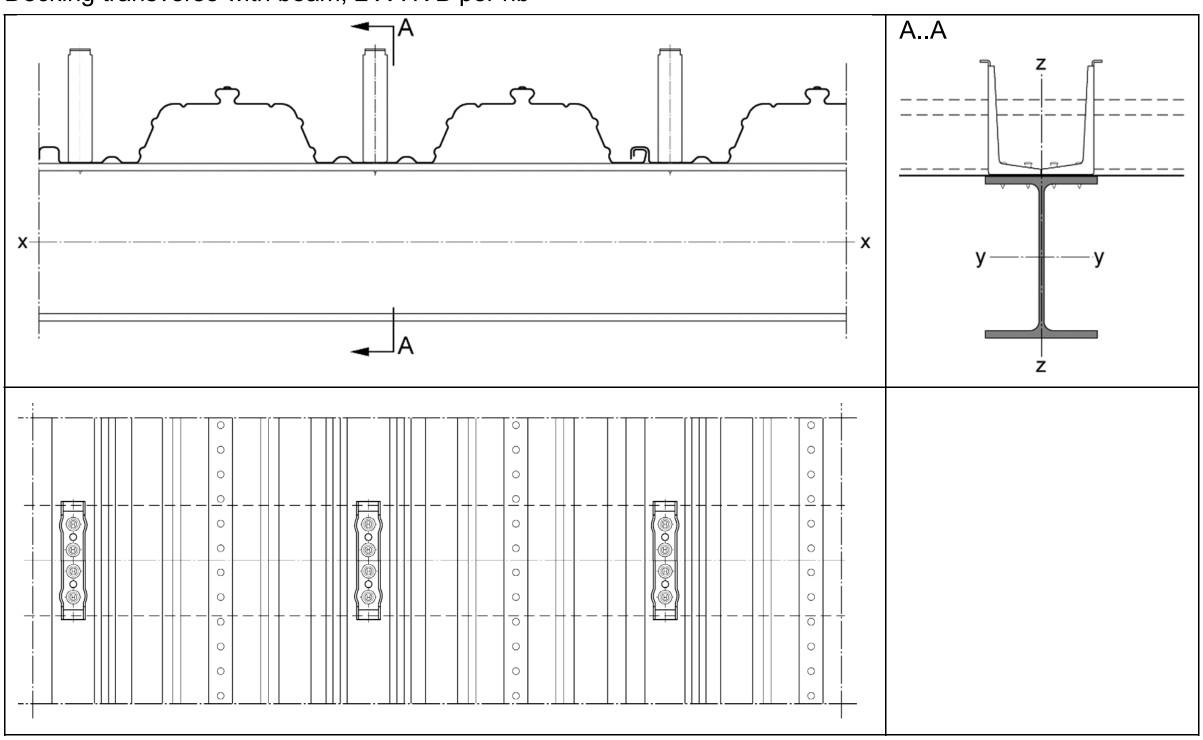


X-HVB positioned in Comflor 60-600 − Orientation: Transverse

Decking transverse with beam, 1 X-HVB per rib

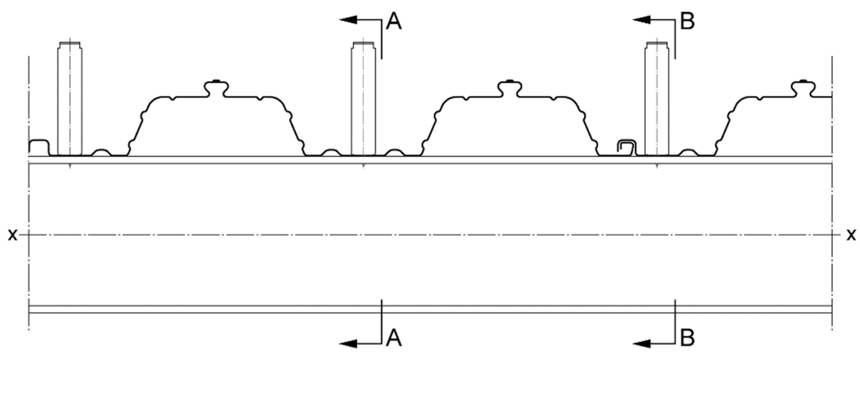


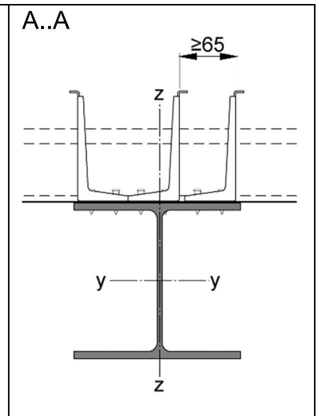
Decking transverse with beam, 2 X-HVB per rib

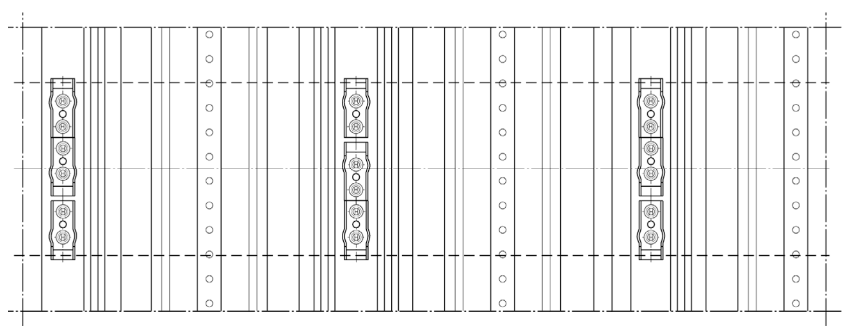


X-HVB positioned in Comflor 60-600 − Orientation: Transverse

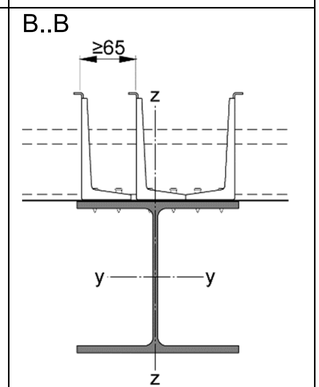
Decking transverse with beam, 3 X-HVB per rib





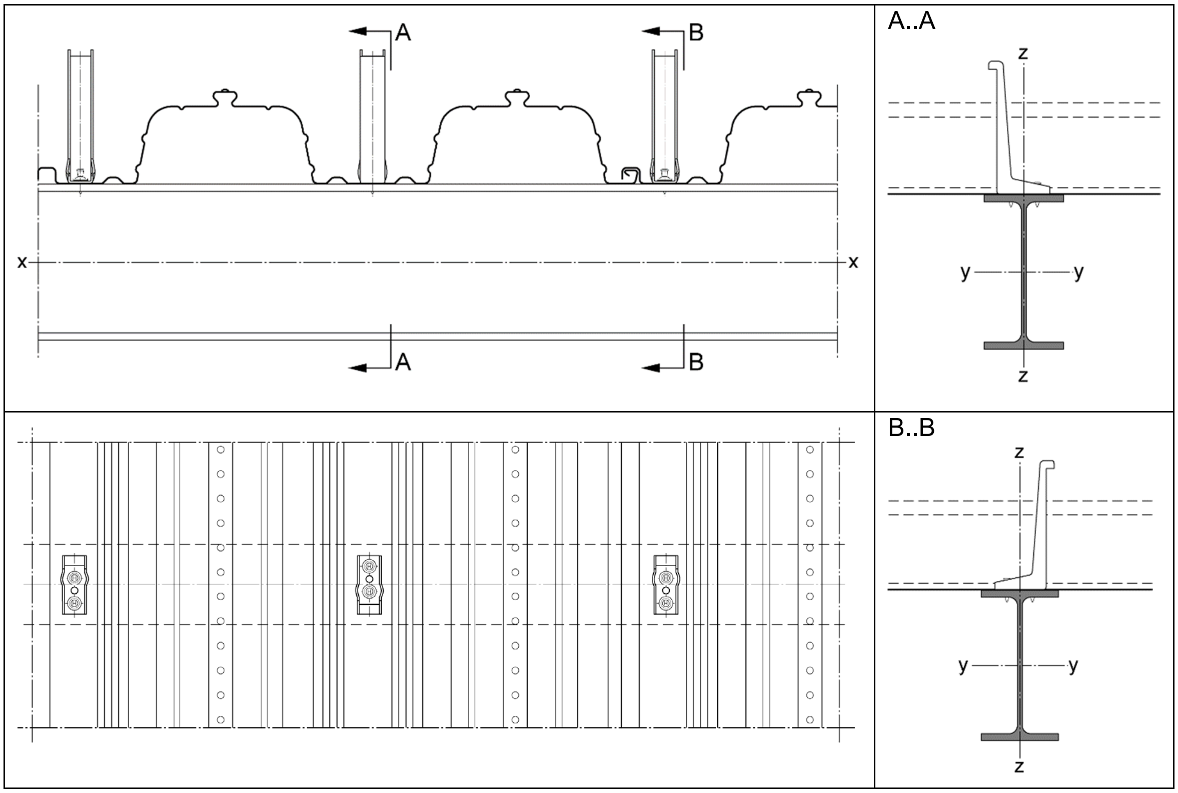


Note: For optimized utilization of available beam width, reduction of the spacing from 65 to 50 mm is possible. However, with respect to tool accessability, both nails of the left X-HVB of section B..B need to be driven first, before the adjacent X-HVB is fixed.

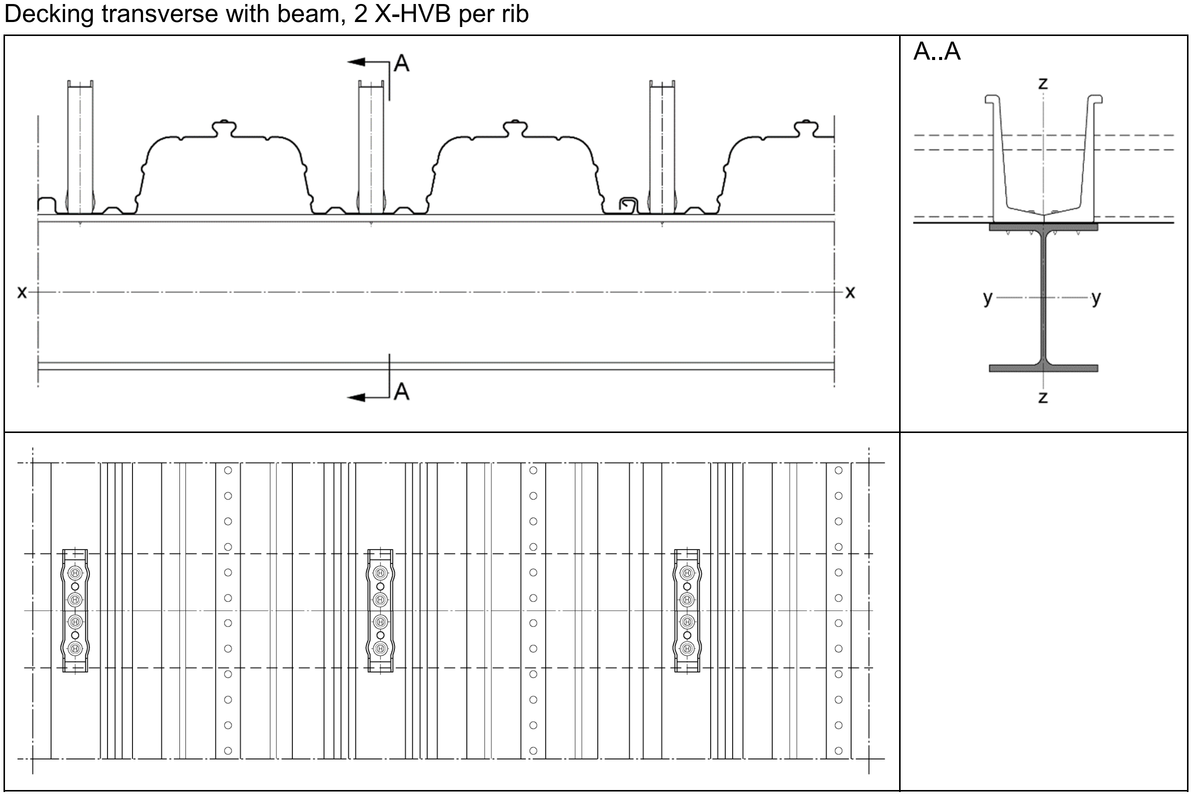


X-HVB positioned in Comflor 80-600 − Orientation: Transverse

Decking transverse with beam, 1 X-HVB per rib

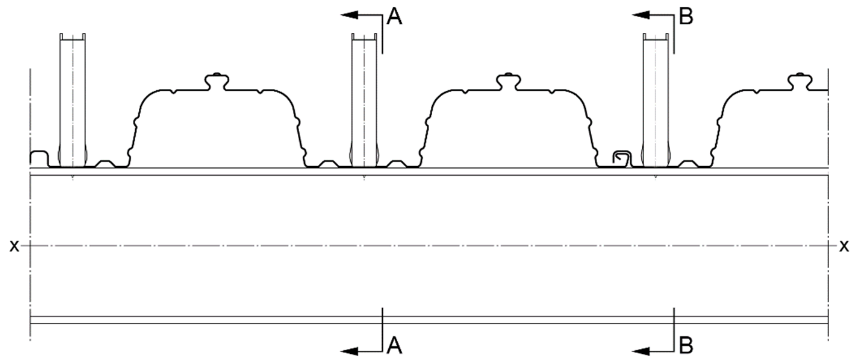


Decking transverse with beam, 2 X-HVB per rib

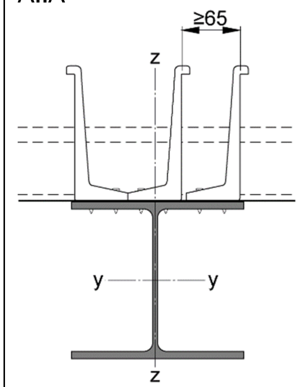


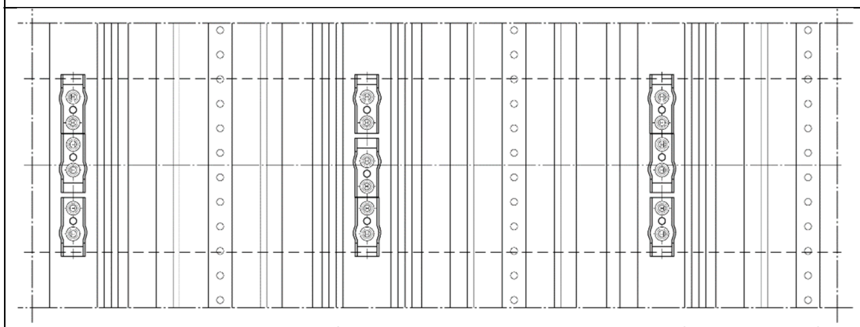
X-HVB positioned in Comflor 80-600 − Orientation: Transverse

Decking transverse with beam, 3 X-HVB per rib

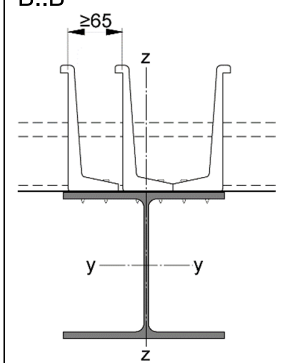


A..A



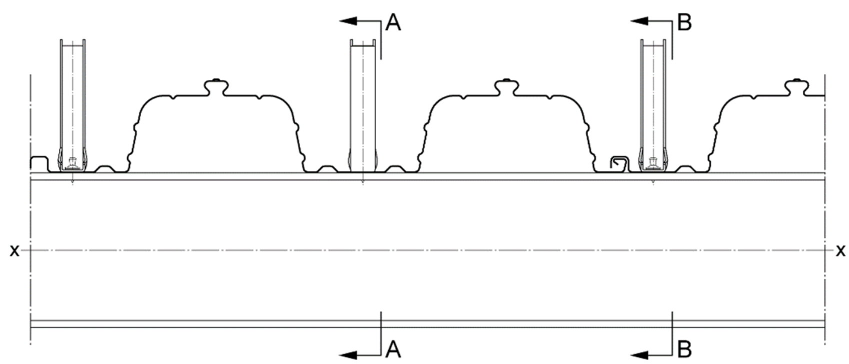


B..B

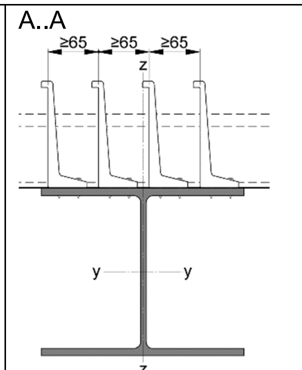


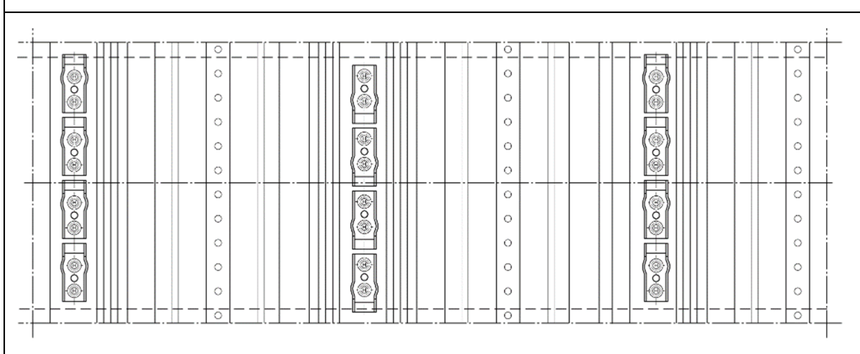
Note: For optimized utilization of available beam width, reduction of the spacing from 65 to 50 mm is possible. However, with respect to tool accessability, both nails of the left X-HVB of section B..B need to be driven first, before the adjacent X-HVB is fixed.

Decking transverse with beam, 4 X-HVB per rib

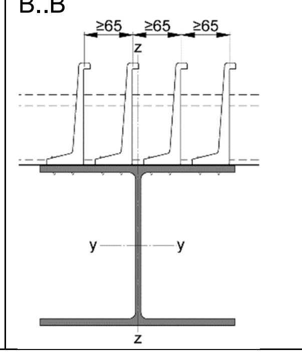


A..A





B..B



Deutsches Institut für Bautechnik
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Approval body for construction products and types of construction

Bautechnisches Prüfamt

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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 determined
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 determined
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

3.3 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content and/or release of dangerous substances	no performance determined

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

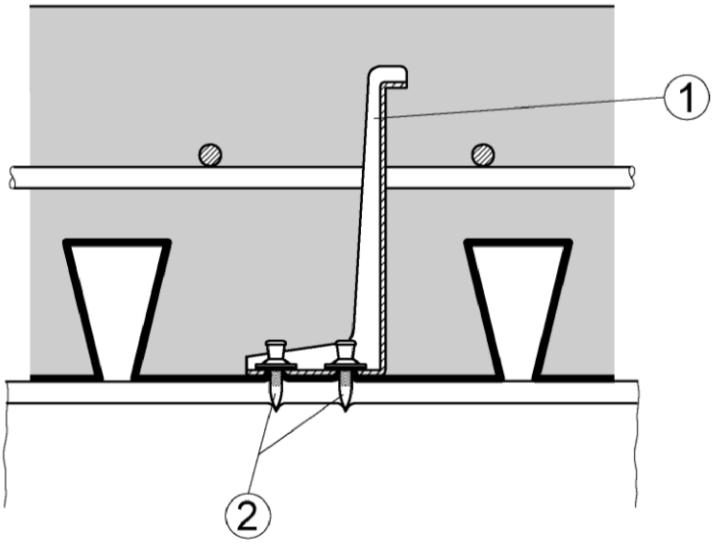
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

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

Uwe Bender
Head of Department

beglaubigt:
Stöhr

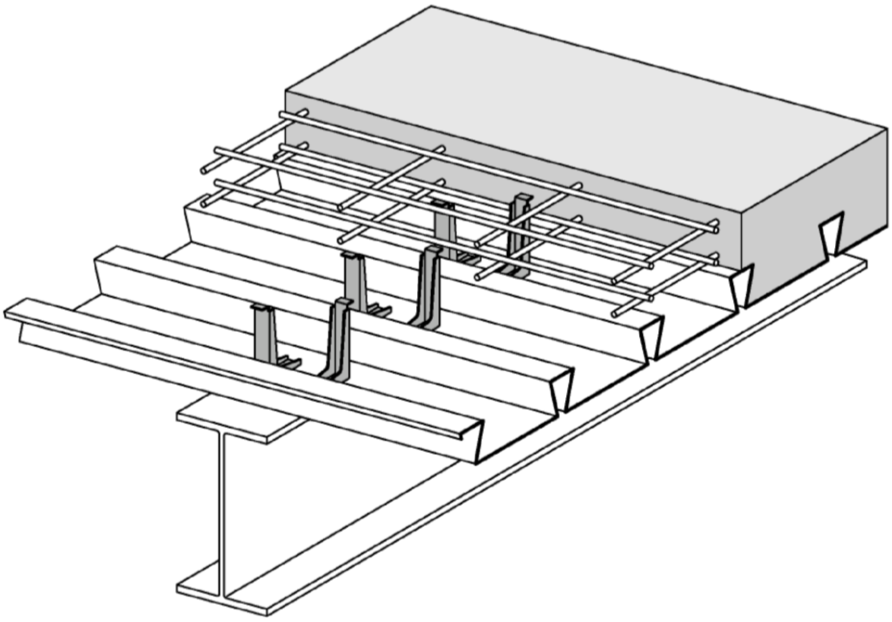
Nailed shear connector X-HVB with powder-actuated fastener X-ENP-21 HVB



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

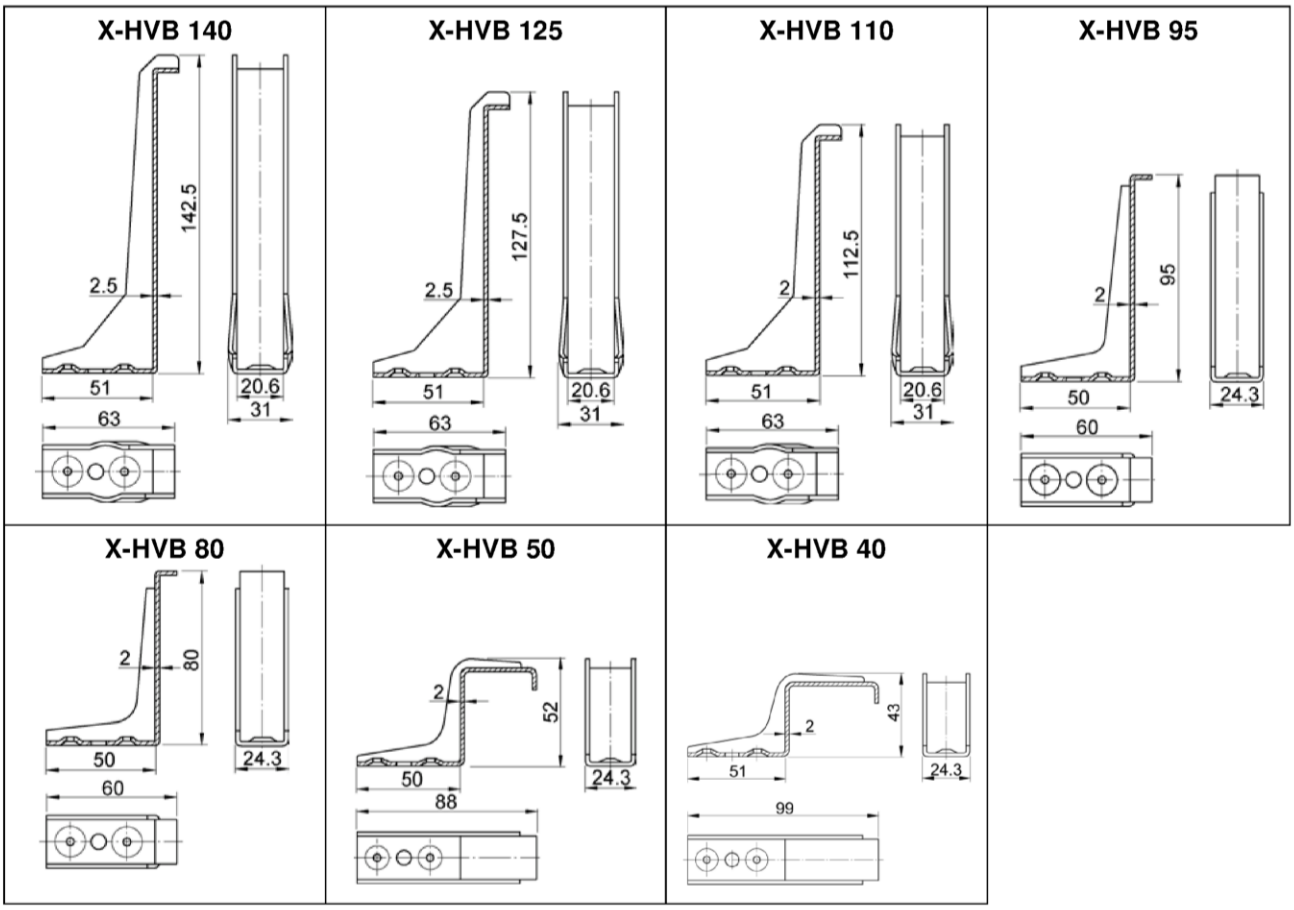
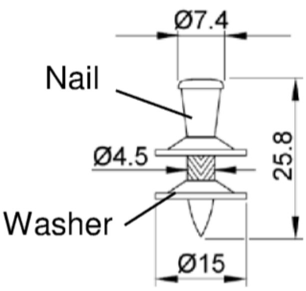


Table 1: Materials

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



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. 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.

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

Powder-actuated fastening tools and cartridge 6.8/18M

Powder-actuated fastening tool
DX 76 HVB

Powder-actuated fastening tool
DX 76 PTR HVB

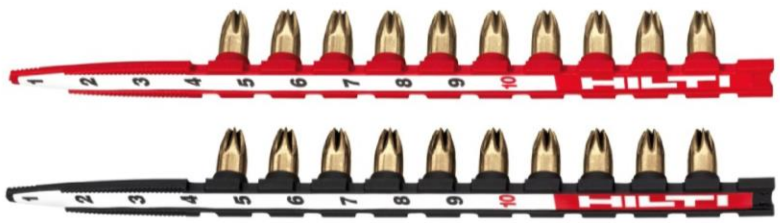
Fastener guide
X-76-F-HVB

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



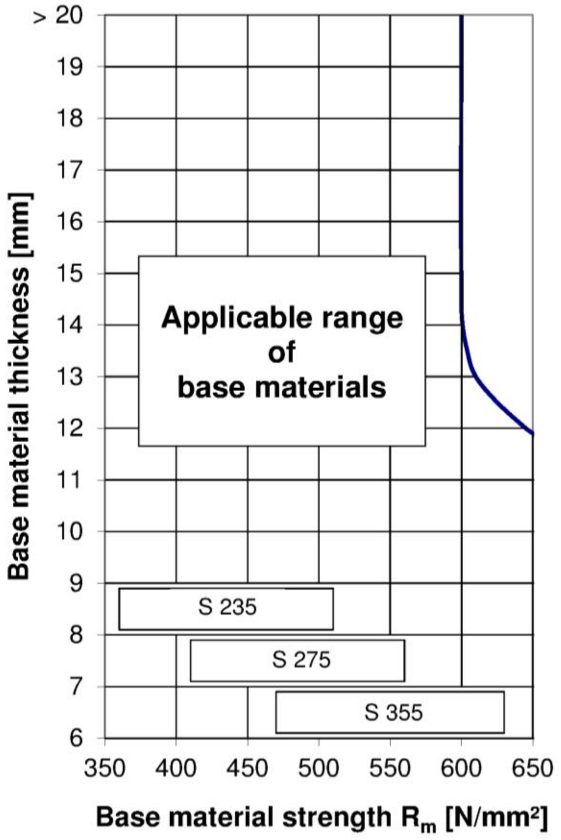
Cartridges 6.8/18 M

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

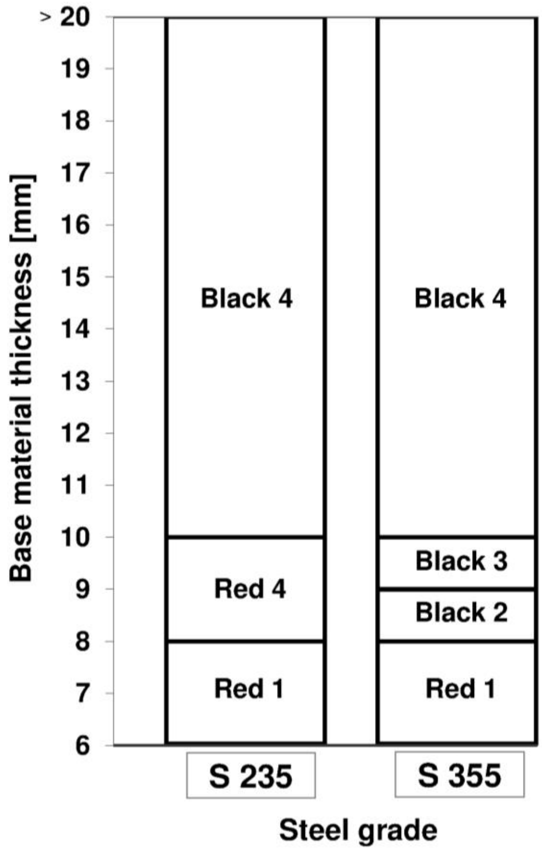
Blue: Medium load (level 5), see Annex B3

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

Application limit and tool energy setting

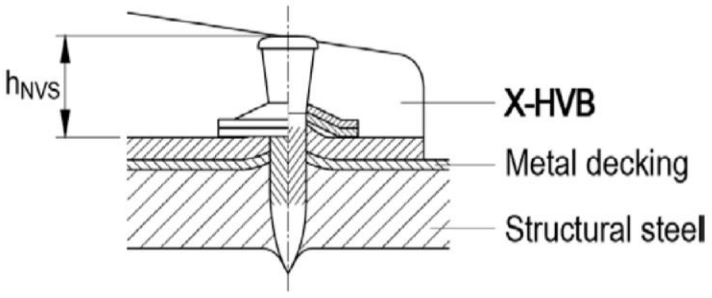


Notes:
Minimum section covered: IPE 100 (see annex C3)
Minimum base material thickness for beams with composite decking: 8 mm



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

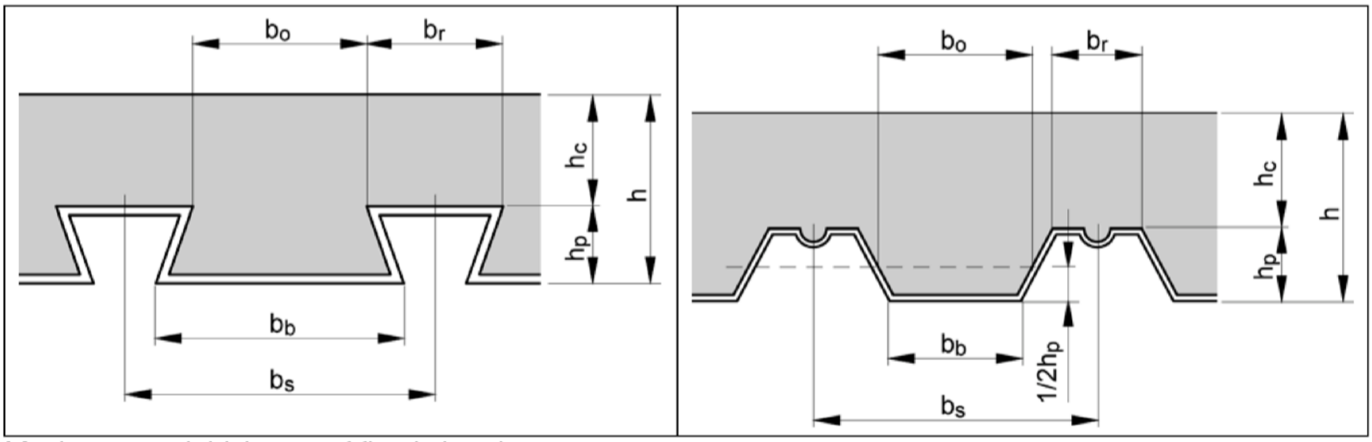


Clearly visible piston mark on top washer

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



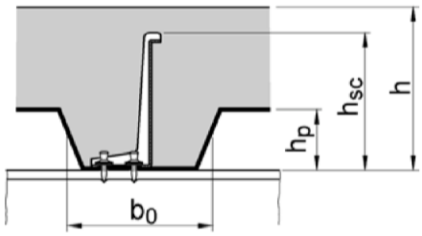
Maximum total thickness of fixed sheeting t_{fix}

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

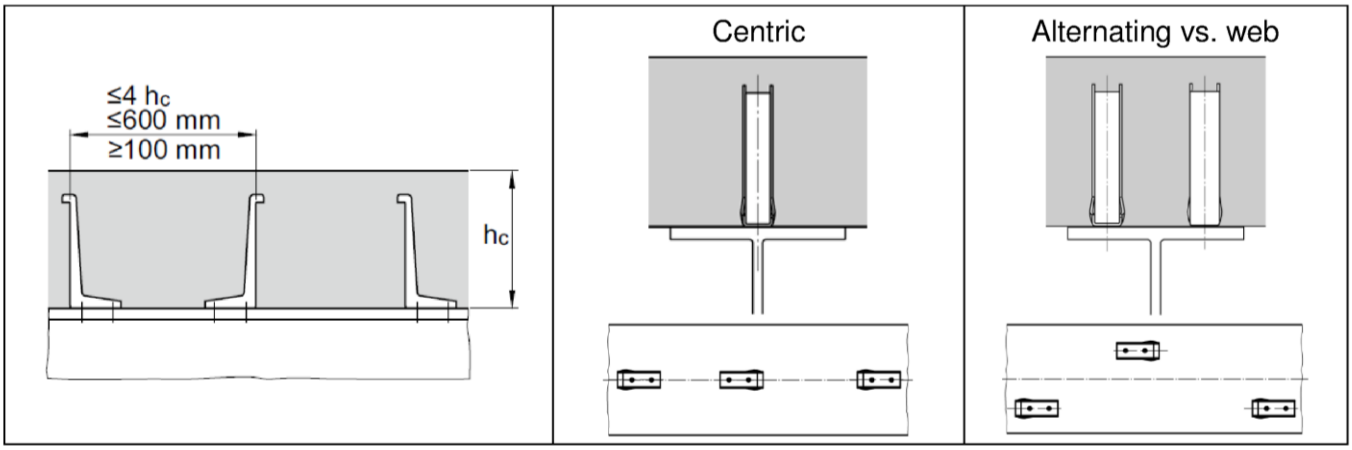
X-HVB	Maximum height of composite decking h_p [mm]		
	$\frac{b_0}{h_p} \geq 1.8$	$1.0 < \frac{b_0}{h_p} < 1.8$	$\frac{b_0}{h_p} \leq 1.0$ x)
80	45	45	30
95	60	57	45
110	75	66	60
125	80	75	73
140	80	80	80

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

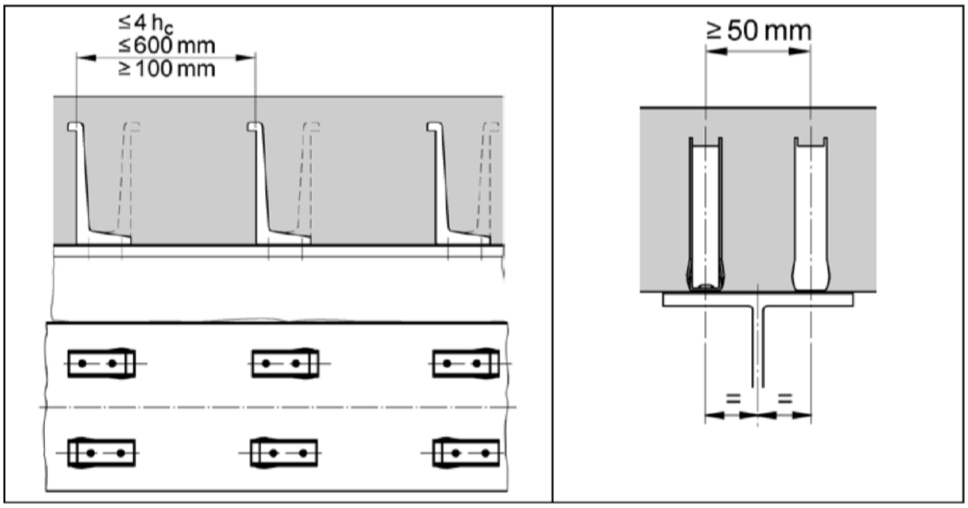
Nailed shear connector X-HVB	Annex B4
Geometric parameters	

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

One row of connectors



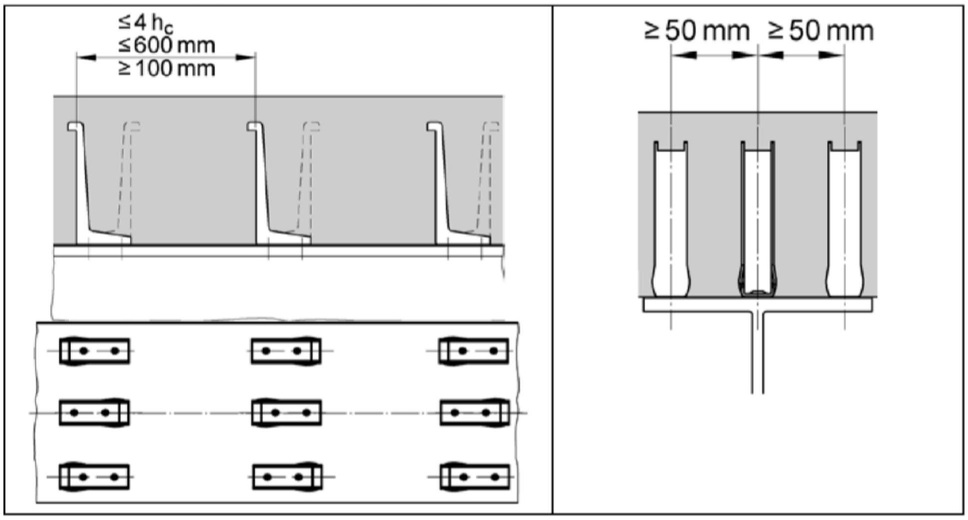
Two rows of connectors



Remark:

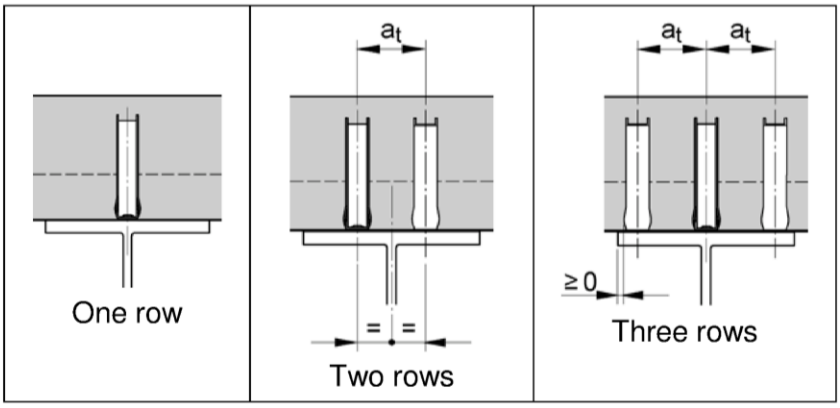
When using thin solid concrete slabs in combination with small I-profiles the „duckwalk“ positioning according to Annex C3 applies.

Maximum three rows of connectors



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

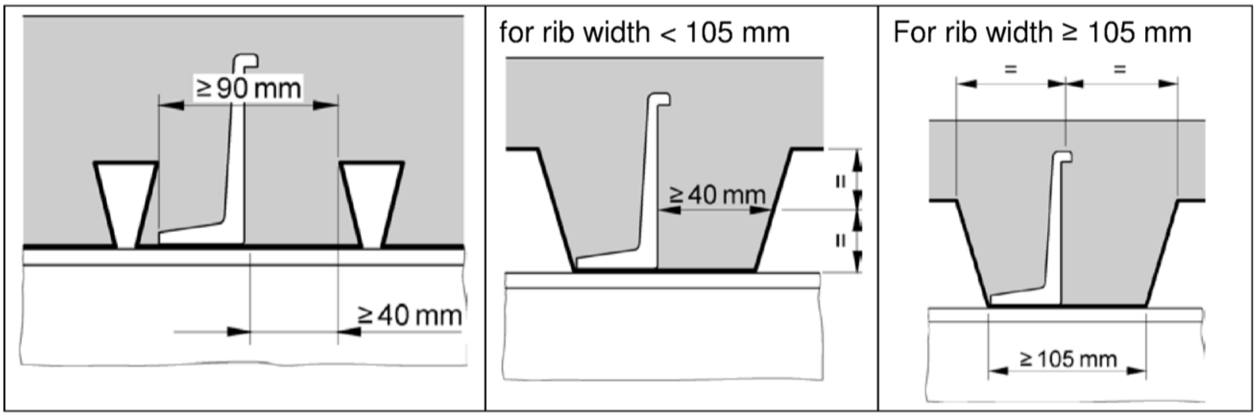
Spacing and positioning within cross section



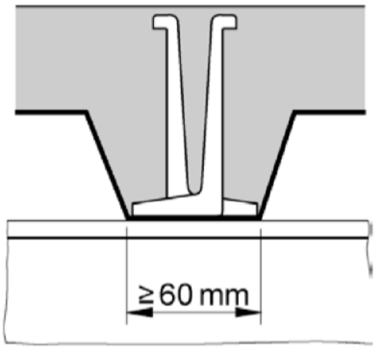
$a_t \geq 50$ mm for compact profiled decking with $b_0/h_p \geq 1.8$

$a_t \geq 100$ mm for other decking

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

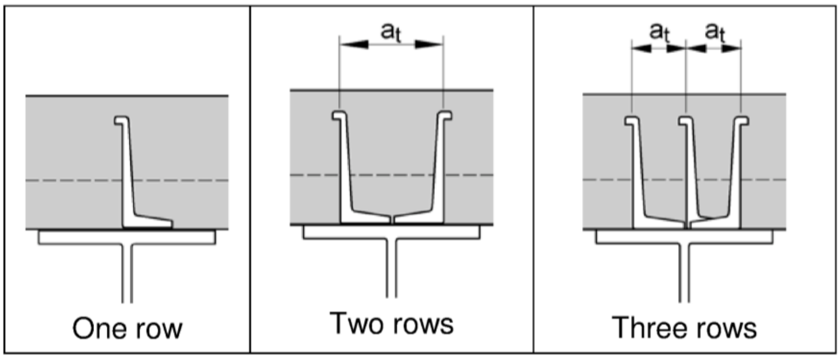


Minimum rib width in case of multiple row positioning



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:

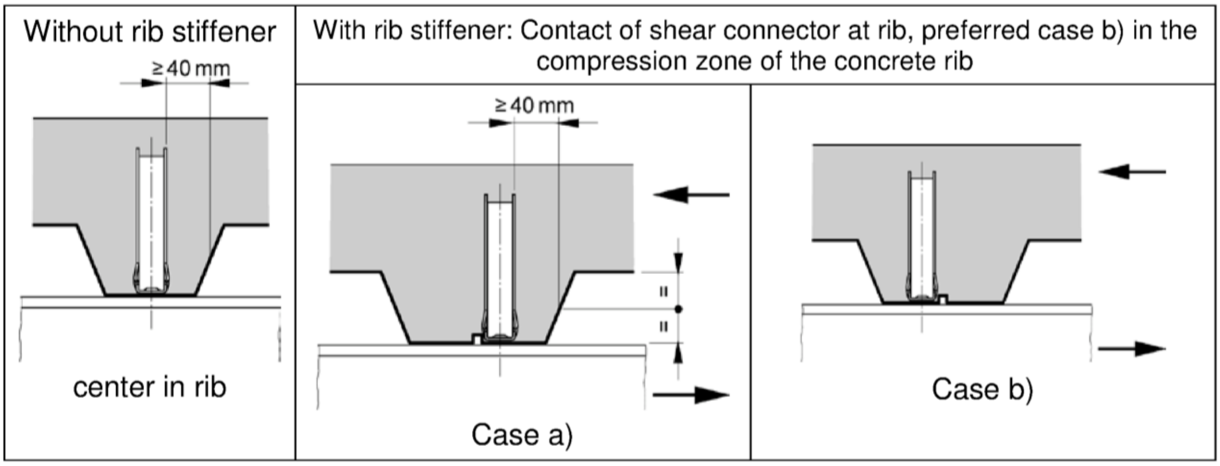
$a_t \geq 100$ mm for all types decking

Three rows:

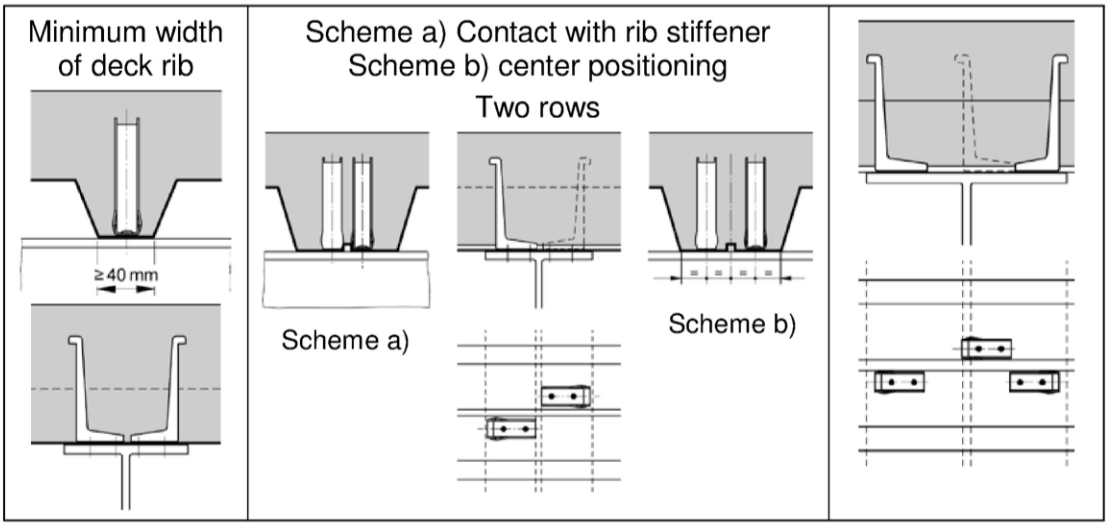
$a_t \geq 50$ mm for compact profiled decking with $b_0/h_p \geq 1.8$

$a_t \geq 100$ mm for other decking

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

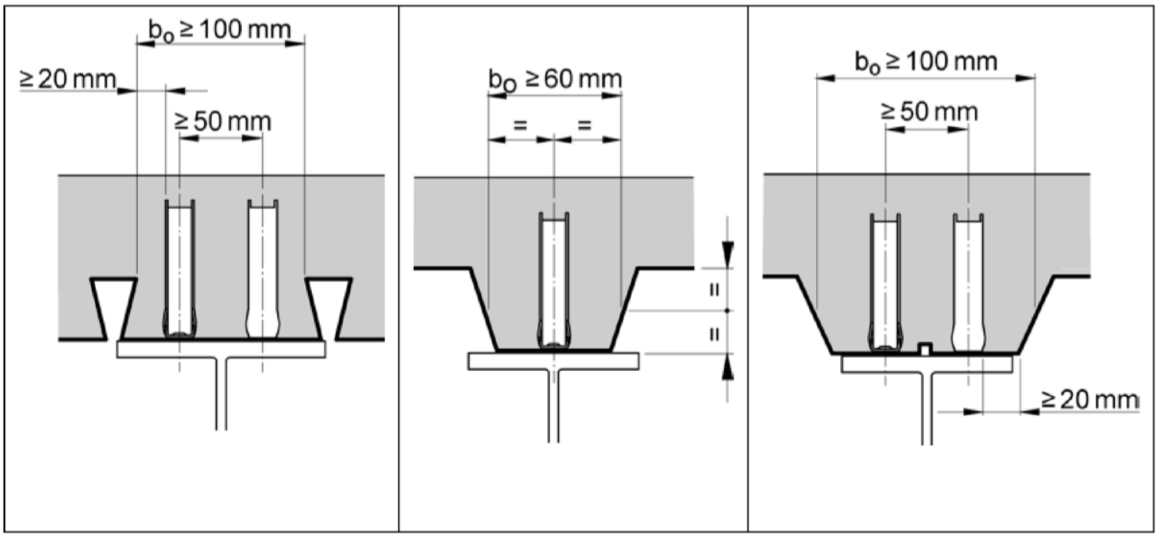


Positioning in two or three rows

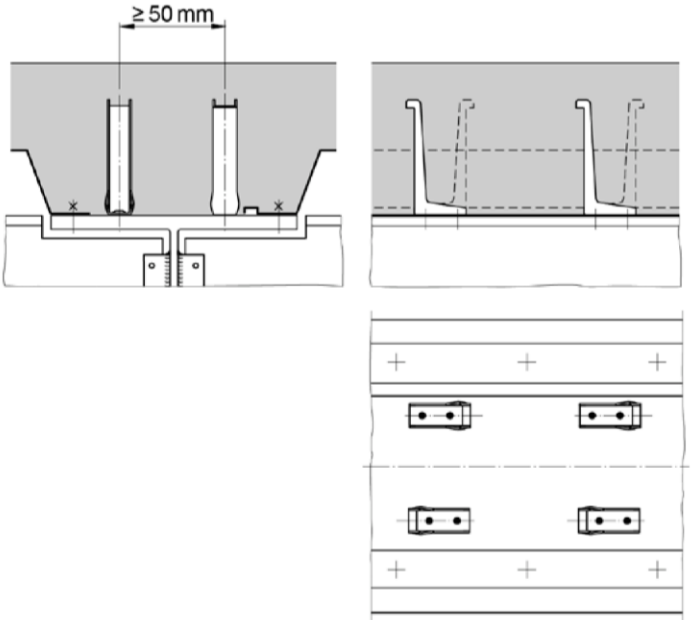


Nailed shear connector X-HVB	Annex B7
Positioning in composite beams with composite decking transverse and X-HVB positioning transverse with beam axis	

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	

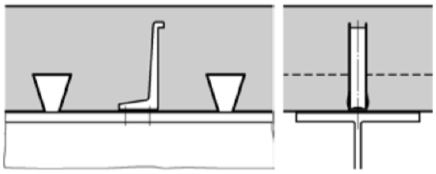
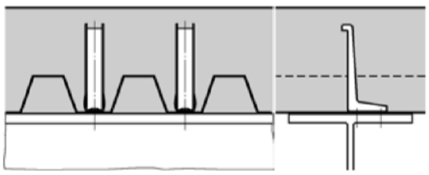
Table 3: Characteristic and design resistance in composite beams with solid slabs[1)]

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 γ_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 ρ = 1750 kg/m³
- Observation of positioning rules according to Annex B5 and Annex C3

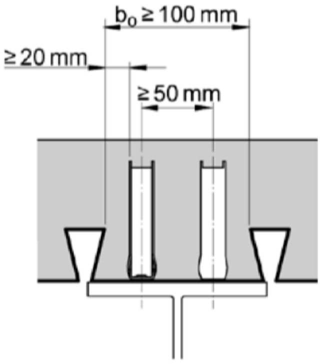
Table 4: Design resistance in composite beams with decking ribs transverse to beam axis

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 ρ = 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 ρ = 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	Annex C2
Characteristic and design values of resistance: Composite slabs with decking parallel to beam	

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)

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

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

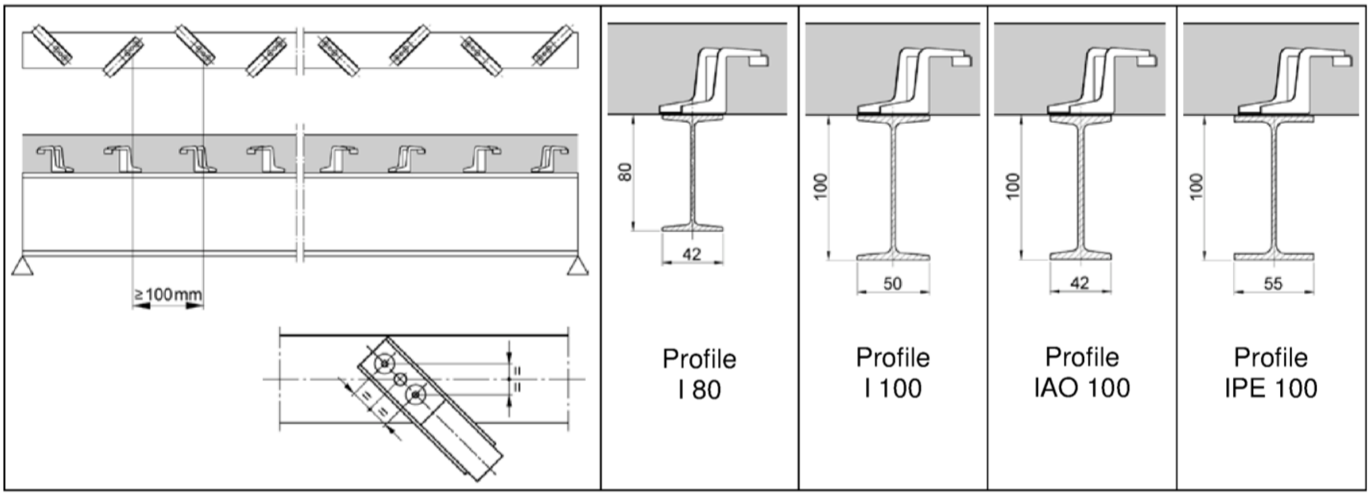
with:

$P_{Rd,red}$ …. 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

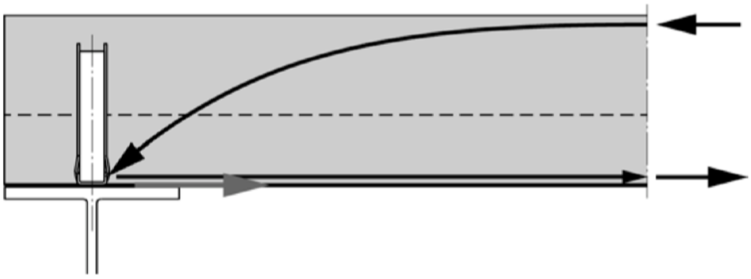
"Duckwalk" positioning of X-HVB 40 and 50 in combination with thin solid slabs:



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

Nailed shear connector X-HVB	Annex C4
Characteristic and design values of end anchorage of composite slabs	

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	