Deutsches Institut für Bautechnik
DIBt

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

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Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment ETA-18/0189 of 6 December 2021

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Halfen Insulated Connection HIT-HP/SP
Product family to which the construction product belongs	Load bearing thermal insulating elements which form a thermal break beetween balconies and internal floors
Manufacturer	Leviat GmbH Liebigstraße 14 40764 Langenfeld DEUTSCHLAND
Manufacturing plant	Leviat Manufacturing Plants
This European Technical Assessment contains	51 pages including 4 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 050001-00-0301, Edition 02/2018
This version replaces	ETA-18/0189 issued on 16 June 2021

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Specific Part

1 Technical description of the product

The Halfen Insulated Connection HIT-HP/SP is used as load-bearing thermal insulating element to connect reinforced concrete slabs.

The product description is given in Annex A.

The characteristic material values, dimensions and tolerances of the Halfen Insulated Connection HIT-HP/SP indicated in Annexes A1 to A15 shall correspond to the respective values laid down in the technical documentation[1] of this European Technical Assessment.

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

The performances given in Section 3 are only valid if the Halfen Insulated Connection HIT-HP/SP is used in compliance with the specifications and conditions given in Annex B.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the Halfen Insulated Connection HIT-HP/SP 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
Load bearing capacity	See Annex C1

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire of materials	See Annex A15
Resistance to fire	See Annex C2

3.3 Protection against noise (BWR 5)

Essential characteristic	Performance
Impact sound insulation	See Annex C6

3.4 Energy economy and heat retention (BWR 6)

Essential characteristic	Performance
Thermal resistance	See Annex C4 – C5

[1] The technical documentation of this European technical assessment is deposited at the Deutsches Institut für Bautechnik and, as far as relevant for the tasks of the approved bodies involved in the attestation of conformity procedure, is handed over to the approved bodies.

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

In accordance with EAD No. 050001-00-0301, the applicable European legal act is: [1997/0597/EC].

The system to be applied is: [1+].

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.

The following standards are referred to in this European Technical Assessment:

– EN 206:2013+A2:2021	Concrete: Specification, performance, production and conformity
– EN 1992-1-1:2004/A1:2014	Eurocode 2: Design of concrete structures – Part 1-1: General design rules and rules for buildings
– EN 1993-1-1:2005 + AC:2009	Eurocode 3: Design of steel structures – Part 1-1: General design rules and rules for buildings
– EN 1993-1-4:2006 + A1:2015	Eurocode 3: Design of steel structures – Part 1-4: General rules – Supplementary rules for stainless
– EN 10088-1:2014	Stainless steels – Part 1: List of stainless steels
– EN 12664:2001	Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Dry and moist products of medium and low thermal resistance
– EN 13162:2012+A1:2015	Thermal insulation products for buildings - Factory made mineral wool (MW) products – Specification
– EN 13501-1:2018	Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests
– EN ISO 6946:2017	Building components and building elements – Thermal resistance and thermal transmittance – Calculation method (ISO 6946:2017)
– EN ISO 10211:2017	Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations (ISO 10211:2017)

– EN ISO 10456:2007+AC:2009 Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values (ISO 10456:2007 + Cor. 1:2009)

Issued in Berlin on 6 December 2021 by Deutsches Institut für Bautechnik

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Head of Section

beglaubigt:
Kisan

A.1 Type overview

Type HIT-HP/SP MVX

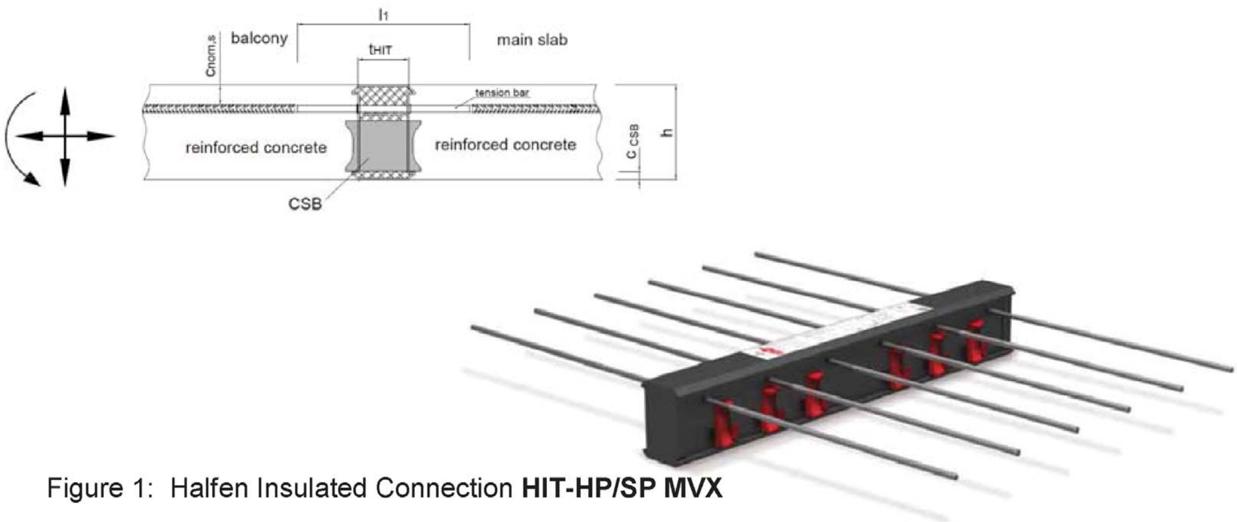


Figure 1: Halfen Insulated Connection **HIT-HP/SP MVX**

Type HIT-HP/SP MVX-…-OD

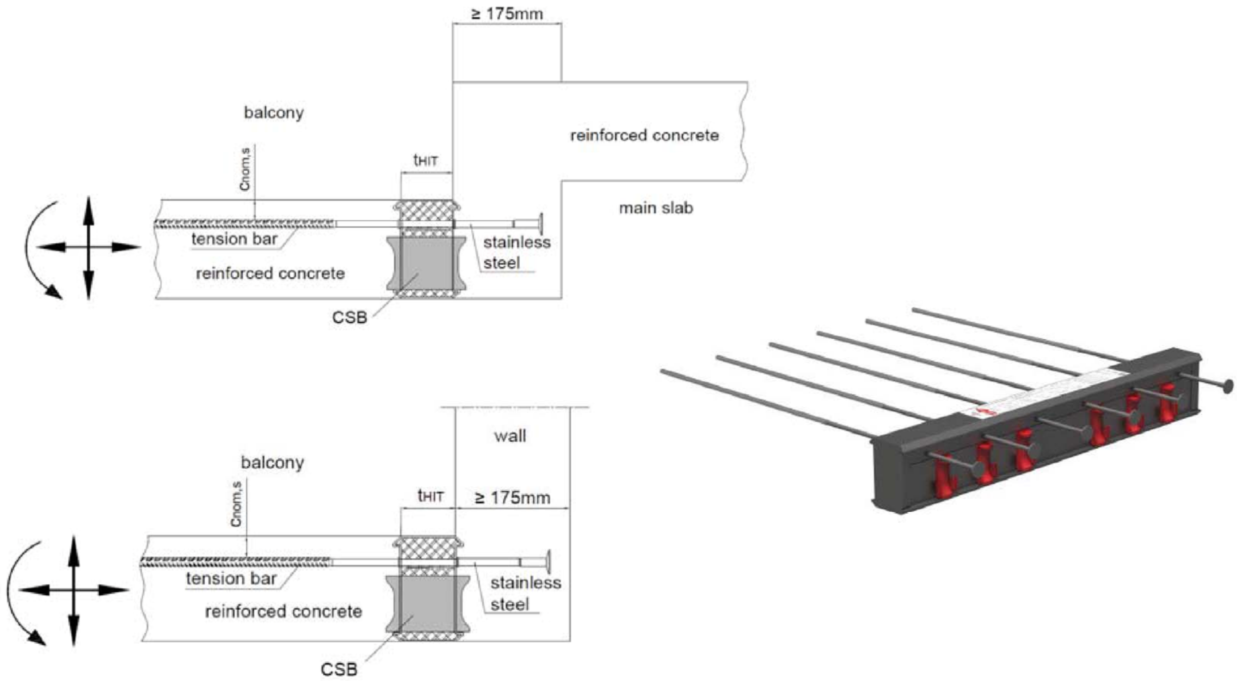


Figure 2: Halfen Insulated Connection **HIT- HP/SP MVX-…-OD**

Halfen Insulated Connection HIT-HP/SP	**Annex A1**
Product description Element types	

Type HIT-HP/SP MVX-…-OU

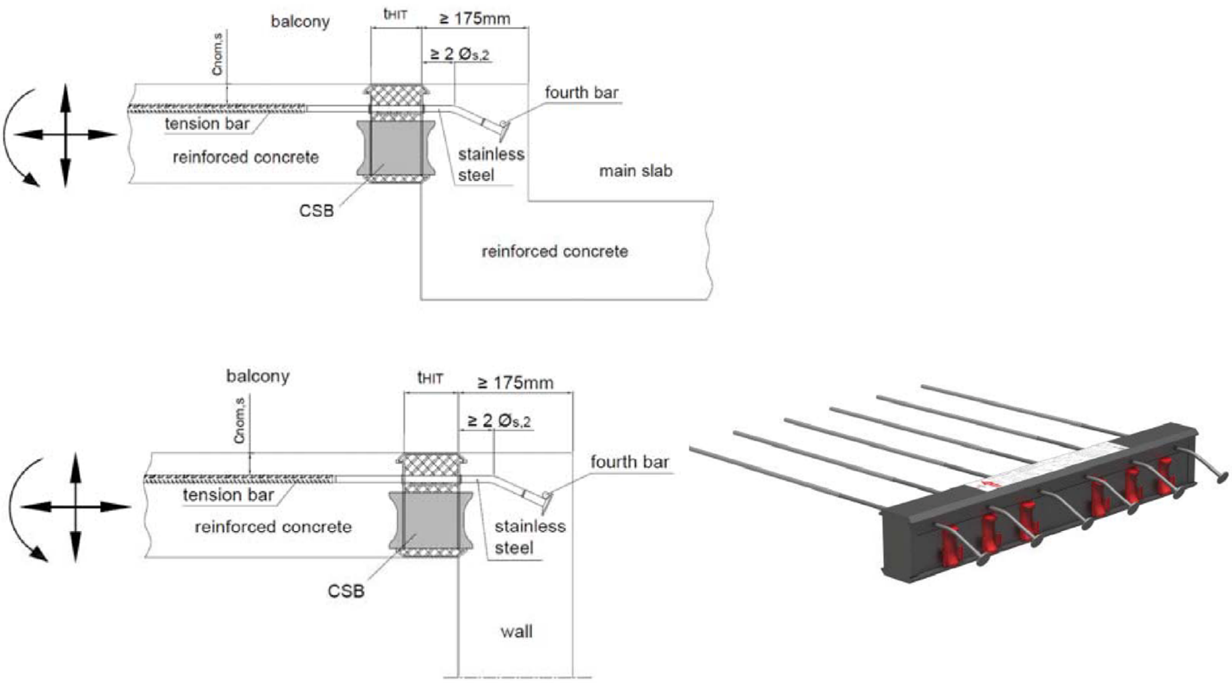


Figure 3: **Halfen Insulated** Connection **HIT- HP/SP MVX-…-OU**

Type HIT-HP/SP MVXL

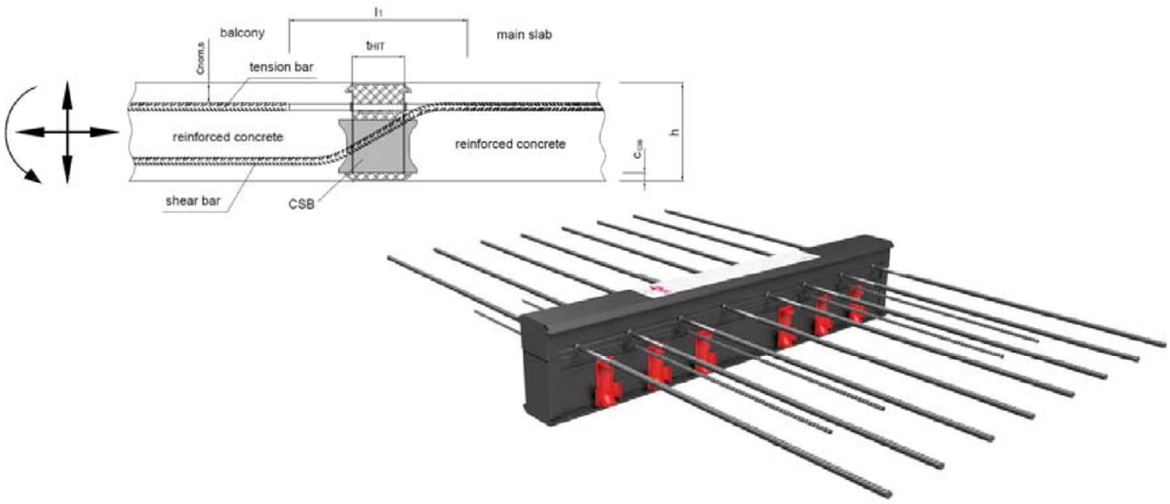
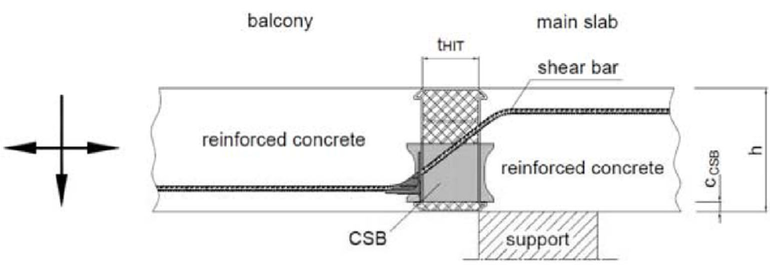


Figure 4: Halfen Insulated Connection **HIT-HP/SP MVXL**

Halfen Insulated Connection HIT-HP/SP	**Annex A2**
Product description Element types	

Deutsches Institut für Bautechnik DIBt

Type HIT-HP/SP ZVX



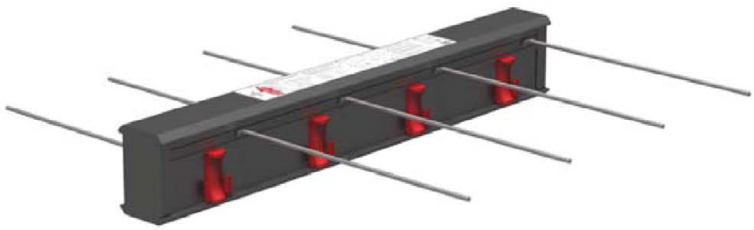
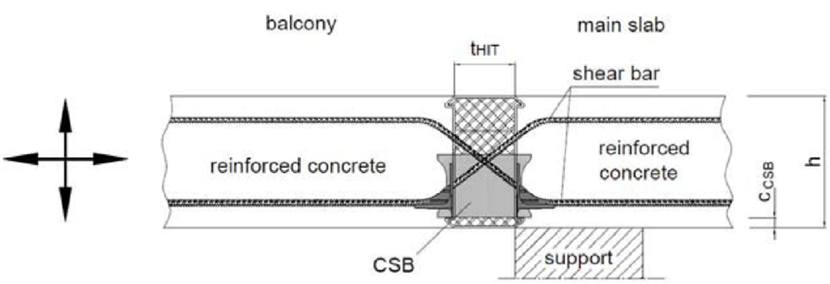


Figure 5: Halfen Insulated Connection **HIT-HP/SP ZVX**

Type HIT-HP/SP ZDX



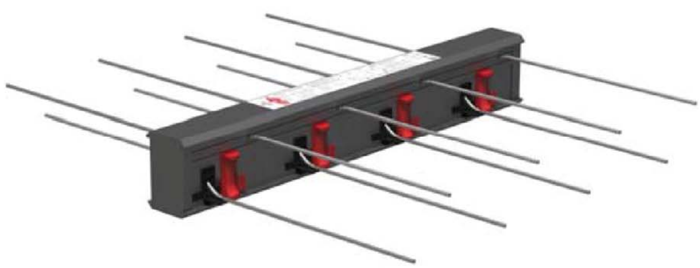


Figure 6: Halfen Insulated Connection **HIT-HP/SP ZDX**

Halfen Insulated Connection HIT-HP/SP	Annex A3
Product description Element types	

Type HIT-HP/SP DD (Type HIT-HP/SP DDL)

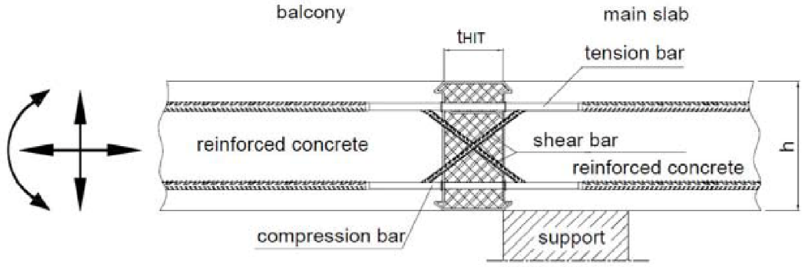


Figure 7: Halfen Insulated Connection **HIT-HP/SP DD**

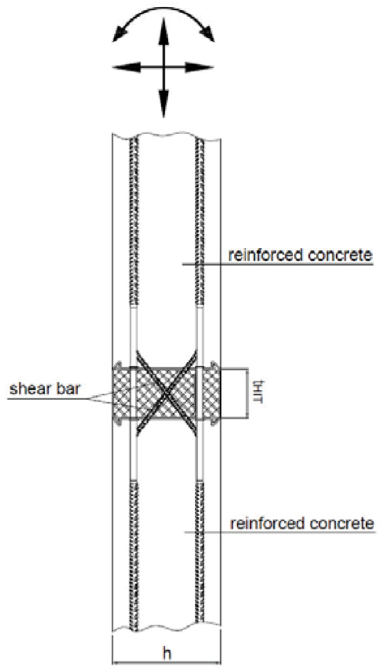


Figure 8: Halfen Insulated Connection **HIT-HP/SP DD**
(Application in the horizontal joint)

Halfen Insulated Connection HIT-HP/SP	**Annex A4**
Product description Element types	

Type HIT-HP/SP DVL

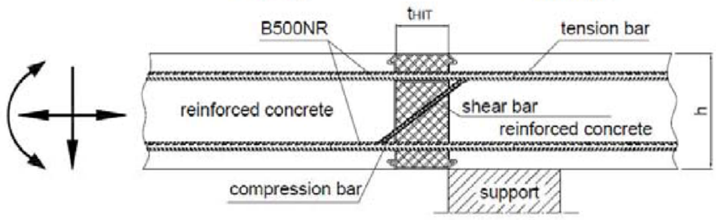
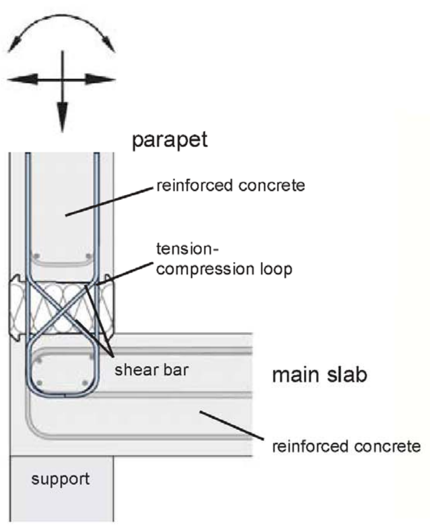


Figure 9: Halfen Insulated Connection **HIT-HP/SP DVL**

Type HIT-HP/SP AT



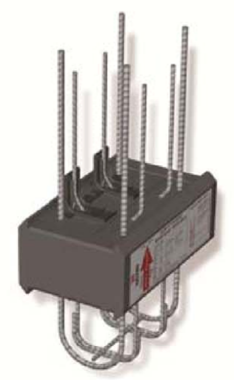


Figure 10: Halfen Insulated Connection **HIT-HP/SP AT**

Halfen Insulated Connection HIT-HP/SP	**Annex A5**
Product description Element types	

Type HIT-HP/SP FT

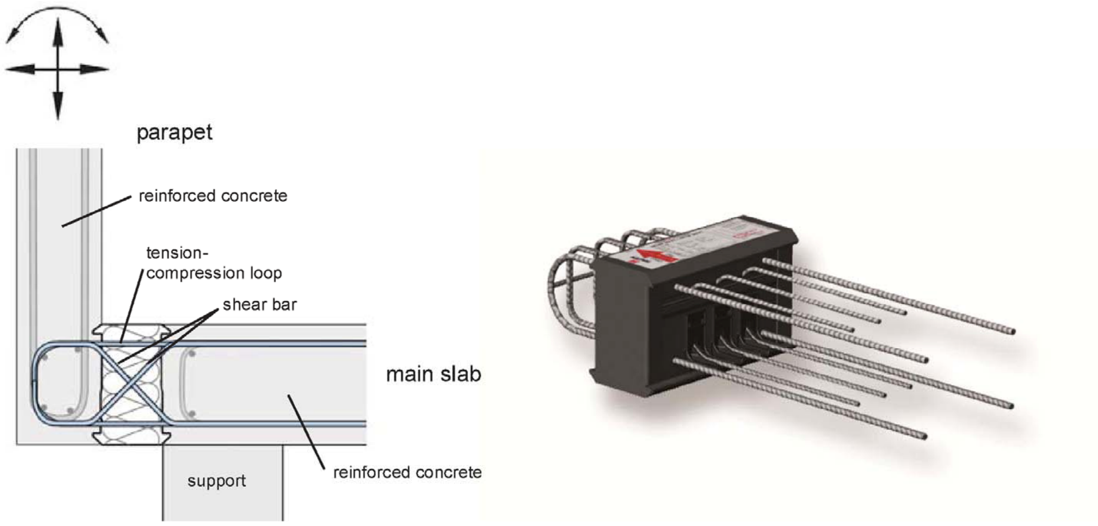


Figure 11: Halfen Insulated Connection **HIT-HP/SP FT**

Type HIT-HP/SP OTX

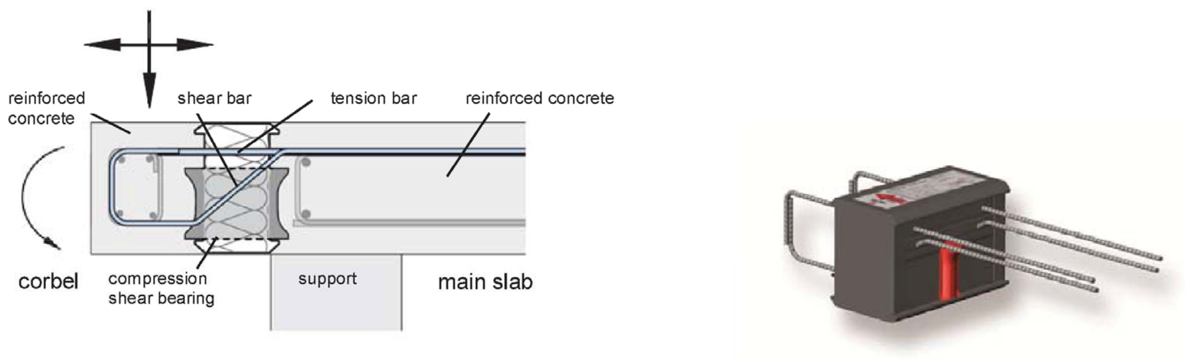


Figure 12: Halfen Insulated Connection **HIT-HP/SP OTX**

Halfen Insulated Connection HIT-HP/SP	Annex A6
Product description Element types	

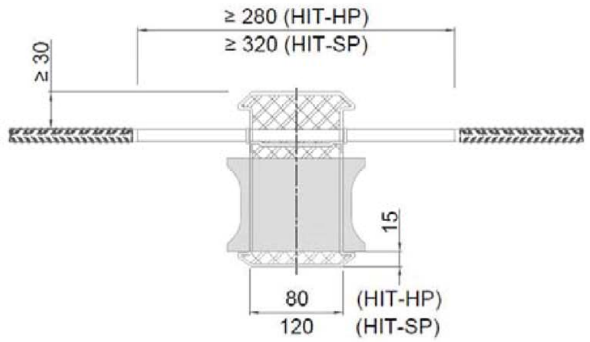


Figure 13: Halfen Insulated Connection HIT-HP/SP completed execution variation

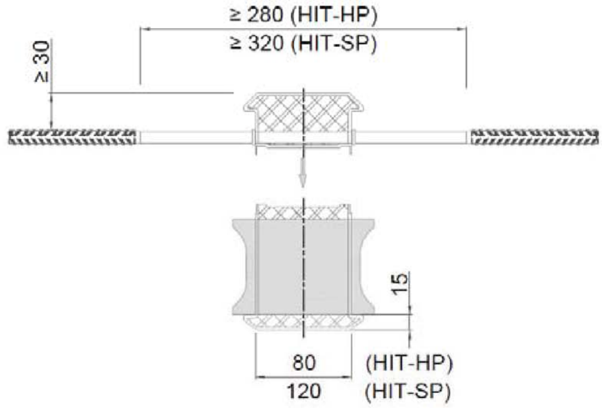


Figure 14: Halfen Insulated Connection HIT-HP/SP separated execution variation

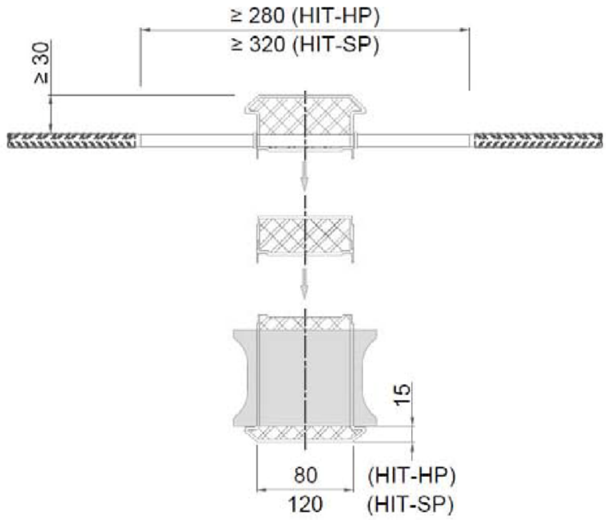


Figure 15: Halfen Insulated Connection HIT-HP/SP multi-part execution variation

Halfen Insulated Connection HIT-HP/SP	Annex A7
Product description Element types	

A.2 Dimensions and positioning of the bars and compression shear elements in the area of the insulation joint

HIT-HP/SP MVX (general)

• Element height h:	160 mm ≤ h ≤ 500 mm
• Number of compression shear bearings per one-meter element n_{CSB}:	≥ 2 (for h ≤ 300 mm) ≥ 4 (for h ≤ 500 mm) ≤ 12
• Concrete cover of the compression shear bearings c_{CSB}:	≥ 15 mm
• Axial distance of the compression shear bearings to the lateral component edge:	≥ 80 mm
• Axial distance of the compression shear bearings:	≥ 75 mm ≤ 600 mm (for n_{CSB} = 2) ≤ 400 mm (for n_{CSB} = 3) ≤ 300 mm (for n_{CSB} ≥ 4)
• Number of tension bars per one-meter element n_{TB}:	≥ 2 (for h ≤ 300 mm) ≥ 4 (for h ≤ 500 mm)
• Diameter of the tension bars $Ø_{s,1}$:	≤ 20 mm
• Concrete cover of tension bars $c_{nom,s}$:	≥ 30 mm
• Axial distance of the tension bars to the lateral component edge:	≥ 50 mm
• Axial distance of the tension bars:	≤ 600 mm (for n_{TB} = 2) ≤ 400 mm (for n_{TB} = 3) ≤ 300 mm (for n_{TB} ≥ 4)

Additional for HIT -HP/SP MVX (-OD, -OU) – Height offset

• Embedment depth of anchor heads:	≥ 145 mm
• Concrete cover of anchor heads to the axis of the bar:	≥ 60 mm
• Concrete cover of anchor heads to the lateral component edge	≥ 60 mm
• Mandrel diameter of headed tension bars	≥ 4 $Ø_{s,1}$
• Minimum transverse reinforcement (fourth bar)	≥ 12 mm, direct at anchor head
• Minimum link reinforcement	$n_l ≥ n_{TB}+1$ with $A_l ≥ \pi/4 * Ø_{s,1}^2 * (n_{TB}+1)$
• diameter of headed tension bars $Ø_{s,1}$	≤ 12 mm
• Number of headed tension bars per one-meter element	≥ 2 (for h ≤ 300 mm) ≥ 4 (for h ≤ 500 mm) ≤ 12
• Diameter of anchor head	≥ 3 $Ø_{s,1}$

HIT-HP/SP ZVX (ZDX)

• Element height h:	160 mm $\leq h \leq$ 500 mm
• Number of compression shear bearings per one-meter element n_{CSB}:	$\geq$ 2 $\leq$ 12
• Concrete cover of the compression shear bearings c_{CSB}:	$\geq$ 15 mm
• Axial distance of the compression shear bearings to the lateral component edge:	$\geq$ 80 mm
• Axial distance of the compression shear bearings:	$\geq$ 75 mm
• Number of shear bars per one-meter element n_{SB}:	$\geq$ 2 (for $Ø_{SB} \leq$ 8 mm) $\geq$ 4 (for $Ø_{SB} >$ 8 mm)
• Diameter of the shear bars $Ø_{SB}$:	$\leq$ 12 mm
• Bending diameter of shear bars:	$\geq 6 \cdot Ø_{SB}$
• Axial distance of the shear bars to the lateral component edge:	$\geq 6 \cdot Ø_{SB}$
• Axial distance of the shear bars:	$\geq 6 \cdot Ø_{SB}$ (average) and $\geq 4 \cdot Ø_{SB}$ (minimum)
• Angle of the shear bars:	$30° \leq \alpha_{SB} \leq 60°$
• Vertical offset between the shear bars and longitudinal reinforcement:	$s_{SB} \leq$ 100 mm

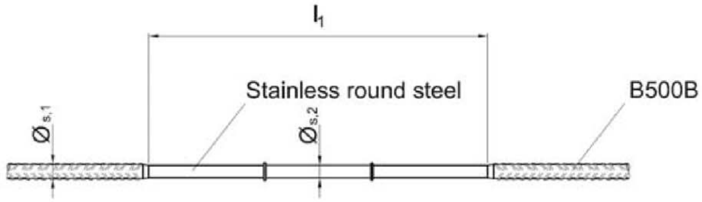
HIT-HP/SP DD (HIT-HP/SP DDL; HIT-HP/SP DVL; HIT-HP/SP AT; HIT-HP/SP FT analogues)

• Element height h:	160 mm ≤ h ≤ 500 mm
• Number of tension and compression bars per one-meter element:	≥ 4
• Diameter of the tension and compression bars $Ø_{s,1}$:	≤ 20 mm
• Concrete cover of tension and compression bars $c_{nom,o}$ resp. $c_{nom,u}$:	≥ 30 mm
• Axial distance of the tension and compression bars to the lateral component edge:	≥ 50 mm
• Axial distance of the tension and compression bars:	≤ 300 mm
• Number of shear bars per one-meter element n_{SB}:	≥ 2 (for $Ø_{SB}$ ≤ 8 mm) ≥ 4 (for $Ø_{SB}$ > 8 mm)
• Diameter of the shear bars $Ø_{SB}$:	≤ 12 mm
• Bending diameter of shear bars:	≥ 6 · $Ø_{SB}$
• Axial distance of the shear bars to the lateral component edge:	≥ 6 · $Ø_{SB}$
• Axial distance of the shear bars:	≥ 6 · $Ø_{SB}$ (average) and ≥ 4 · $Ø_{SB}$ (minimum)
• Angle of the shear bars:	30° ≤ α_{SB} ≤ 60°
• Vertical offset between the shear bars and longitudinal reinforcement:	s_{SB} ≤ 100 mm

HIT-HP/SP MVXL (HIT-HP/SP OTX analogues)

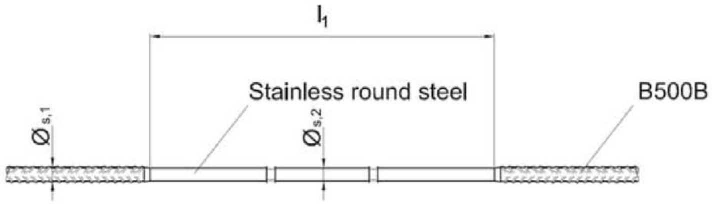
All structural conditions of HIT-HP/SP MVX <u>and</u> HIT-HP/SP ZVX are analogous valid for HIT-HP/SP MVXL.

Halfen Insulated Connection HIT-HP/SP	Annex A10
Product description Dimensions	

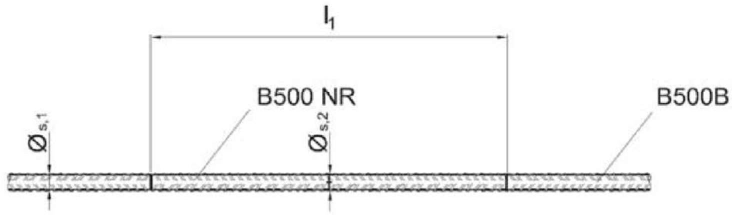


l_1 ≥ 280mm (HIT-HP)
l_1 ≥ 320mm (HIT-SP)
(embedment length of stainless steel of ≥10cm in the adjacent concrete)

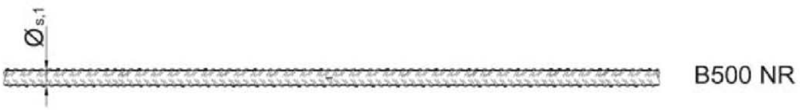
a) Execution with stainless round steel S460 or S690 welded with B500B



b) Alternative execution with stainless round steel S690 welded with B500B



c) Execution with stainless reinforcing steel B500 NR welded with B500B



d) Execution with stainless reinforcing steel B500 NR

Figure 16: Tension/compression bar variations Halfen Insulated Connection HIT-HP/SP

$Ø_{s,1}$ (B500B, B500 NR)	**$Ø_{s,2}$ (stainless round steel S690)**	**$Ø_{s,2}$ (stainless round steel S 460, B500 NR)**
6 mm	-	6 mm
8 mm	≥ 7 mm	8 mm
10 mm	≥ 8,5 mm	10 mm
12 mm	≥ 10,5 mm*	12 mm
14 mm	-	14 mm
16 mm	-	16 mm
20 mm	-	20 mm

* at minimum 9,5mm at both notches with maximum length of 6mm (see Figure 16b)

Table A.1 Diameter combinations of HIT-HP/SP tension/compression bars

Halfen Insulated Connection HIT-HP/SP

Product description
tension/compression bar variations

Annex A11

The height offset tensions bars are executed with headed anchors on one side.

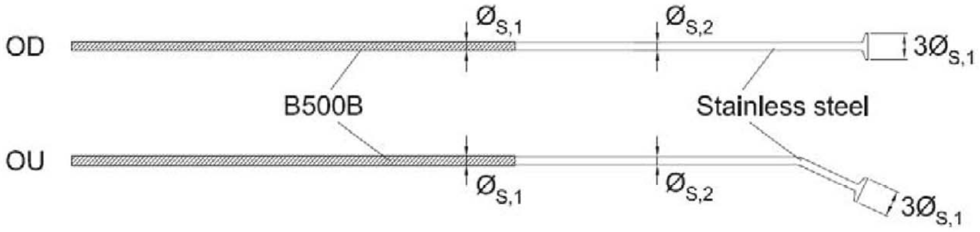
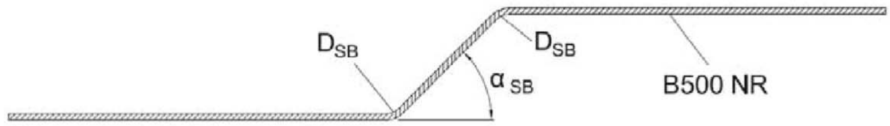
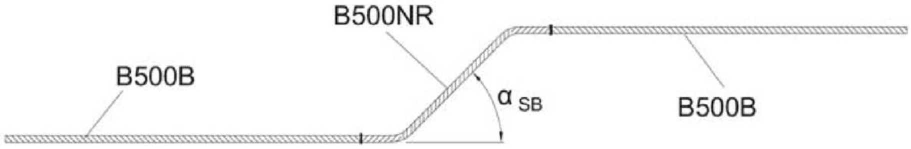


Figure 17: Tension bar variations Halfen Insulated Connection HIT-HP/SP MVX OU/OD (embedment length of stainless steel of ≥10cm in the adjacent concrete)

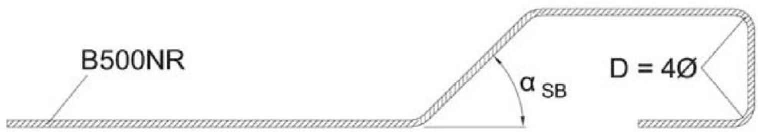
Halfen Insulated Connection HIT-HP/SP	**Annex A12**
Product description tension/compression bar variations	



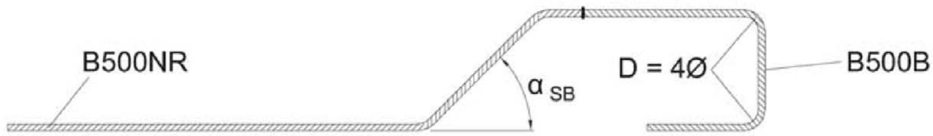
a) Execution with stainless reinforcing steel B500 NR



b) Execution with stainless reinforcing steel B500 NR in combination with B500B
(embedment length of B500 NR of ≥10 cm in the adjacent concrete)



c) Execution with stainless reinforcing steel B500 NR, upper leg of shear bar carried out as loop



d) Execution with stainless reinforcing steel B500 NR, upper leg of shear bar carried out as loop made of B500B
(embedment length of B500 NR of ≥10 cm in the adjacent concrete)

Figure 18: Shear bar variations Halfen Insulated Connection HIT-HP/SP

$Ø_{SB}$ (B500B, B500 NR)	**D_{SB} bending diameter**	**$α_{SB}$ [°]**
6 mm	6 $Ø_{SB}$	30 - 60
8 mm		
10 mm		
12 mm		

Table A.2 Execution variations HIT-HP/SP-Shear bars

Halfen Insulated Connection HIT-HP/SP

Product description
shear bar variations

Annex A13

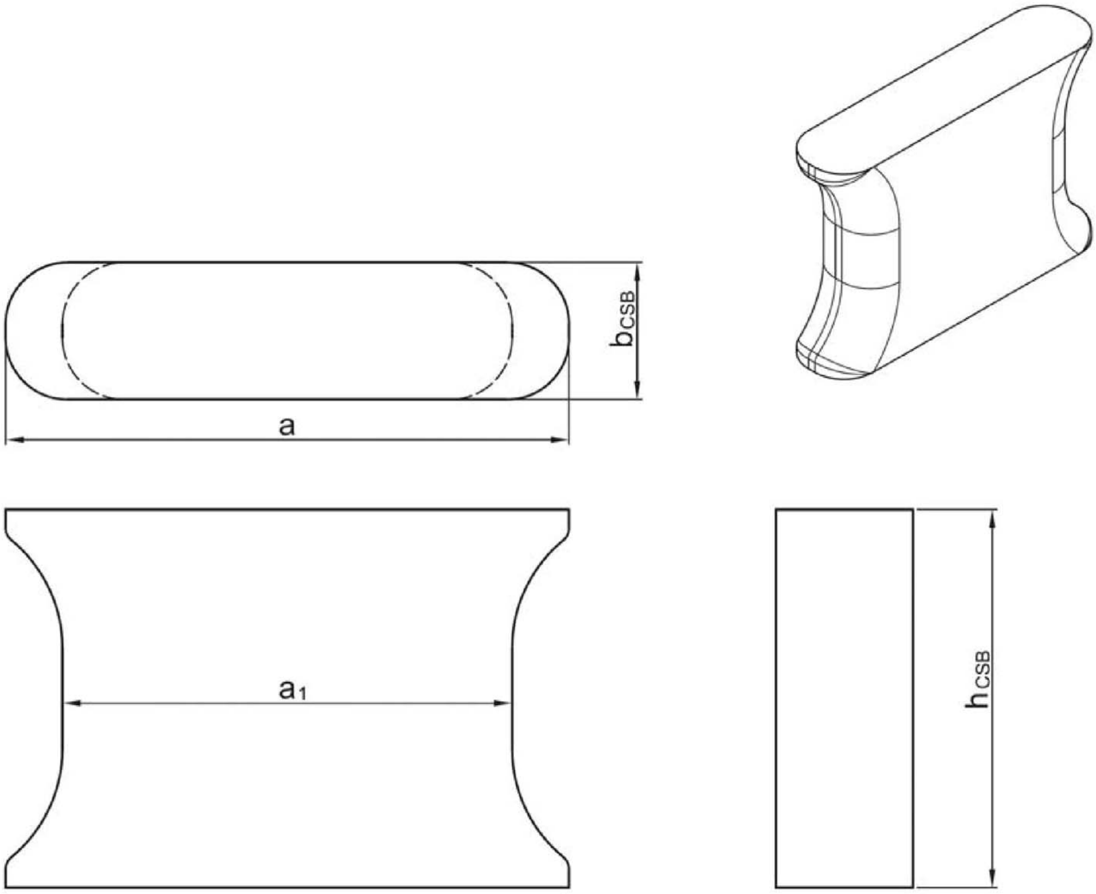


Figure 19: Double-symmetric compression shear bearing (CSB)

element type	HIT-HP	HIT-SP
h_{CSB}	83mm	83mm
b_{CSB}	30mm	30mm
a	123,6mm	163,6mm
a_1	98,6mm	138,6mm

Table A.3 Dimensions of HIT-HP/SP- CSB

Halfen Insulated Connection HIT-HP/SP

Product description
Double symmetric compression shear bearing

Annex A14

A.3 Materials

stainless steel:	B500 NR or stainless round steel (S460, S690) with corrosion resistence class III according to EN 1993-1-4, class A1 according to EN 13501-1
reinforcing steel:	B500B, class A1 according to EN 13501-1
compression shear bearings:	ultra high fibre-reinforced mortar, class A1 according to EN 13501-1
insulation joint:	thermal insulating fire protection material, mineral wool, class A1 according to EN 13501-1
plastic cover :	plastic material, performance as per EN 13501-1 is not determined

B.1 Intended use

As external slabs also vertical members like balustrades, walls or parapets can be connected with the product too.The forces are transmitted to the adjacent components by bond and surface pressure, respectively.
In particular the product is intended to be used:

- To minimise thermal bridges in buildings,
- To transfer static and quasi static bending moments, tension, compression and/or shear forces,
- For fire protection,
- Minimum concrete strength class of slabs made of reinforced normalweight concrete according to EN 206 is C20/25 (for internal components) and C25/30 (for external components).
- elements are applicable for slab heights between 160 to 500mm.

B.1.1 Design

EN 1992-1-1 in connection with EN 1993-1-1 and the provisions in accordance to Annex D shall apply to design.

- The connected slab shall be divided by joints which are installed in order to reduce the thermal stress in accordance with section B.2.1
- the static verification of the transfer of the transmitted loads shall be performed. The verification of the force transmission between the HIT-HP/SP elements and adjacent concrete shall be performed according to Annex D.
- strain state deviating from a monolithic concrete construction is limited to the joint area as well as to the adjacent edges when load bearing thermal insulation elements are used.
- At a distance h from the joint edge the undisturbed strain state may be assumed.
- Variable moments and shear forces along a connected edge shall be taken into account in the structural analysis.
- The slab connections are not suited for the locally limited transfer of torsional moments which are required to create the balance.
- Small normal forces due to imposed deformation in the girder bars (related to the strut-and-tie model) which occur at the end of the line supports e. g. next to free edges or expansion joints shall be neglected in the calculation. Normal constraining forces in the direction of the bars of the slab connection shall be eliminated.
- If the slabs connected to the load bearing thermal insulation elements are implemented as precast elements, an in-situ concrete stripe with a width of at least 10 cm according to Annex B6 to B8 shall be carried out between the load bearing thermal insulation elements and the precast concrete slab.
- The height-to-length ratio of the adjacent components should not exceed the ratio 1/3, unless a separate verification of the transfer of the occurring transverse tensile stresses is made.
- Cutting the elements to size is allowed. The conditions due to Annex A8 – A10 have to be fulfilled after cutting. Elements must be protected against systematic moisture during storage, installation and assembling.

Halfen Insulated Connection HIT-HP/SP	Annex B1
Intended use Design	

B.2 Installation requirements

B.2.1 Joint distances

To limit the thermal stress expansion joints shall be installed perpendicular to the insulating layer in the external concrete components (see Figure 20). The joint distances are listed in table B.1.

joint thickness	Diameter of the tension bar in the joint [mm]					
	≤ 10,5	11	12	14	16	20
HIT-HP	13,5	12,2	11,7	10,1	9,2	8,0
HIT-SP	23,0	20,6	19,8	17,0	15,5	13,5

Table B.1 Joint distances s_{joint} [m]

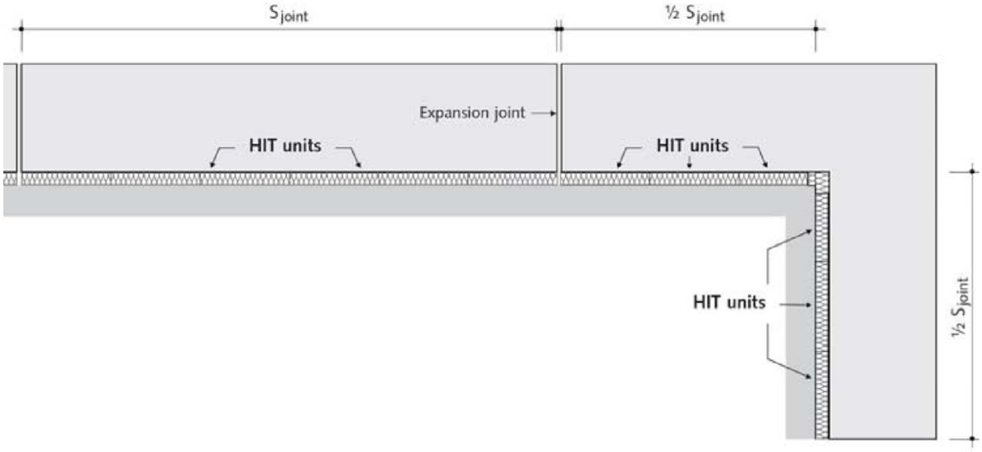


Figure 20: Installation situation with expansion joint

B.2.2 Structural Design

The minimum concrete cover according to EN 1992-1-1 shall be observed. This applies to the tension/compression bars, shear bars or to existing reinforcement.
The reinforcement of the concrete structure connected to the load bearing thermal insulation elements shall be extended to the insulating layer considering the required concrete cover according to EN 1992-1-1.
The transverse bars of the upper connecting reinforcement shall generally lie on top of the longitudinal bars of the slab connections. In case of bars with a nominal diameter smaller than 16 mm, under the respective existing in-situ conditions, the transverse bars can also be installed directly underneath the longitudinal bars of the slab connections and if this is monitored e. g. by the construction engineer. The corresponding required installation steps shall be specified in the installation manual (see Annexes B3 to B5).
The front surfaces of the components to be connected shall receive edge reinforcement according to EN 1992-1-1, chapter 9.3.1.4. U-bars Ø≥ 6mm, s ≤ 25cm and 2 longitudinal bars Ø≥ 8mm shall be positioned on the front surface of the connected slabs parallel to the insulating joint. Lattice girders with a maximum space of 100mm to the insulating joint can be taken into account.
A subsequent bending of the bars of the thermal insulation element is not permitted.

Halfen Insulated Connection HIT-HP/SP	Annex B2
Intended use Installation requirements	

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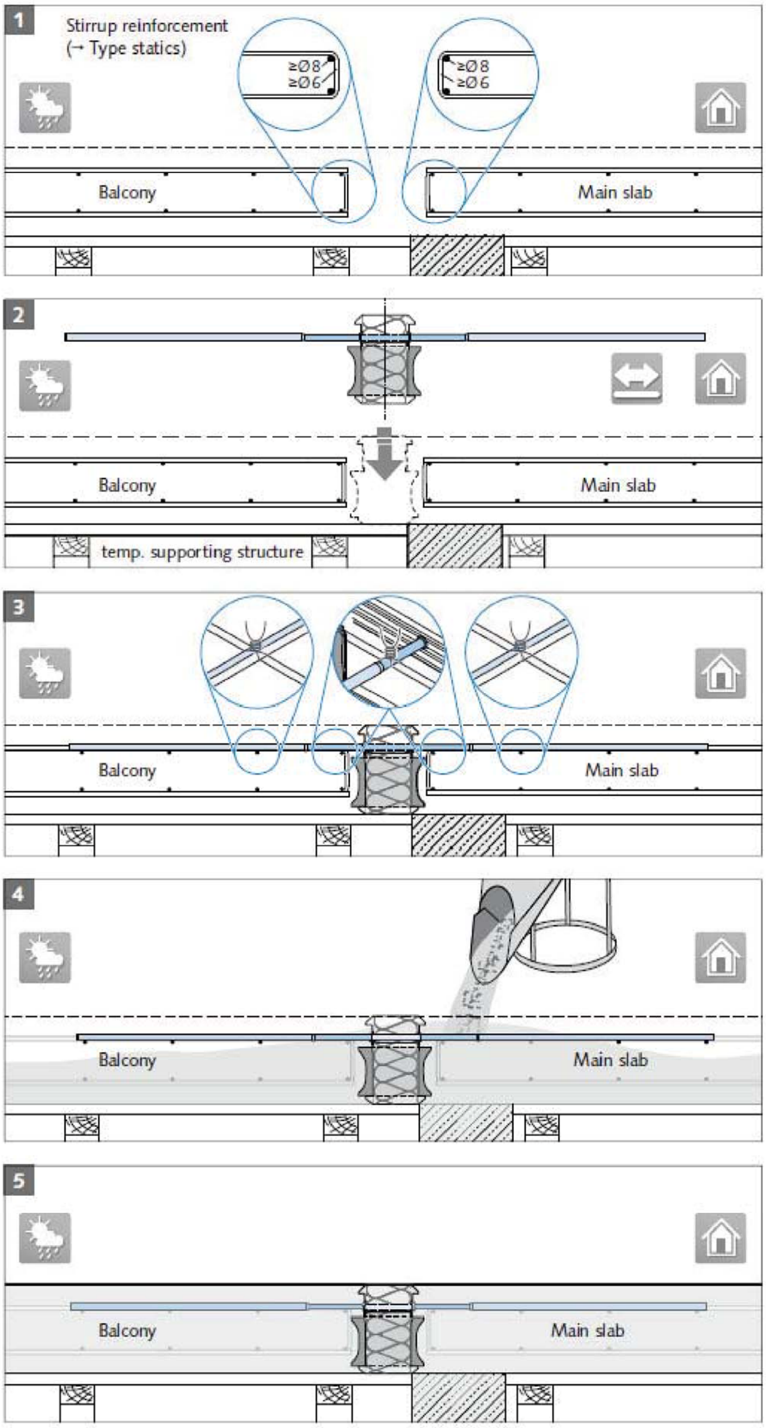
Installation diagram

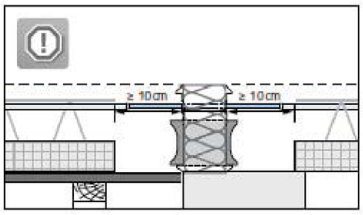


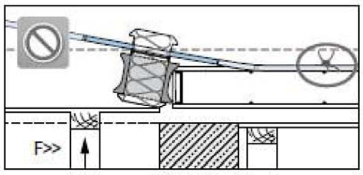
1 Installation of on-site reinforcement

The on-site reinforcement must be placed as specified by the structural engineer.

2 Installation of the HIT Element from above

The HIT-MVX Element is symmetrical; therefore, both installation directions are correct (custom solutions may vary).





Ensure that the formwork is at the correct height!

3 Fix the HIT Tension bars to on-site reinforcement using tying wire

4 Pour the concrete

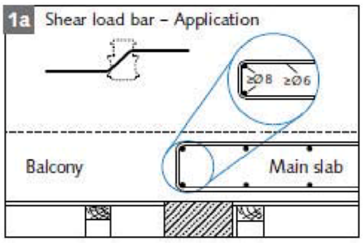
To ensure the HIT Elements are not displaced, pour and compact the concrete evenly. Secure the HIT Elements against movement.

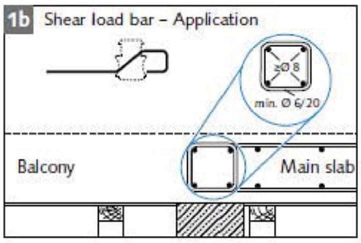
5 Freshly concreted balcony slab on supporting structure

For further installation instructions please go to **www.halfen.com**.

Halfen Insulated Connection HIT-HP/SP	Annex B3
Intended use Installation manual Type HIT-MVX	

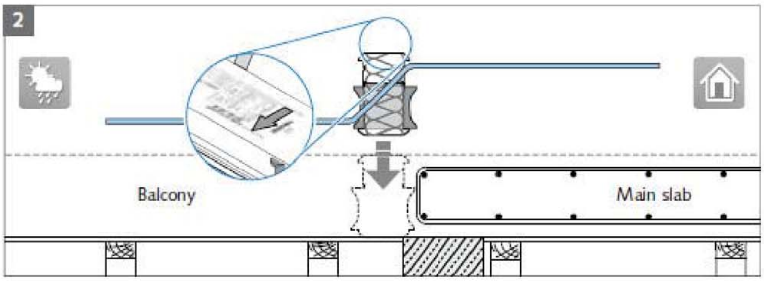
Installation diagram



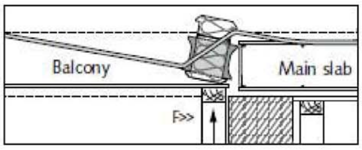


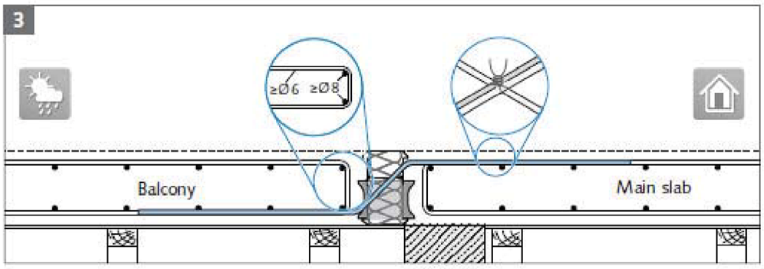
1 Installation of on-site reinforcement for the main slab

On-site reinforcement as specified by the structural engineer.



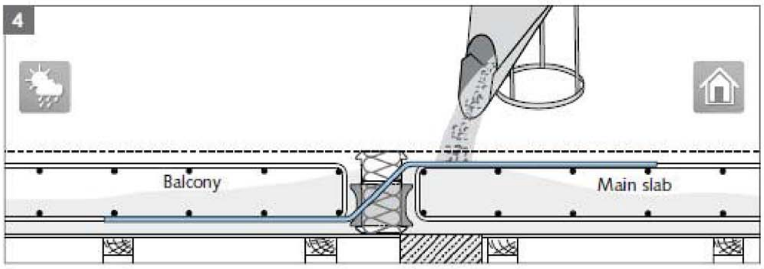
2 Installation of HIT Elements from above
HIT-ZDX Elements with bar diameters of Ø8, 10 or 12 are symmetrical and do not have a dedicated installation direction.





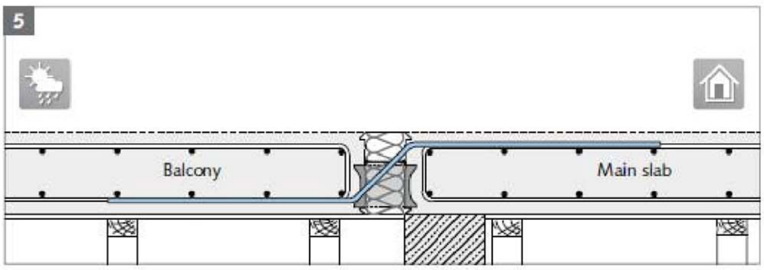
Ensure that the formwork is at the correct height!

3 Installation of the on-site reinforcement, balcony side
Fixing of the shear bars to on-site reinforcement using tying wire.



4 Pouring the concrete

To ensure the HIT Elements are not displaced, pour and compact the concrete evenly.

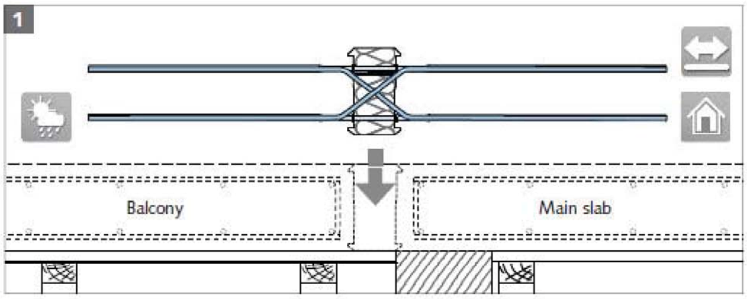


5 Freshly poured concrete balcony slab on support structure

Further installation diagrams for the types HIT-HP/SP ZVX and HIT-HP/SP ZDX can be found in the installation instructions – available for download at our website www.halfen.com.

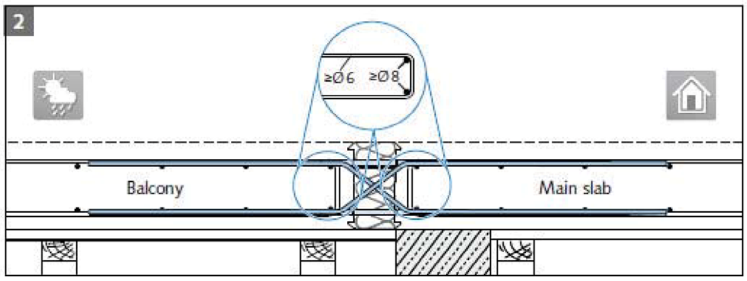
Halfen Insulated Connection HIT-HP/SP	**Annex B4**
Intended use Installation manual Type HIT-ZVX	

Installation diagram



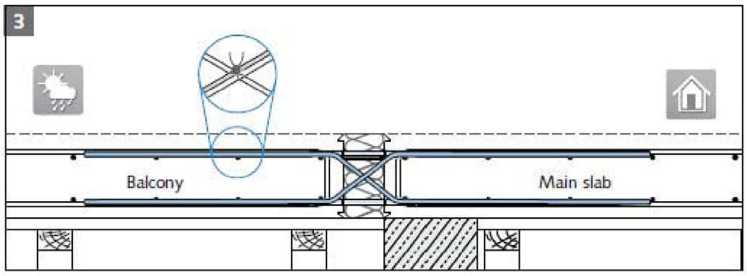
1 Positioning the HIT Element from above

The HIT-DD Element is symmetrical; therefore both installation directions are correct

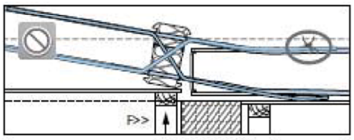


2 Installing on-site reinforcement

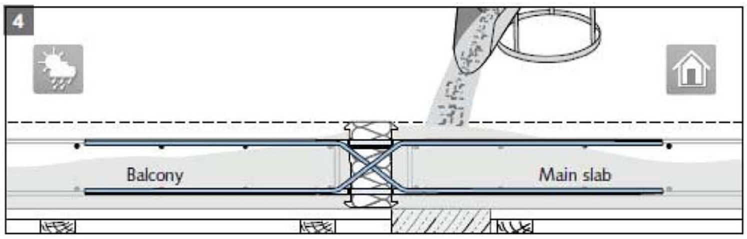
The on-site reinforcement must be placed as specified by the structural engineer



3 Fixing the tension bars and the shear bars to on-site reinforcement using tying wire

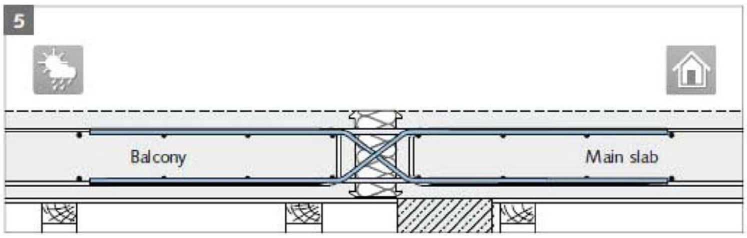


Ensure the formwork is at the correct height!



4 Pour the concrete

To ensure the HIT Elements are securly installed, pour and compact the concrete evenly. Ensure all HIT Elements are securely fixed.



5 Freshly concreted balcony slab on supporting structure

For further installation instructions please visit **www.halfen.com**.

Halfen Insulated Connection HIT-HP/SP	Annex B5
Intended use Installation manual Type HIT-DD	

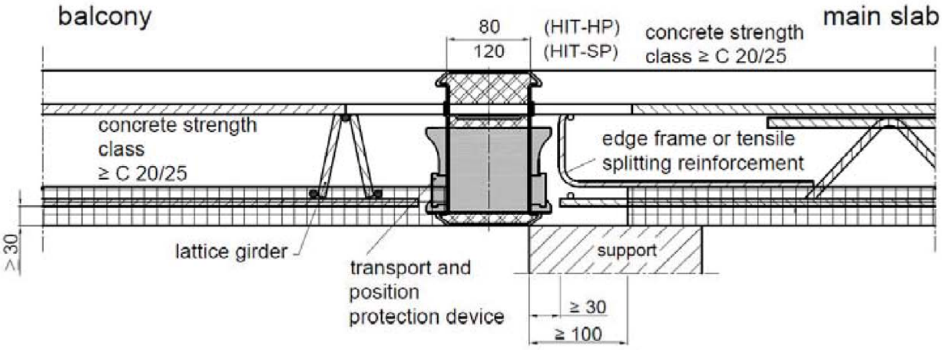


Figure 21: Example of the connection HIT-HP/SP MVX to element slabs with statically effective in-situ layer

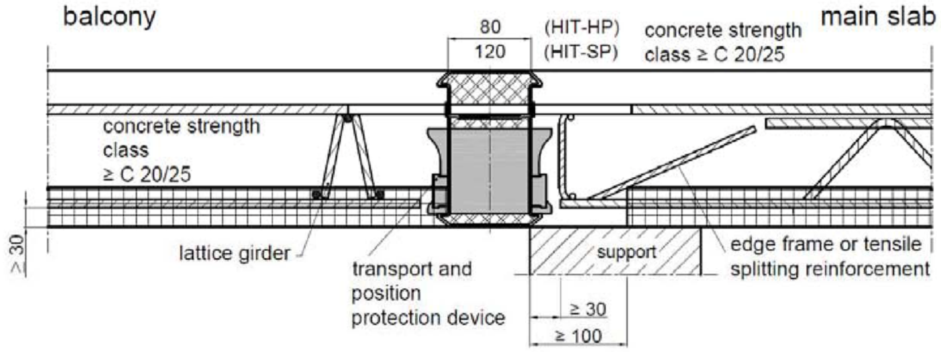


Figure 22: Example of the connection HIT-HP/SP MVX to element slabs with statically effective in-situ layer

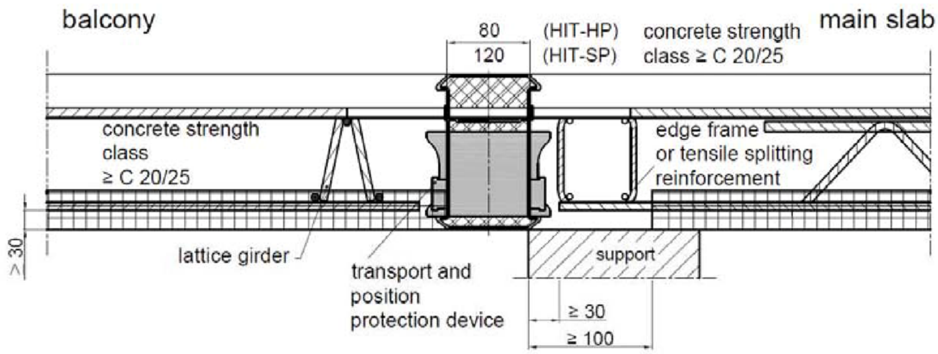


Figure 23: Example of the connection HIT-HP/SP MVX to element slabs with statically effective in-situ layer

Halfen Insulated Connection HIT-HP/SP	Annex B6
Intended use Connection of precast concrete	

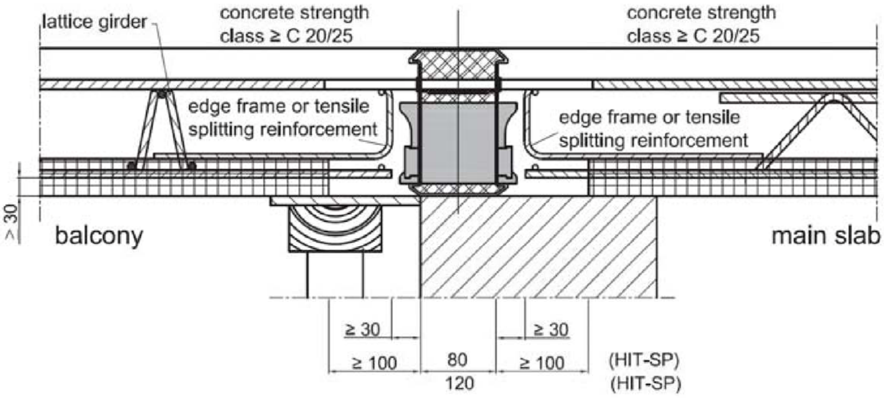


Figure 24: Example of the connection HIT-HP/SP MVX to element slabs with statically effective in-situ layer

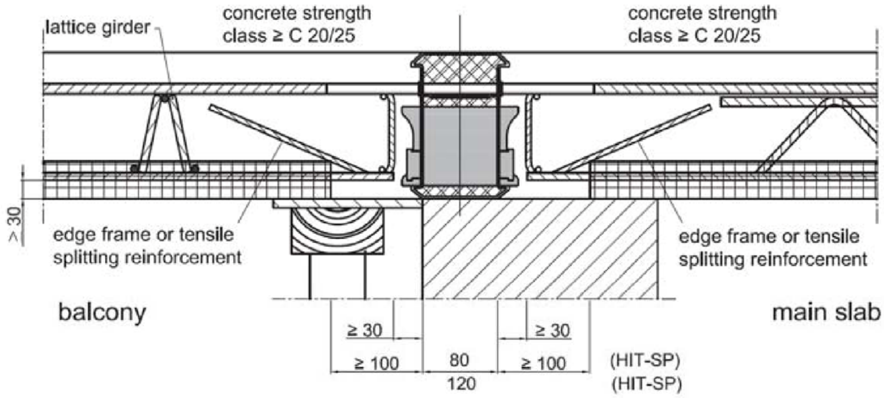


Figure 25: Example of the connection HIT-HP/SP MVX to element slabs with statically effective in-situ layer

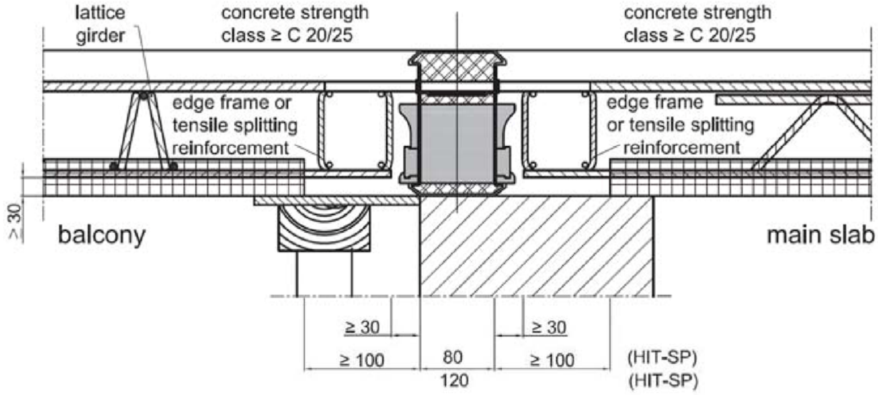


Figure 26: Example of the connection HIT-HP/SP MVX to element slabs with statically effective in-situ layer

Halfen Insulated Connection HIT-HP/SP	Annex B7
Intended use Connection of precast concrete	

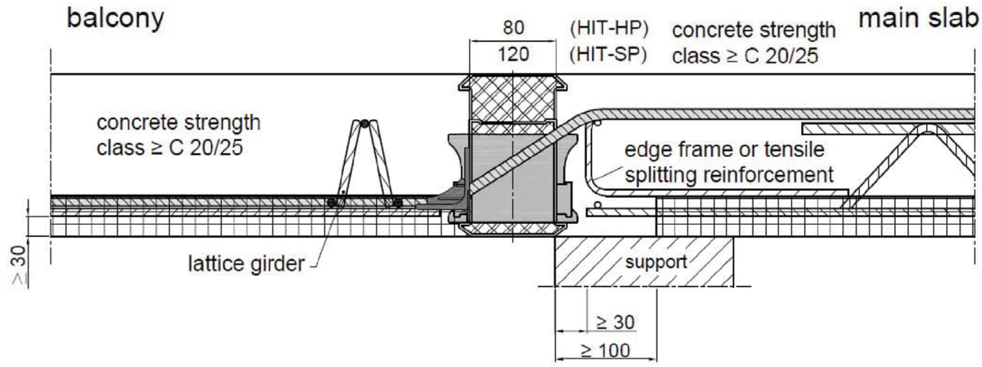


Figure 27: Example of the connection HIT-HP/SP ZVX to element slabs with statically effective in-situ layer

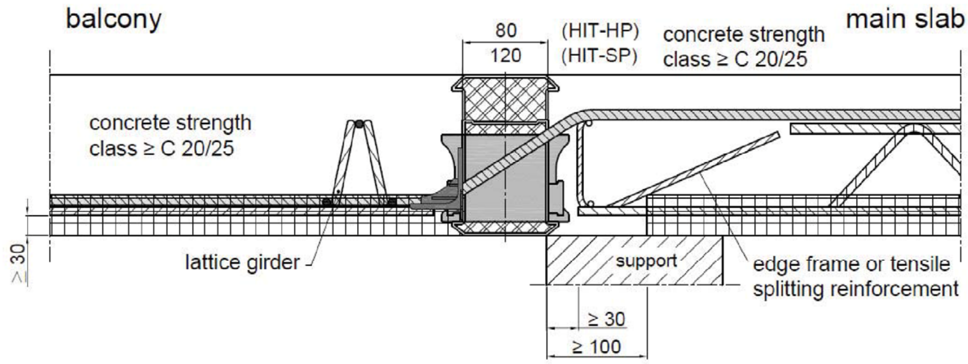


Figure 28: Example of the connection HIT-HP/SP ZVX to element slabs with statically effective in-situ layer

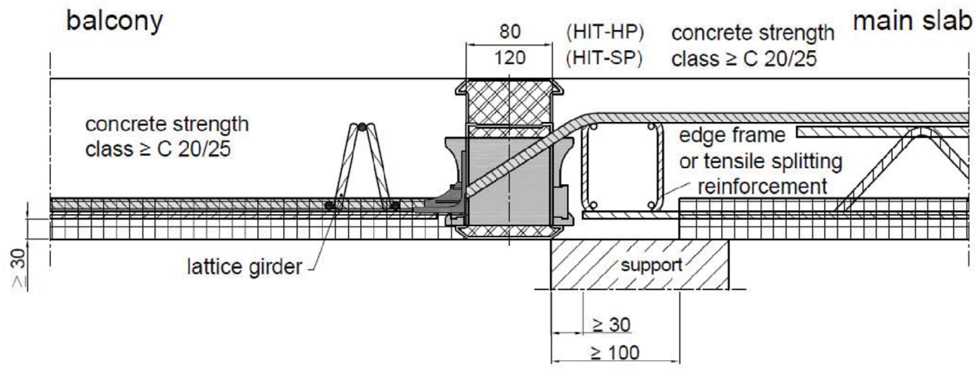


Figure 29: Example of the connection HIT-HP/SP ZVX to element slabs with statically effective in-situ layer

Halfen Insulated Connection HIT-HP/SP	**Annex B8**
Intended use Connection of precast concrete	

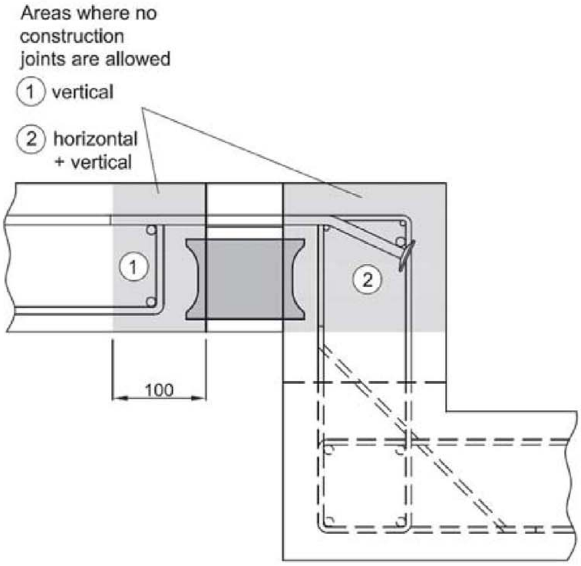


Figure 30: Reinforcement layout for height offset HIT-HP/SP MVX _OU

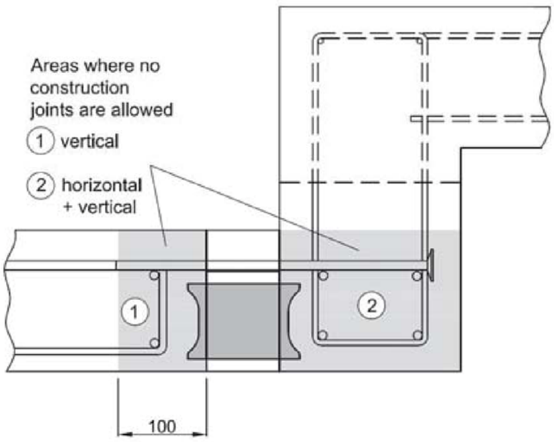


Figure 31: Reinforcement layout for Height offset HIT-HP/SP MVX _OD

Halfen Insulated Connection HIT-HP/SP	Annex B9
Intended use Reinforcement layout for HIT-MVX_OU/OD	

C.1 Load bearing capacity
C.1.1 Load bearing capacity of the bars in use

Bars made from	f_{yd} [N/mm²]
B500B	435
B500 NR	435
Stainless round steel S460	418
Stainless round steel S690	627

Table C.1 Design values of the yield strength for tension loads

Diameter bar [mm]	Material [-]	$F_{sR,d}$ [kN]
8	ribbed stainless steel, f_{yk} >700 N/mm²	19,0
10	ribbed stainless steel, f_{yk} >700 N/mm²	34,1
12	ribbed stainless steel, f_{yk} >700 N/mm²	49,2
10,5	S690	49,2

Table C.2 Design values of the buckling loads of compression steel bars

C.1.2 Design value of the transferable forces

$V_{CSB,d} \leq$ 18.200 N

To determine the maximum load capacities M_{Rd} and V_{Rd}, M_{Ed} and V_{Ed} must be increased until one of the proofs becomes decisive.

M_{Ed} and V_{Ed} combinations according to
- Annex D3-D5 (HIT-MVX)
- Annex D6-D8 (HIT-MVXL) (HIT-OTX analogues)
- Annex D9-D10 (HIT-ZVX (ZDX))
- Annex D11-D12 (HIT-DD) (HIT-DDL, HIT-DVL, HIT-AT, HIT-FT analogues).

C.1.3 Bearing design resistance

$F_{c,Rd}$ according to
- Annex D5 (HIT-MVX)
- Annex D7 (HIT-MVXL) (HIT-OTX analogues)
- Annex D10 (HIT-ZVX (ZDX)).

C.2 Fire resistance

C.2.1 Performance features regarding load bearing capacity in case of fire

If the performance characteristics specified in Annex C1 for verification according to the intended use under normal temperatures are met, the load bearing capacity of connections with HALFEN HIT-HP/SP is also guaranteed in case of fire for the fire resistance period 120 minutes for design variants according to Figures (see Annex A1 to A7). This applies to a reduction coefficient η_{fi} according to EN 1992-1-2, section 2.4.2 to η_{fi} = 0,7.

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C.2.2 Resistance to fire of building elements (informative)

Floor or roof structures as well as balcony and walkways connected to reinforced concrete components with HALFEN HIT-HP/SP as far the intended use can be classified as specified in Table C.3 in terms of fire resistance in accordance with EN 13501-2. The following boundary conditions must be observed:

- The load bearing capacity on case of fire has been declared for Halfen Insulated Connection HIT-HP/SP.
- Connections of the remaining edges of floor or roof structures, which are not connected with the Halfen Insulated Connection HIT-HP/SP to adjacent or supporting components, shall be verified in accordance with the provisions of the member states for the corresponding fire resistance.

Design variant according to	Floor or roof construction wires fire separating function	Balcony and walkway
Annex A1 to A7	REI 120	R120

Table C.3 Component classification

C.3 Thermal resistance

Thermal resistance shall be calculated according to EN ISO 6946 and EN ISO 10211. The equivalent thermal resistance of thermal insulation element $R_{eq,TI}$ shall be determined by using numerical methods (e.g. finite element method) and a detailed 3D model of the thermal insulation element for the configuration shown in figure 32. As an alternative to these simplified models, detailed models can also be used. The nominal thickness $d_{n,TI}$ of the thermal insulation element shall be determined and all indentations as well as all protrusions shall be taken into account.

$$R_{cal} = R_{eq,TI} + R_{con}$$

$$R_{eq,TI} = R_{cal} - R_{con} = R_{cal} - \frac{0{,}06\,\text{m}}{2{,}3\,\text{W}/(\text{mK})}$$

$$\lambda_{eq,TI} = \frac{d_{n,TI}}{R_{eq,TI}}$$

Where:
- $d_{n,TI}$ nominal thickness of thermal insulation element
- $\lambda_{eq,TI}$ equivalent thermal conductivity of thermal insulation element
- R_{cal} calculated thermal resistance for configuration
- R_{con} thermal resistance of concrete
- $R_{eq,TI}$ equivalent thermal resistance of thermal insulation element

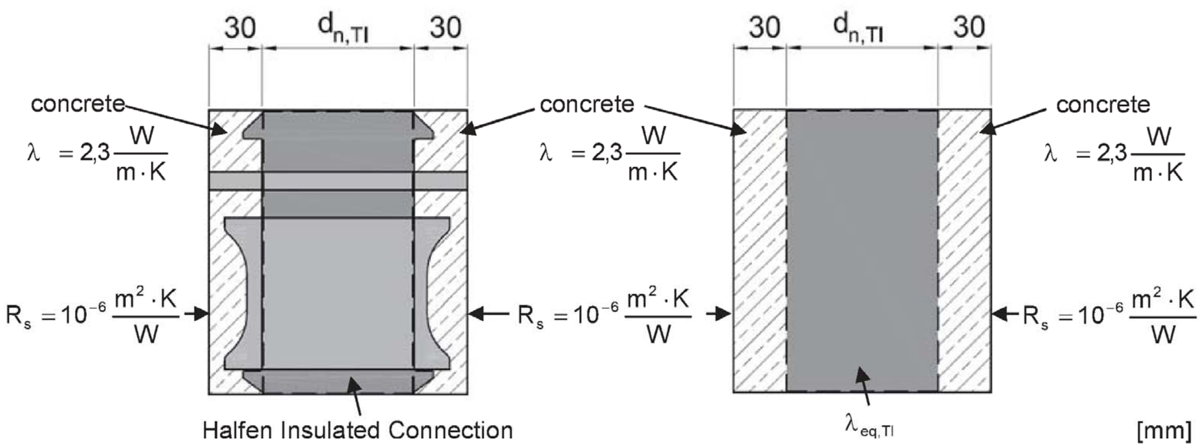


Figure 32: Cross section of configuration to calculate the equivalent thermal resistance $R_{eq,TI}$ and simplified analogous model

Halfen Insulated Connection HIT-HP/SP	Annex C4
Performance parameters Thermal resistance	

As an alternative to the using numerical methods the following simplify equation can be used.

$$\lambda_{eq,TI} = C_{eq} \cdot \sum_i \frac{A_i \cdot \lambda_i}{B_{HIT} \cdot H_{HIT}}$$

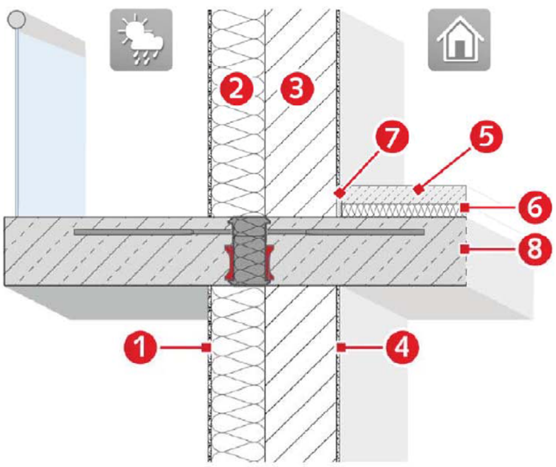
Where: C_{eq} correction coefficient according to table C.4
A_i cross section of the layer i according to table C.5
λ_i thermal conductivity of the layer i according to table C.5
B_{HIT} width of the HIT element
H_{HIT} height of the HIT element

HIT type	HIT-MVX	HIT-ZVX	HIT-ZDX	HIT-DD	HIT-MVXL
C_{eq}	0,84	0,79	0,73	0,83	0,84

Table C.4 Correction coefficient C_{eq} for wall constructions according to Figure 33

i	Layer	material	A_i	λ_i [W/(mK)]	According to
1	tension bar	Stainless steel	Cross section in the joint (A_{TB})	13 - 17	EN 10088-1
2	shear bar	Stainless steel	Cross section in the joint (A_{SB})	13 - 17	EN 10088-1
3	CSB	fibre-reinforced mortar	$A_{CSB} = n_{CSB} \cdot 24{,}9\ cm^2$	acc. to data sheet	EN 12664 and EN ISO 10456
4	cover	PVC-U	Horizontal cross section (A_{cover})	0,17	EN ISO 10456
5	insulation	Mineral wool	Cross section in the joint (A_{Miwo})	0,035	EN 13162 and EN ISO 10456

Table C.5 Design values of the thermal conductivity and other information of the different layers



1	Plaster exterior
2	Insulation (120-300mm)
3	Bearing layer (150-350mm)
4	Plaster interior
5	Screed
6	Insulation
7	Edge insulation
8	Bearing layer (≥ 160mm)

Figure 33: Wall construction with ETICS

C.4 Impact sound insulation according to EN ISO 10140

HIT unit	Weighted normalized impact sound pressure level difference $\Delta L_{n,w}$ [dB]
HIT-HP MVX-0504-18-100-35	12
HIT-HP MVX-0705-18-100-35	11
HIT-HP MVX-1207-18-100-35	11
HIT-SP MVX-0504-18-100-35	14
HIT-SP MVX-0705-18-100-35	15
HIT-SP MVX-1208-18-100-35	10

Table C.6 Weighted normalized impact sound pressure level difference $\Delta L_{n,w}$ [dB] derived from laboratory tests

HIT unit	Weighted normalized impact sound pressure level difference $\Delta L_{n,w}$ [dB]
HIT-HP ZVX-0504-18-100-30-12	12
HIT-HP ZVX-0705-18-100-30-12	11
HIT-HP ZVX-1207-18-100-30-12	11
HIT-SP ZVX-0504-18-100-30-12	14
HIT-SP ZVX-0705-18-100-30-12	15
HIT-SP ZVX-1208-18-100-30-12	10

Table C.7 Weighted normalized impact sound pressure level difference $\Delta L_{n,w}$ [dB] derived from laboratory tests

D.1 Structural analysis

D.1.1 Signs and Symbols

(units in [N] and [mm])

h	element height
b_{Unit}	width of Halfen Insulated Connection HIT-HP/SP
d	effective depth of the slab (floor and balcony)
n_{CSB}	number of compression shear bearings
h_{CSB}	height of compression shear bearings (= 83 [mm])
c_{CSB}	concrete cover of the CSB (=15 [mm])
$c_{nom,s}$	concrete cover of the tension bars
n_{TB}	number of tension bars
$Ø_{s,1}$	diameter of the tension/compression bars
$Ø_{s,2}$	diameter of the stainless steel part of the tension/compression bars
α_{SB}	Inclination of shear bar
$Ø_{SB}$	diameter of the shear bar
$c_{v,l}$	concrete cover of reinforcement of the slabs
$c_{nom,o}$	concrete cover of the bars at the top
$c_{nom,u}$	concrete cover of the bars at the bottom
f_{yd}	design value of the yield stress of the reinforcing steel

element type	HIT-HP	HIT-SP
t_{HIT}	80mm	120mm
l_1	280mm	320mm
a_{CSB}	110mm	150mm
a_{Rd}	140	122

Table D.1 Various Dimensions for HIT-HP and HIT-SP

element type	HIT-HP/SP	HIT-HP	HIT-SP
concrete compressive class	$\beta_{c1,M}$ [N/mm]	$\beta_{c2,V}$ [N/mm²]	$\beta_{c2,V}$ [N/mm²]
C20/25	800	14,5	10,7
≥ C25/30	945	17,2	12,6

Table D.2 Factors $\beta_{c1,M}$ and $\beta_{c2,V}$ for HIT-HP and HIT-SP

D.1.2 General

- Structural verification shall be performed for each individual case.
- Type-tested load tables may be used.
- The corrosion protection is ensured by compliance with the concrete cover of the on-site reinforcement according to EN 1992-1-1 and the use of the materials according to Annex A15
- Verification of the welded connection between reinforcement steel and stainless steel is not necessary.
- The shear force reinforcement required in the insulation layer does not determine the minimum slab thickness according to EN 1992-1-1, chapter 9.3.2 (1).
- Verification of the required bending diameter is fulfilled if the conditions according to Annex A8-A10 are met.
- The anchorage and lap length of the bars passing the insulation layer shall be verified in accordance with EN 1992-1-1.
- The verification of fatigue due to temperature difference is provided by the limitation of the joint distances according to Table B.1

Design of the on-site vertical reinforcement for the adjacent components

Structural vertical reinforcement

The front surfaces of the components to be connected shall at least receive edge reinforcement according to EN 1992-1-1, chapter 9.3.1.4 U-bars Ø ≥ 6mm, s ≤ 25cm (=$A_{sV,min}$)

Vertical tensile splitting reinforcement

$$F_{Sp,v} = \frac{|F_{cd}|}{4} \cdot \left(1 - \frac{x_c}{x_c + c}\right)$$

Where: F_{cd}, x_c according to Annex D4 (HIT-MVX)
Annex D6 (HIT-MVXL) (HIT-OTX analogues)
Annex D9 (HIT-ZVX (ZDX))

c = 30mm

$$A_{sV,Sp} = \frac{F_{Sp,v}}{f_{yd}}$$

Supporting reinforcement
Supporting reinforcement shall be designed for the entired shear force V_{Ed}.

$$A_{sV,s} = \frac{V_{Ed}}{f_{yd}}$$

D.1.3 Verification in the ultimate limit state

According to	Annex D3-D5	(HIT-MVX)
	Annex D6-D8	(HIT-MVXL) (HIT-OTX analogues)
	Annex D8-D10	(HIT-ZVX (ZDX))
	Annex D11-D12	(HIT-DD) (HIT-DDL, HIT-DVL, HIT-AT, HIT-FT analogues)

Halfen Insulated Connection HIT-HP/SP	Annex D2
Structural analysis General	

D.1.3.1 HIT-HP/SP MVX

Strut-and-tie model of Halfen Insulated Connection HIT-HP/SP MVX (general)

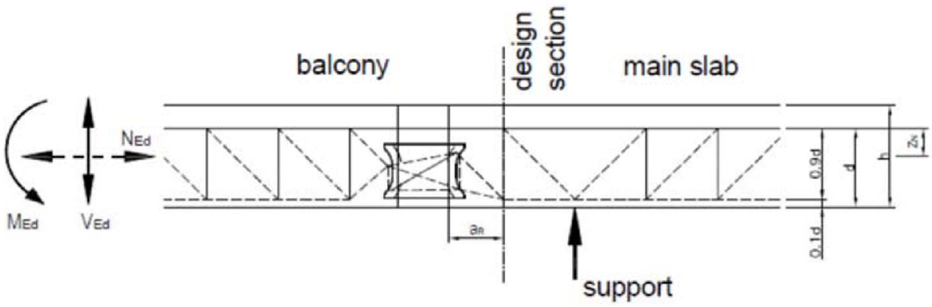


Figure 34: Strut-and-tie model and design section **HIT-HP/SP MVX** with compression shear bearing

Strut-and-tie model Halfen Insulated Connection HIT-HP/SP MVX-…-OD/-OU (Height offset)

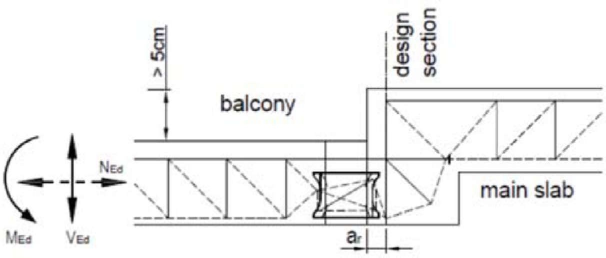


Figure 35:
Strut-and-tie model **HIT-HP/SP MVX-…-OD**

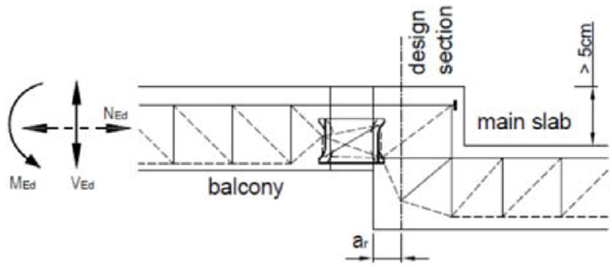


Figure 36:
Strut-and-tie model **HIT-HP/SP MVX-…-OU**

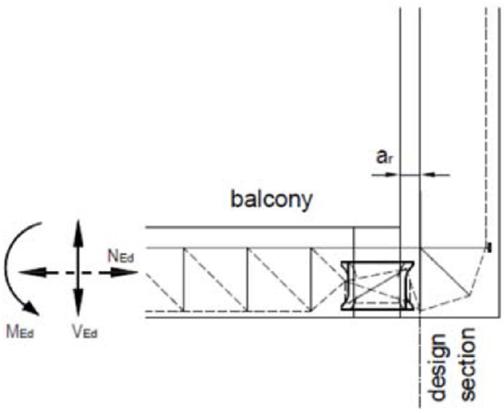


Figure 37:
Strut-and-tie model **HIT-HP/SP MVX-…-OD**
(wall connection)

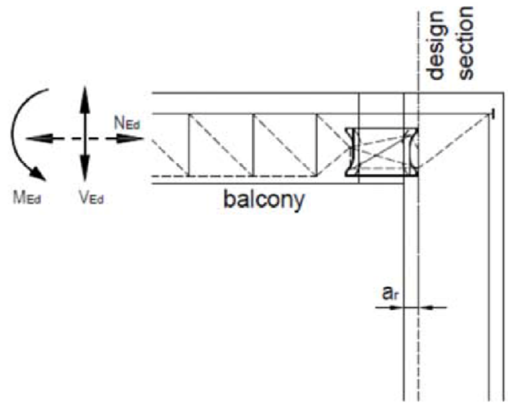


Figure 38:
Strut-and-tie model **HIT-HP/SP MVX-…-OU**
(wall connection)

Halfen Insulated Connection HIT-HP/SP	Annex D3
Structural analysis HIT-HP/SP MVX	

Distance between design section and component edge

$a_r = 96$ mm – 0,1 · d   ($a_r \approx 80$ mm)

For taking into account an additional normal force N_{Ed} a determination of equivalent loads is necessary
(moment M_{Ed} in direction of arrow negative, shear force V_{Ed} in downward positive, normal force N_{Ed} as tensile force positive, positive (lifting) moments M^*_{Ed} are not allowed)

$$M^*_{Ed} = M_{Ed} + N_{Ed} \cdot z_N$$

where: z_N = Distance of the normal force to the tension bar level

If there is no additional normal force applies $M^*_{Ed} = M_{Ed}$.

Determination of internal forces resulting from moment / shear force interaction

In the ultimate limit state a ratio between bending moment M^*_{Ed} and shear force V_{Ed} of at least $-M^*_{Ed}/V_{Ed} \geq 0{,}15$ [m] shall be adhered to.

Concrete compression zone height of compression shear bearing:

$$x_c = \text{Max} \begin{cases} d_{CSB} - \sqrt{(d_{CSB})^2 - \dfrac{|M^*_{Ed}|}{\beta_{c1,M} \cdot n_{CSB}}} \\ \dfrac{h_{CSB}}{2} - \sqrt{\left(\dfrac{h_{CSB}}{2}\right)^2 - \dfrac{|V_{Ed}|}{\beta_{c2,V} \cdot n_{CSB}}} \end{cases} \leq h_{CSB}$$

(units in [N] and [mm])

where: $$d_{CSB} = h - c_{nom,s} - \frac{d_{s,1}}{2} - c_{CSB}$$

Concrete compressive force F_{cd} (negative) and steel tensile force F_{sd} (positive):

$$-F_{cd} = 2 \cdot x_c \cdot n_{CSB} \cdot \beta_{c1,M}$$

(units in [N] and [mm])

$$F_{sd} = -F_{cd} + N_{Ed}$$

$$V_{Rd} = \text{Min} \begin{cases} n_{CSB} \cdot V_{CSB,d} \\ |F_{cd}| \cdot \dfrac{(h_{CSB} - x_c)}{a_{CSB}} \end{cases}$$

Verification: Shear load: $|V_{Ed}| \leq V_{Rd}$

Halfen Insulated Connection HIT-HP/SP	Annex D4
Structural analysis HIT-HP/SP MVX	

Verification of required tension bar reinforcement:

$$A_{s,req} = \frac{F_{sd}}{f_{yd}}$$

Verification of concrete edge failure

Actions in the design section:

$$F_{c,Ed} = 0{,}25 \cdot |F_{cd}| + |V_{Ed}|$$

Bearing resistance:

$$F_{c,Rd} = a_{Rd} \cdot (f_{ck})^{\frac{1}{4}} \cdot b_{eff} \cdot \psi_{BK}$$

Where: $b_{eff} = n_{CSB} \cdot 137[mm] \leq b_{Unit}$

ψ_{BK} = 1,0 general

ψ_{BK} = 0,7 applicable to HIT-HP/SP MVX-…-OD (Balcony offset downward, see Annex A1, Figure 2)

Verification:

$$F_{c,Ed} \leq F_{c,Rd}$$

Design moments of the adjacent slabs

(V_{Ed} and N_{Ed} are to be applied on both sides)

Main slab: $M_{Ed,Decke} = \text{Max}\begin{cases} M^*_{Ed} \\ F_{cd} \cdot z_1 \end{cases}$ in the design section, tension bar level

mit $z_1 = d - ½ \cdot x_c - c_{CSB}$

balcony slab: $M_{Ed,balkony} = M_{Ed,Decke} - |V_{Ed}| \cdot a_{CSB}$

On-site vertical reinforcement at the front surfaces of the adjacent components

moment and downward shear force:

- Balcony side: $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} \end{cases}$
- Main slab side: direct support $A_{sV,min}$

  indirect support $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} + A_{sV,s} \end{cases}$

- moment and upward shear force:
- Balcony side: $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} + A_{sV,s} \end{cases}$
- Main slab side: direct support $A_{sV,min}$

  indirect support $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} \end{cases}$

$A_{sV,min}$, $A_{sV,sp}$ and $A_{sV,s}$ according to Annex D2

Halfen Insulated Connection HIT-HP/SP	Annex D5
Structural analysis HIT-HP/SP MVX	

D.1.3.2 HIT-HP/SP MVXL

Strut-and-tie model of Halfen Insulated Connection HIT-HP/SP MVXL

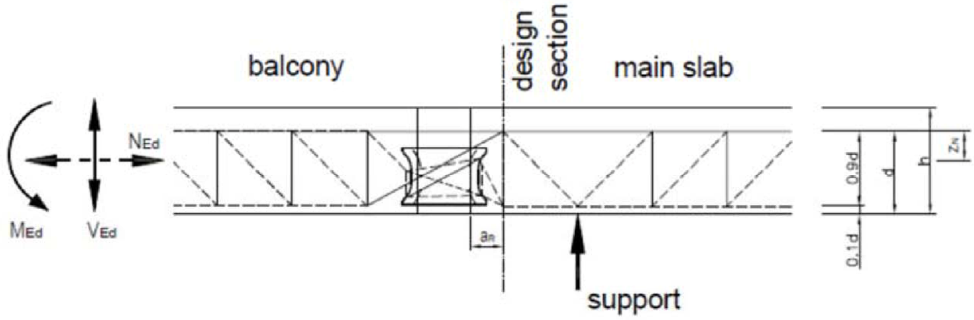


Figure 39: Strut-and-tie model and design section **HIT-HP/SP MVXL** with compression shear bearing

For taking into account an additional normal force N_{Ed} a determination of equivalent loads is necessary
(moment M_{Ed} in direction of arrow negative, shear force V_{Ed} in downward positive, normal force N_{Ed} as tensile force positive, positive (lifting) moments M^*_{Ed} are not allowed)

$M^*_{Ed} = M_{Ed} + N_{Ed} \cdot z_N$ where: z_N = Distance of the normal force to the tension bar level

$V^*_{Ed} = V_{Ed} - \tan\alpha_{SB} \cdot N_{Ed}$

If there is no additional normal force applies $M^*_{Ed} = M_{Ed}$ and $V^*_{Ed} = V_{Ed}$.

For upward shear force the design is analogous to HIT-HP/SP MVX (Annex D3-D5).

Concrete compression zone height of compression shear bearing from moment:

$$x_{c,M} = (d_{CSB}) - \sqrt{(d_{CSB})^2 - \frac{|M^*_{Ed}|}{n_{CSB} \cdot \beta_{c1,M}}} \leq h_{CSB}$$

Concrete compressive force $F_{cd,M}$ (negativ) from moment

$$-F_{cd,M} = 2 \cdot x_{c,M} \cdot n_{CSB} \cdot \beta_{c1,M}$$ (units in [N] and [mm])

Determination of internal forces from shear force

Concrete compression zone height of compression shear bearing from shear force (units in [N],[mm])

$$x_{c,V} = \max \begin{cases} \dfrac{h_{CSB} + a_{CSB} \cdot \tan\alpha_{SB} \cdot \beta}{2} - \sqrt{\left(\dfrac{h_{CSB} + a_{CSB} \cdot \tan\alpha_{SB} \cdot \beta}{2}\right)^2 - \dfrac{|V^*_{Ed}|}{\beta_{c2,v} \cdot n_{CSB}}} \\ \dfrac{V^*_{Ed} - \min\begin{Bmatrix} n_{CSB} \cdot V_{CSB,d} \\ |F_{cd,M}| \cdot \dfrac{(h_{CSB} - x_{c,M})}{a_{CSB}} \quad [\text{only for } x_{c,M} > \frac{h_{CSB}}{2}] \end{Bmatrix}}{2 \cdot n_{CSB} \cdot \beta_{c1,M} \cdot \tan\alpha_{SB} \cdot \beta} \end{cases} \leq h_{CSB}$$

Halfen Insulated Connection HIT-HP/SP	Annex D6
Structural analysis HIT-HP/SP MVXL	

$$\beta = \left(1 + \frac{A_{TB,\varnothing_{s,2}}}{60 \quad (mm^2) \cdot n_{CSB}}\right)$$ where: $$A_{TB,\varnothing_{s,2}} = n_{TB} \cdot \frac{\pi}{4} \cdot \varnothing_{s,2}{}^2$$ [mm²]

Concrete compressive force $F_{cd,V}$ from shear force:

$-F_{cd,V} = 2 \cdot x_{c,V} \cdot n_{CSB} \cdot \beta_{c1,M}$ (units in [N] and [mm])

$$F_{SB,Hd} = \min \begin{cases} N_{Ed} - \beta \cdot F_{cd,V} \\ \dfrac{V_{Ed}}{\tan\alpha_{SB}} \end{cases} \geq 0$$

Verification of shear bar reinforcement:

$$A_{s,SB,req} = \frac{F_{SB,d}}{f_{yd}}$$ where: $$F_{SB,d} = \frac{F_{SB,Hd}}{\cos \alpha_{SB}}$$

Verification of tension bar reinforcement:

$$A_{s,req} = \frac{|F_{Sd}|}{f_{yd}}$$ where: $$F_{Sd} = N_{Ed} - \min(F_{cd,M}; F_{cd,V}) - F_{SB,Hd}$$

Verification of concrete edge failure

Actions in the design section:

$$F_{c,Ed} = 0{,}25 \cdot |\min(F_{cd,M}; F_{cd,V})| + |V_{Ed,CSB}|$$

where: $$V_{Ed,CSB} = |F_{cd,V}| \cdot \frac{\max(41{,}5; 83 - x_{c,V})}{a_{CSB}}$$

bearing resistance:

$$F_{c,Rd} = a_{R,d} \cdot (f_{ck})^{\frac{1}{4}} \cdot b_{eff}$$ where: $$b_{eff} = n_{CSB} \cdot 137(mm) \leq b_{element}$$

verification: $F_{c,Ed} \leq F_{c,Rd}$

Design moments of the adjacent slabs

See Annex D5.

Halfen Insulated Connection HIT-HP/SP	Annex D7
Structural analysis HIT-HP/SP MVXL	

On-site vertical reinforcement at the front surfaces of the adjacent components

- Balcony side: $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} \end{cases}$
- Main slab side: direct support $A_{sV,min}$

  indirect support $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} + A_{sV,s} \end{cases}$

$A_{sV,min}$, $A_{sV,sp}$ and $A_{sV,s}$ according to Annex D2.

D.1.3.3 HIT-HP/SP ZVX (ZDX)

Strut-and-tie model of Halfen Insulated Connection HIT-HP/SP ZVX

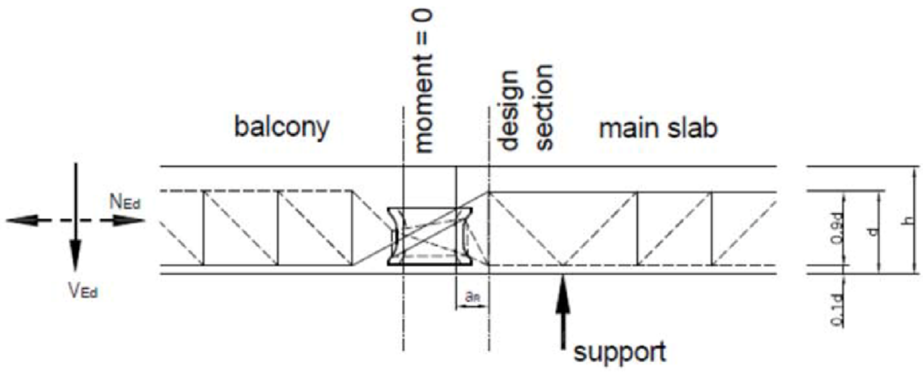


Figure 40: Strut-and-tie model and design section **HIT-HP/SP ZVX** with compression shear bearings (**HIT-HP/SP ZDX** analogue)

The design action V_{Ed} is to be calculated at the defined position of the joint (Moment = 0), the verification has to be performed at the design section.

For taking into account an additional normal force N_{Ed} a determination of equivalent loads is necessary
(shear force V_{Ed} in downward positive, normal force N_{Ed} as tensile force positive)

$$V_{Ed}^{*} = V_{Ed} - \tan\alpha_{SB} \cdot N_{Ed}$$

If there is no additional normal force applies $V_{Ed}^{*} = V_{Ed}$.

Determination of internal force

Concrete compression zone height of compression shear bearings (units in [N] and [mm])

$$x_c = \mathrm{Max}\begin{cases} \left(\frac{h_{CSB} + a_{CSB} \cdot \tan\alpha_{SB}}{2}\right) - \sqrt{\left(\frac{h_{CSB} + a_{CSB} \cdot \tan\alpha_{SB}}{2}\right)^2 - \frac{|V_{Ed}^{*}|}{\beta_{c2,V} \cdot n_{CSB}}} \\ \frac{(V_{Ed}^{*} - n_{CSB} \cdot V_{CSB,d})}{2 \cdot n_{CSB} \cdot \beta_{c1,M} \cdot \tan\alpha_{SB}} \end{cases} \leq h_{CSB}$$

Concrete compressive force F_{cd} (negative)

$$-F_{cd} = 2 \cdot x_c \cdot n_{CSB} \cdot \beta_{c1,M}$$

Verification of required shear bar reinforcement

$A_{s,req} = \frac{F_{SB,d}}{f_{y,d}}$ where: $F_{SB,d} = \frac{-F_{SB,Hd}}{\cos\alpha_{SB}}$

$$F_{SB,Hd} = \min\begin{cases} N_{Ed} - F_{cd} \\ \frac{V_{Ed}}{\tan\alpha_{SB}} \end{cases} \geq 0$$

Verification of concrete edge failure
Actions in the design section:

$$F_{c,Ed} = 0{,}25 \cdot |F_{cd}| + |V_{Ed,CSB}|$$

$$V_{Ed,CSB} = F_{cd} \cdot \frac{\text{Max}(h_{CSB} - x_c; 0{,}5 \cdot h_{CSB})}{a_{CSB}}$$

Bearing resistance:

$F_{c,Rd} = a_{Rd} \cdot (f_{ck})^{\frac{1}{4}} \cdot b_{eff}$ (units in [N] and [mm])

where: $b_{eff} = n_{CSB} \cdot 137[\text{mm}] \leq b_{element}$

Verirfication:

$$F_{c,Ed} \leq F_{c,Rd}$$

Additional design force for the verification of the main slab (moment of displacement)

$$M_{Ed,Decke} = V_{Ed}^{*} \cdot t_{HIT}$$

On-site vertical reinforcement at the front surfaces of the adjacent components

HIT-ZVX

- Balcony side: $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} \end{cases}$
- Main slab side: direct support $A_{sV,min}$

  indirect support $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} + A_{sV,s} \end{cases}$

HIT-ZDX

- Balcony side: $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} + A_{sV,s} \end{cases}$
- Main slab side: direct support $A_{sV,min}$

  indirect support $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,sp} + A_{sV,s} \end{cases}$

$A_{sV,min}$, $A_{sV,sp}$ and $A_{sV,s}$ according to Annex D2.

Halfen Insulated Connection HIT-HP/SP	Annex D10
Structural analysis HIT-HP/SP ZVX (ZDX)	

D.1.3.4 HIT-HP/SP DD

Strut-and-tie model of Halfen Insulated Connection HIT-HP/SP DD

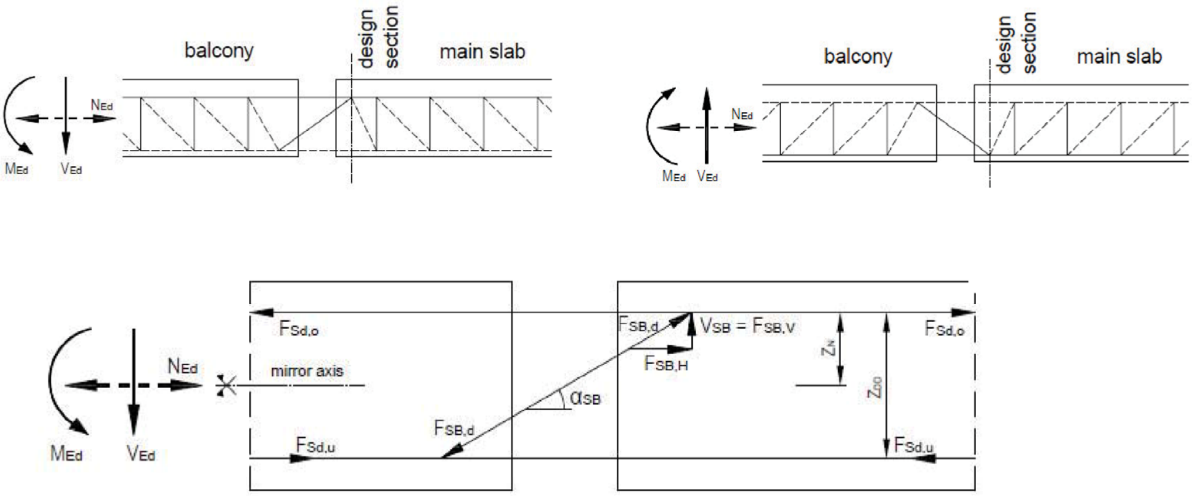


Figure 41: Strut-and-tie model and design section **HIT-HP/SP DD**

For taking into account an additional normal force N_{Ed} a determination of equivalent loads is necessary
(moment M_{Ed} in downward positive, normal force N_{Ed} positive as tensile force)

$M^*_{Ed} = M_{Ed} + N_{Ed} \cdot z_N$ where: z_N = Distance of the normal force to the tension bar level

If there is no additional normal force applies $M^*_{Ed} = M_{Ed}$.

Verification of the ultimate limit state

$$F_{sd,u} = \frac{M^*_{Ed}}{z_{DD}}$$ (compression bars)

$$F_{sd,o} = -\frac{M^*_{Ed}}{z_{DD}} - F_{SB,H} + N_{Ed}$$ (tension bars)

where:

$$F_{SB,H} = \frac{V_{Ed}}{\tan \alpha_{SB}}$$ (horizontal tension force of the shear bars)

$$F_{SB,d} = \frac{V_{Ed}}{\sin \alpha_{SB}}$$ (shear bars)

Halfen Insulated Connection HIT-HP/SP	Annex D11
Structural analysis HIT-HP/SP DD	

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Determination of the tension bar and shear bar reinforcement

$$A_{s,req} = \frac{F_{(..)}}{f_{yd}}$$

Verification of compression bars

$F_{sd,u} \leq F_{sR,d}$ $F_{sR,d}$ according to Annex C1, Table C.2.

On-site vertical reinforcement at the front surfaces of the adjacent components

Balcony and main slab side: $A_{sV} = \text{Max}\begin{cases} A_{sV,min} \\ A_{sV,s} \end{cases}$

$A_{sV,min}$, $A_{sV,s}$ according to Annex D2.

Halfen Insulated Connection HIT-HP/SP	Annex D12
Structural analysis HIT-HP/SP DD	

D.1.4 Serviceability limit states

D.1.4.1 Limitation of crack width

- EN 1992-1-1, section 7.3 shall apply
- at the surface of the joint and the load transmission area is no additional verfication necessary, if the provisions of this European technical assessment are complied with.

D.1.4.2 Limitation of Deformation

When calculating the deflection, the following influencing factors must be taken into account:

- Elastic deformations of the thermal insulation element and the adjacent slab concrete
- temperature expansions

If an additional normal force acts outside the centre of gravity of the connecting element, the moment of displacement must be taken into account.

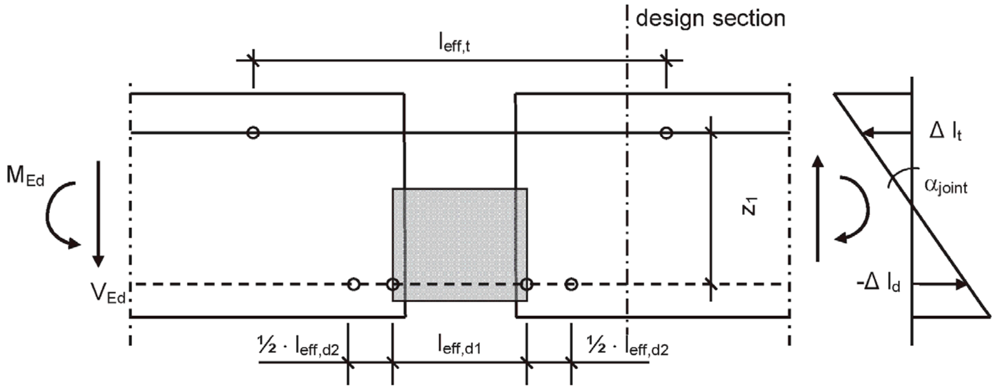

Figure 42: Model to determine the bending deformations in the joint

Angle of rotation in the joint: $\tan \alpha_{joint} = \frac{\Delta l_t - \Delta l_{d1} - \Delta l_{d2}}{z_1} = \frac{\Delta l_t - \Delta l_d}{z_1}$

Internal lever arm HIT-HP/SP MVX: $z_1 = d - \frac{x_c}{2} - 15\text{ mm}$

Tension bar strain for $Ø_{s1} = Ø_{s2}$: $\Delta l_t = \varepsilon_t \cdot l_{eff,t} = \frac{\sigma_{s,t}}{E_s} \cdot l_{eff,t}$

Tension bar strain for $Ø_{s1} > Ø_{s2}$: $\Delta l_t = \varepsilon_{t,ds1} \cdot l_{eff,t,ds1} + \varepsilon_{t,ds2} \cdot l_{eff,t,ds2}$

$$= \frac{\sigma_{s,t,ds1}}{E_{s,ds1}} \cdot l_{eff,t,ds1} + \frac{\sigma_{s,t,ds2}}{E_{s,ds2}} \cdot l_{eff,t,ds2}$$

where: $l_{eff,t,ds1} = 20 \cdot Ø_{s1}$ and $l_{eff,t,ds2} = 280$ mm for HIT-HP
$l_{eff,t,ds1} = 20 \cdot Ø_{s1}$ and $l_{eff,t,ds2} = 320$ mm for HIT-SP

Halfen Insulated Connection HIT-HP/SP

Structural analysis
Limitation of deformation (elements with compression shear bearings)

Annex D13

Compression strain of the compression shear bearing: $\Delta l_{d1} = -\varepsilon_{d1} \cdot l_{eff,d1}$

Compression strain of the adjacent slab concrete: $\Delta l_{d2} = -\varepsilon_{d2} \cdot l_{eff,d2} = \frac{-\alpha_{l,d2}}{E_{cm}}$

Δl_d according to Table D.3.

Concrete strength class	**C20/25**	**C25/30**	**C30/37**	**C35/45**
Δl_d [mm] for HIT-HP MVX / MVXL	0,160	0,187	0,186	0,185
Δl_d [mm] for HIT-SP MVX / MVXL	0,216	0,254	0,253	0,252

Table D.3 Coefficients Δl_d to calculate the deformation of HIT-HP/SP MVX/MVXL with compression shear bearings

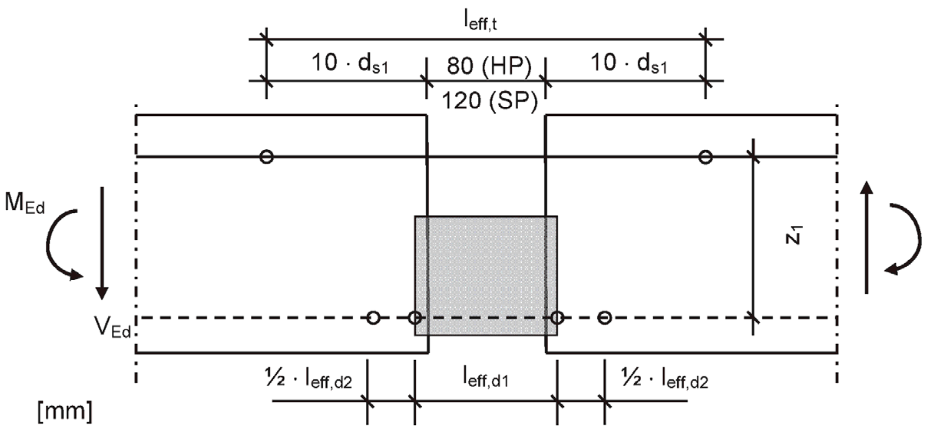

Figure 43: l_{eff} for reinforcing steel B500 NR

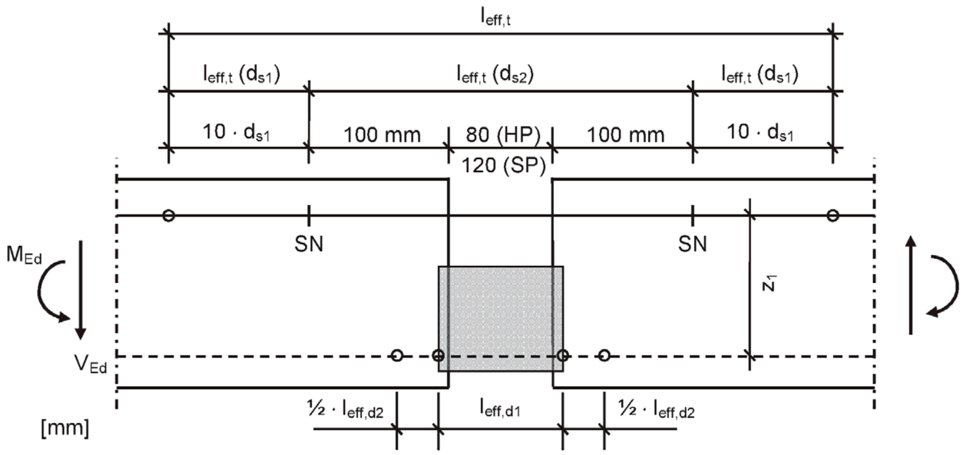

Figure 44: l_{eff} for stainless round steel S 460 and S 690 according to Annex A15

Halfen Insulated Connection HIT-HP/SP	**Annex D14**
Structural analysis Limitation of deformation (elements with compression shear bearings)	

D.1.4.2.2 Elements with steel framework

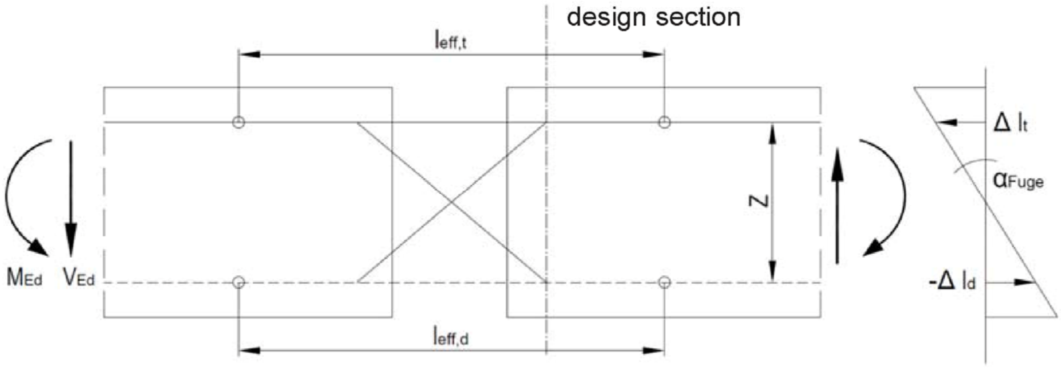

Figure 45: Model to determine the bending deformations in the joint

Angle of rotation in the joint: $\tan\alpha_{joint} = \frac{\Delta l_t - \Delta l_d}{z}$

Determinaton of deformations according to Figure 46 (B500 NR)

tension bar strain for $d_{s1} = d_{s2}$: $\Delta l_t = \varepsilon_t \cdot l_{eff,t} = \frac{\sigma_{s,t}}{E_s} \cdot l_{eff,t}$

compression bar strain for $d_{s1} = d_{s2}$: $\Delta l_d = \varepsilon_d \cdot l_{eff,d} = \frac{\sigma_{s,d}}{E_s} \cdot l_{eff,d}$

Determinaton of deformations according to Figure 47 (stainless round steel)

tension bar strain for $d_{s1} > d_{s2}$:

$$\Delta l_t = \varepsilon_{t,ds1} \cdot l_{eff,t,ds1} + \varepsilon_{t,ds2} \cdot l_{eff,t,ds2}$$

$$= \frac{\sigma_{s,t,ds1}}{E_{s,ds1}} \cdot l_{eff,t,ds1} + \frac{\sigma_{s,t,ds2}}{E_{s,ds2}} \cdot l_{eff,t,ds2}$$

compression bar strain for $d_{s1} > d_{s2}$:

$$\Delta l_d = \varepsilon_{d,ds1} \cdot l_{eff,d,ds1} + \varepsilon_{d,ds2} \cdot l_{eff,d,ds2}$$

$$= \frac{\sigma_{s,d,ds1}}{E_{s,ds1}} \cdot l_{eff,d,ds1} + \frac{\sigma_{s,d,ds2}}{E_{s,ds2}} \cdot l_{eff,d,ds2}$$

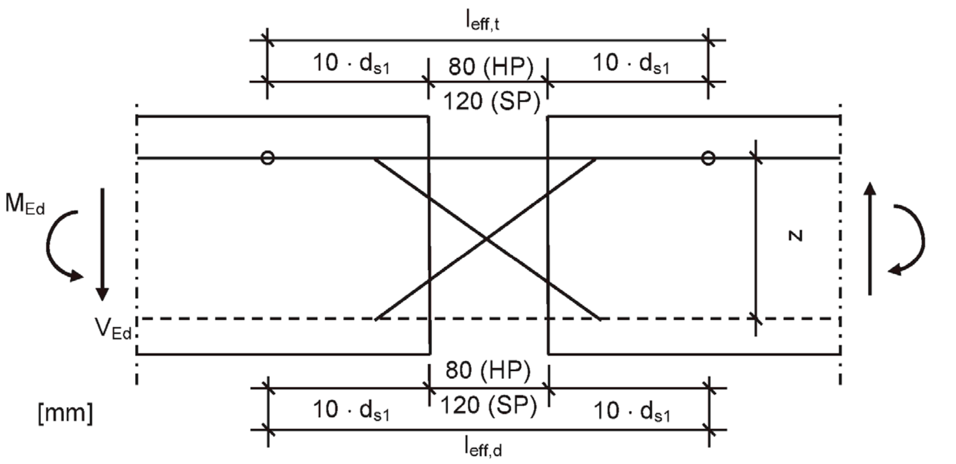

Figure 46: l_{eff} for B500 NR, $d_{s1} = d_{s2}$

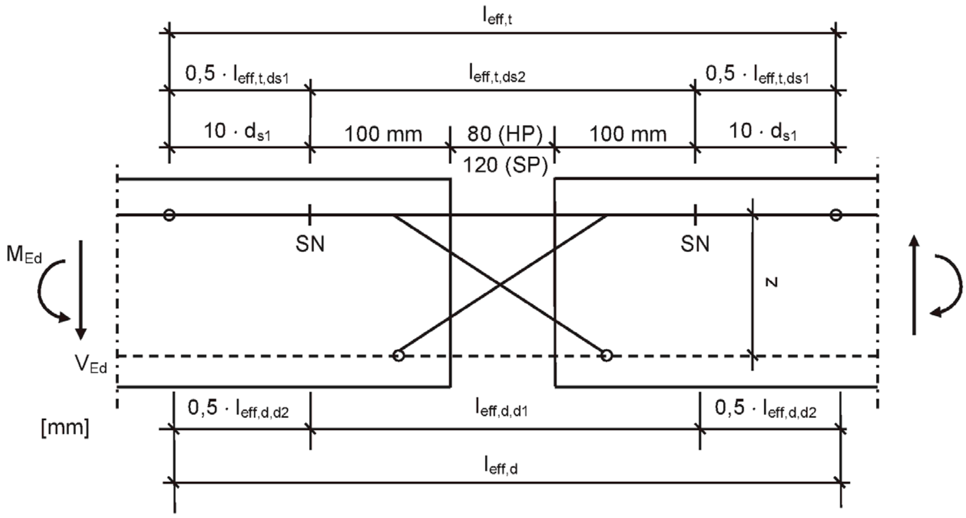

Figure 47: l_{eff} for stainless round steel, $d_{s1} > d_{s2}$

Halfen Insulated Connection HIT-HP/SP	Annex D16
Structural analysis Determination of deformation (elements with steel framework)	