Hilti X-HVB shear connector

The product data is taken from the Hilti Direct Fastening Technology Manual Edition August 2011

For further details including details of product European Technical Approvals, Guidance on product selection and detailed design assistance please contact Hilti (Gt Britain) Ltd Technical Advisory Service.

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Quality Management Approvals

ISO 9001: 2008 Quality Management System
Certified by: The Swiss Association for Quality and Management Systems.
Registration No: 12455 Valid until 30th June 2013
Scope No: 18, Machinery and Equipment.

Note: Under our accreditation with SQS the scope of accreditation is not contained within an appendix but is stated as Scope 18 on the SQS Certificate. Scope No. 18 is Machinery and Equipment.”
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The Hilti X-HVB shear connector

Introduction
The X-HVB nailed shear connector allows for shear connection to be developed in composite beams in situations where the use of welded headed studs is impractical (fixing to pre-galvanized beams for example) or where access for stud welding equipment is a problem. This L-shaped, deep-drawn sheet metal “bracket” consists of the fastening leg and the anchorage leg which is cast into the concrete. The fastening leg is fixed to the steel beam by 2 powder-actuated fasteners as shown in Figure 1.

Figure 1. Shear connection in composite beams with Hilti X-HVB shear connector

The shear connector, its basic load-bearing characteristics and the design provisions are described in our Direct Fastenings Technology Manual. The following description provides a brief overview of its function, information about the positioning of the connector on profile metal sheets and some comments on the cost effectiveness of the system. Figure 2 shows examples of load-displacement diagrams for push-out tests conducted with the X-HVB shear connector. Its load-displacement characteristics meet the requirements of Eurocode 4 for connectors with plastic properties.
The connector's load-bearing capacity in solid concrete slabs is limited by the performance of the nailed joint. Deformation capacity is the result of a combination of hole elongation in the fastening leg of the connector, bending of the fasteners and local deformation of the concrete in the contact zone with the connector. As the load-bearing capacity of each connector in the solid concrete slab is initially lower than that of headed welded studs with \( d \geq 19 \text{ mm} \), it is much less influenced by the form of the metal deck (as part of the composite deck) and because of this only with a deck with very narrow concrete ribs has a resistance-reducing influence resulting in plastic bending of the anchorage leg of the X-HVB shear connector. The load-bearing capacity of the X-HVB in conjunction with Holorib HR51 undercut composite decking sheet, for example, is identical to its loading capacity in solid concrete slabs. The connector's ductile load-bearing characteristics are ensured by the observing the design provisions minimum distance to the edge of the steel sheet, minimum connector spacings and minimum connector height. As far as the design of the structure will allow, the fastening legs of the X-HVB shear connectors should be aligned in parallel with the axis of the beam as the achievable loading capacity is then slightly higher than with transverse positioned connectors. Transverse alignment of the shear connectors is necessary in the case of very narrow ribs or, respectively, with profile sheets with rigid base corrugations. Figure 3 shows the optimum positioning of shear connectors when two rows of shear connectors are applied for metal sheets approved for use in Germany in composite structures.
Figure 3. Optimum positioning of X-HVB shear connectors

When comparing the cost effectiveness of shear connectors and headed studs, not only the cost of the shear connector but the effect of the selected...
method has on the whole construction procedure must be considered. It is a prerequisite for the cost-efficient use of nailed shear connectors is that the connectors are installed on the jobsite. This enables continuous profile sheets to be used, reducing the profile cross section that is required compared with using single-span sheets and reducing the amount of work required to seal the joints between the metal sheets. If headed studs are pre-welded in the fabrication shop, continuous sheets must have holes punched at the points where the headed studs are positioned. This requires more planning and preparation work for the metal sheets used in the composite structure. This extra work can be avoided with the use of nailed shear connectors fixed over the sheet to the underlying beams. Considering the number of shear connectors required, comparison of the applicable design values for these two applications shows that headed studs cannot achieve their full capacity when compared to HVB shear connectors as allowance must be made for a reduction in loading capacity in accordance with Eurocode 4 when perforated sheets are used or when studs are welded through the sheets. With nailed shear connectors, however, the method results in no loss of loading capacity. Table 1 shows an example for comparison.

Table 1. Comparison of the maximum design values for headed studs and nailed shear connectors X-HVB for C30/37

<table>
<thead>
<tr>
<th>Means of shear connection</th>
<th>Solid slab</th>
<th>Composite slab</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Perforated profile metal sheet</td>
</tr>
<tr>
<td>Headed studs d = 19 mm $^1$</td>
<td>70.6</td>
<td>42.4</td>
</tr>
<tr>
<td>Shear connectors X-HVB 125 $^2$</td>
<td>32.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

$^1$ Where $\alpha = 1$, $nr = 2$, $t \leq 1$

$^2$ Positioned longitudinally relative to the beam

Cost-effective use of X-HVB shear connectors or other nailed solutions for composite structures requires that the installation of these items is done on...
the jobsite, driving the fasteners through the sheet metal. The fastener driving operation can be carried regardless of the weather conditions. Under these circumstances the HVB shear connector can become a cost effective option.

Another area where HVB shear connectors of this type can be used cost-effectively is in the renovation or strengthening of steel beam and concrete infill floors with a concrete overlay in old buildings, especially those subject to regulations on the protection of historic buildings. With only limited height available for the necessary strengthening, there is a need to form a composite action between the old steel beams and a new layer of concrete. In cases such as this, the flexibility and mobility during the installation that the nailed shear connectors allow are an additional advantage. When considering the option for using welded headed studs the question of whether or not the old steel (e.g. structural iron) can be welded must also be considered. In France, use of nailed shear connectors on old structural iron beams that are unsuitable for welding has been approved for many years. For this type of application HVB Shear connectors with a height of only 50 mm are available for use where a thin concrete overlay is to be applied.
X-HVB shear connectors

Product data

**Dimensions**

<table>
<thead>
<tr>
<th>X-HVB 140</th>
<th>X-HVB 125</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Dimensions" /></td>
<td><img src="image2" alt="Dimensions" /></td>
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<table>
<thead>
<tr>
<th>X-HVB 110</th>
<th>X-HVB 95</th>
</tr>
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<tbody>
<tr>
<td><img src="image3" alt="Dimensions" /></td>
<td><img src="image4" alt="Dimensions" /></td>
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<table>
<thead>
<tr>
<th>X-HVB 80</th>
<th>X-HVB 50</th>
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<tbody>
<tr>
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<td><img src="image6" alt="Dimensions" /></td>
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<table>
<thead>
<tr>
<th>X-ENP-21 HVB</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image7" alt="Dimensions" /></td>
</tr>
</tbody>
</table>

**General information**

**Material specifications**

- **X-HVB**
  - Carbon steel: $R_m = 295–350 \text{ N/mm}^2$
  - Zinc coating: $\geq 3 \mu m$

- **X-ENP-21 HVB**
  - Carbon steel shank: HRC58
  - Zinc coating: $8–16 \mu m$

**Fastening tools and equipment**

- **Tool**
  - DX 76
  - DX 76 PTR

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

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

- **Cartridges**
  - 6.8/18M black, red
  - (for details see application limit X-ENP-21 HVB)

See fastener selection for more details.

**Approvals and design guidelines**

- **SOCOTEC (France)**
- **DIBt (Germany)**
- **SCI (UK), TZÚS (Czech)**

Note: technical data presented in these approvals and design guidelines reflect specific local conditions and may differ from those published in this handbook. If the fastening is subject to an approval process or where a design guideline must be used, technical data in the approval or design guideline has precedence over data presented here. Approval copies are available from your Hilti technical advisory service.
### Design data

**Solid slabs**

<table>
<thead>
<tr>
<th>Nominal</th>
<th>Characteristic shear resistance $P_{Rk}$ [kN] 1)</th>
<th>Design shear resistance $P_{Rd}$ [kN] 2)</th>
<th>Allowable horizontal shear $q$ [kN] 3)</th>
<th>Allowable resistance (working load) $R_D$ [kN] 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-HVB 50</td>
<td>23</td>
<td>18</td>
<td>N.A</td>
<td>13</td>
</tr>
<tr>
<td>X-HVB 80</td>
<td>28</td>
<td>23</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>X-HVB 95</td>
<td>35</td>
<td>28</td>
<td>17.5</td>
<td>22</td>
</tr>
<tr>
<td>X-HVB 110</td>
<td>35</td>
<td>28</td>
<td>17.5</td>
<td>22</td>
</tr>
<tr>
<td>X-HVB 125</td>
<td>35</td>
<td>28</td>
<td>17.5</td>
<td>22</td>
</tr>
<tr>
<td>X-HVB 140</td>
<td>35</td>
<td>28</td>
<td>17.5</td>
<td>22</td>
</tr>
</tbody>
</table>

1) As defined in EN 1994-1-1 (Nominal strength in AISC-LRFD; unfactored shear resistance in CISC, $Q_k$ in BS 5950:3.3.1:1990)

2) As defined in EN 1994-1-1 ($Q_p$ in BS 5950:3.3.1:1990)

3) Allowable shear in AISC-ASD

4) Allowable shear for working load design

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**Applications**

**Examples**

Shear connectors for building constructions:
- composite beam action
- end anchorage of composite decking
- floor diaphragm
- resist lateral buckling

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**Figure**: Shear connectors in solid slabs.
Reduction factors for profile metal decks
Ribs transverse to beams

\[ k_t = \frac{K}{\sqrt{N_r}} \cdot \frac{b_0}{h_{ap}} \cdot \frac{h_{sc-hap}}{h_{ap}} \]

**EN 1994-1-1** designs:
- \( K = 0.70 \)
- \( N_r = \text{HVBs / rib (≤ 2 in the calculation even if 3 are placed in a rib)} \)

Note: \( k_t \leq 1.0 \)

Ribs parallel to beams

\[ k_p = \begin{cases} 1.0 & \text{for } \frac{b_0}{h_{ap}} \geq 1.8 \\ 0.6 \times \frac{b_0}{h_{ap}} \times \frac{h_{sc-hap}}{h_{ap}} & \text{for } \frac{b_0}{h_{ap}} < 1.8 \end{cases} \]

Note: \( k_p \leq 1.0 \)

Engineering advice

Connector placement along the beam
The HVB is a flexible connector and may be uniformly distributed between points where large changes in shear flow occur. These points may be supporting points, points of application of point loads or areas with extreme values of bending moments.

Partial shear connection
Strength:
The minimum connection depends on the design code used:
- In **EN 1994-1-1 and BS 5950** designs, \( N/N_f \), must be at least 0.4. This is increased depending on span length and decking geometry.
- In **AISC**, \( N/N_f \) must be at least 0.25.
- In **CISC**, \( N/N_f \) must be at least 0.50.

Deflection control only:
If the shear connection is needed for deflection control only, there is no minimum degree of connection. However, minimum allowable connector spacing applies and steel beam must have enough strength to carry the self-weight and all imposed loads.
Application requirements

Thickness of base material

≥8

Minimum thickness of steel base material \( t_{II} = 8 \text{ mm} \)

Thickness of fastened material

≤1 x 1.25

Maximum thickness of decking \( t_{I} = 1.25 \text{ mm} \)

Connector positioning, spacing and edge distances

General positioning

Position the HVBs so that the shear force is transferred symmetrically to the beam. The HVB orientation parallel to the axis of the beam is preferred.

Positioning on metal decks - ribs transverse to beam

1) One, two or three HVB’s per rib

parallel to beam

perpendicular to beam
2a) Position in the rib: 1 HVB per rib – leg centred in the rib or 40 mm clearance

![Diagram showing HVB placement with a 40 mm clearance.]

2b) With 2 or 3 HVBs per rib – legs centred in the rib or alternated about the centre

![Diagram showing HVB placement with legs centred or alternated.]

3) Spacing along the ribs

- basic minimum spacing, \( a \geq 50 \text{ mm} \)
- \( a \geq 100 \text{ mm} \) for:
  - \( b_o/m < 0.7 \) and \( b_o/h_{ap} < 1.8 \)
- SDI 3” composite decking (USA)

\( m = \text{rib spacing} \)

Positioning on solid slabs and metal decks – ribs parallel to beam

![Diagram showing positioning on solid slabs and metal decks.]

- With 1 connector per row, alternate direction of connectors from X-HVB to X-HVB.
- With 2 or 3 connectors per row, alternate direction of connectors inside of each row and from row to row.
Corrosion information
The intended use only comprises fastenings which are not directly exposed to external weather conditions or moist atmospheres.

Application limits
Application limits are valid only if correct cartridge and power setting are used!

Application limits X-ENP-21 HVB

In thermo-mechanically rolled construction steel, e.g. S 355M per EN 10025-4 the application limit is reduced by 50 N/mm²

Fine adjustment by setting tests on site

Cartridge preselection and power setting

Split decking if necessary for spacing / clearance
Fastener selection

<table>
<thead>
<tr>
<th>Designation</th>
<th>Item no.</th>
<th>Maximum decking height $h_{ap}$ [mm] $b_0 / h_{ap} \geq 1.8$</th>
<th>$b_0 / h_{ap} &lt; 1.8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-HVB 50</td>
<td>56467</td>
<td>Not for use with profiled decking</td>
<td></td>
</tr>
<tr>
<td>X-HVB 80</td>
<td>239357</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>X-HVB 95</td>
<td>239358</td>
<td>60</td>
<td>57</td>
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<tr>
<td>X-HVB 110</td>
<td>239359</td>
<td>75</td>
<td>66</td>
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<tr>
<td>X-HVB 125</td>
<td>239360</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>X-HVB 140</td>
<td>239361</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>all connectors with two nails</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ENP-21 HVB</td>
<td>283512</td>
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</tr>
</tbody>
</table>

Fastening quality assurance

Fastening inspection

$X$-ENP-21 HVB $h_{NVS} = 8.2–9.8$ mm
Visit our web site at [www.Hilti.co.uk/technical](http://www.Hilti.co.uk/technical) to access our comprehensive technical support services

<table>
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<tr>
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<th>Profis Anchor Software</th>
<th>Technical Library</th>
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Download the latest technical documents (approvals, test reports, etc.) and software (PROFIS Anchor).

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