Deutsches Institut für Bautechnik DIBt

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Technical authority granting approvals and permits for construction products and construction techniques

National technical approval / General construction technique permit

Date: 14 Nov 2023

Reference number: I 24-1.15.7-30/21

Number:
Z-15.7-379

Validity
from: **14 November 2023**
to: **14 November 2028**

Applicant:
Leviat GmbH
Liebigstraße 14
40764 Langenfeld, Germany

Subject of decision:
Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs

The subject named above is herewith granted a national technical approval (*allgemeine bauaufsichtliche Zulassung*) / general construction technique permit (*allgemeine Bauartgenehmigung*).
This decision contains nine pages and nine annexes with 15 pages.

Translation authorised by DIBt

I GENERAL PROVISIONS

1 This decision confirms the fitness for use and application of the subject concerned within the meaning of the Building Codes of the federal states (*Landesbauordnungen*).

2 This decision does not replace the permits, approvals and certificates required by law for carrying out construction projects.

3 This decision is granted without prejudice to the rights of third parties, in particular private property rights.

4 Notwithstanding further provisions in the 'Special Provisions', copies of this decision shall be made available to the user and installer of the subject concerned. The user and installer of the subject concerned shall also be made aware that this decision must be made available at the place of use or place of application. Upon request, copies of the decision shall be provided to the authorities involved.

5 This decision shall be reproduced in full only. Partial publication requires the consent of DIBt. Texts and drawings in promotional material shall not contradict this decision. In the event of a discrepancy between the German original and this authorised translation, the German version shall prevail.

6 This decision may be revoked. The provisions contained herein may subsequently be supplemented and amended, in particular if this is required by new technical findings.

7 This decision is based on the information and documents provided by the applicant. Alterations to this basis are not covered by this decision and shall be notified to DIBt without delay.

II SPECIAL PROVISIONS

1 Subject concerned and field of use and application

This approval covers Halfen Iso-ElemenT HIT-HP PI connections, which are composed of an 80 mm thick mineral wool insulation layer and a structurally effective arrangement of steel bars.

In the area of the insulation joint and the directly adjacent steel concrete area, the tensile bars, shear bars and compression bars or compression bearings, making up this arrangement of bars, consist of steel with increased corrosion resistance in a section at least 10 cm in length.

The forces between the connected reinforced concrete slabs are transferred through the screw connection or contact and bond or butt joint to the adjacent members.

The tensile bars and compression bars or compression bearings are used to transfer bending moments. Bars in the insulation layer angled at 30° to 60° in a longitudinal direction are used to transfer the shear forces.

The subject of the permit is the planning, design and execution of load-bearing thermally insulating connecting elements for the post-installed connection of 20 to 50 cm thick reinforced concrete slabs in accordance with DIN EN 1992-1-1 and DIN EN 1992-1-1/NA with a minimum strength class of C20/25 and a density between 2,000 kg/m³ and 2,600 kg/m³ under static or quasi-static loading.

2 Provisions for the construction product

2.1 Properties and composition

2.1.1 Dimensions

The permissible bar diameters for the tensile, compression and shear bars as well as the dimensions the Halfen Iso-ElemenT HIT-HP PI connection are provided in Annex 9.

The shear bars shall not have any bends in the concrete-free area. The bends of the bars shall be started at a distance of at least $0.9 \cdot \phi_{SB}$ inside the concrete.

In the concrete-free area, the tensile and compression bars consist of stainless round steel bars or reinforcing steel B500B NR, and the shear bars consist of reinforcing steel B500B NR or reinforcing steel B500B NR, which is welded to a reinforcing steel B500B part.

The tensile bars are welded to load distribution plates on one connection side and are bolted to load distribution plates via slots on the other connection side to compensate for tolerances (see Annex 2). The screw connection shall either be secured with a lock nut or the recess shall be filled with mortar.

The shear bars shall be welded to steel brackets (see Annex 6, Figure 15).

Regarding the compression bar designs, two different design variants are possible. The compressive loads are transmitted either via the bond of the reinforcing steel or via a compression plate. The compression plate takes the form of a stainless steel anchor plate, which is welded to the compression bar. The compression bars and compression bearings shall have a groove to compensate for tolerances (see Annex 4).

2.1.2 Materials

The following materials shall be used:

Reinforcing steel:	B500B in accordance with DIN 488-1
Stainless steel:	Bars made of stainless steel with corrosion resistance class III in accordance with DIN EN 1993-1-4 and the mechanical properties and surface characteristics in accordance with the data sheet,
	steel bars with corrosion resistance class III in accordance with DIN EN 1993-1-4 of strength class S690 in accordance with DIN EN 10088-5 and the data sheet,
	steel with corrosion resistance class III in accordance with DIN EN 1993-1-4 of minimum strength class S235 in accordance with DIN EN 10088-5 and the data sheet for the steel plates and installation parts,
	threaded steel in accordance with DIN EN ISO 3506-1 of strength A4-80,
	nuts in accordance with DIN EN ISO 3506-2 of strength A4-80
Insulation:	Mineral wool in accordance with DIN EN 13162 and the data sheet
Plastic for the casings:	Material in accordance with the data sheet

The concrete of the adjacent members shall at least correspond to strength class C20/25. For external members, the concrete strength class shall be at least C25/30.

2.2 Manufacture, packaging, transport, storage and marking

2.2.1 Manufacture of welded connections

For welded connections, the specifications of national technical approval no. Z-30.3-6 in conjunction with DIN EN ISO 17660-1 apply.

2.2.2 Packaging and marking

The manufacturer shall mark every packaging unit of the Halfen Iso-ElemenT HIT-HP PI connections in a durable and easily legible manner, e.g. using a sticker bearing the national conformity mark (*Ü-Zeichen*) in accordance with the Conformity Marking Ordinances (*Übereinstimmungszeichen-Verordnungen*) of the federal states. The mark shall only be applied if the requirements given in Section 2.3 'Confirmation of conformity' are met.

In addition, the mark shall include at least the following information:

- decision no. (Z-15.7-379),
- type designation.

Clear information regarding the installation of the connections shall be attached to every Halfen Iso-ElemenT HIT-HP PI connection. The manufacturer shall supply an installation manual with every delivery.

2.3 Confirmation of conformity

2.3.1 General

The manufacturer shall confirm for each manufacturing plant that the Halfen Iso-ElemenT HIT-HP PI construction product complies with the provisions of this national technical approval by way of a declaration of conformity based on factory production control and a certificate of conformity issued by a certification body recognised for these purposes as well as on regular external surveillance carried out by a recognised inspection body in accordance with the following provisions: To issue the certificate of conformity and for external surveillance including the associated product testing, the applicant of the construction product shall use a certification body and an inspection body recognised for these purposes.

The declaration of conformity shall be submitted by the manufacturer through marking of the construction products with the national conformity mark including statement of the intended use.

The certification body shall send a copy of the certificate of conformity issued by it to DIBt.

2.3.2 Factory production control

A factory production control system shall be set up and implemented in each manufacturing plant. Factory production control is understood to be continuous surveillance of production by the manufacturer to ensure that the manufactured construction products satisfy the provisions of this national technical approval.

The factory production control shall at least include the following measures:

– Verification of the starting material and the components:

Only building materials for which the verification of conformity in accordance with the applicable standards and approvals has been provided and which are marked in a corresponding manner or which are monitored and tested in accordance with the provisions of this decision shall be used for the Halfen Iso-ElemenT HIT-HP PI connection.

– Checks and tests to be performed during manufacture:

The properties of the bars shall be tested in accordance with the applicable approvals, standards and test plans.

– Verifications and tests to be carried out on the finished construction product:

The dimensions of the construction product Halfen Iso-ElemenT HIT-HP PI connection as well as the execution and after-treatment of the welded connections shall be verified for every connection.

The results of factory production control shall be recorded and evaluated. The records shall at least include the following information:

– designation of the construction product or the starting material and the components,
– type of check or test,
– date of manufacture and testing of the construction product or the starting material or the components,
– results of the checks and tests as well as, if applicable, comparison with the requirements,
– signature of the person responsible for factory production control.

The records shall be kept for at least five years. They shall be submitted to DIBt and the competent supreme building authority upon request.

If the test result is unsatisfactory, the manufacturer shall immediately take the necessary measures to resolve the defect. Construction products which do not meet the requirements shall be handled in such a way that they cannot be confused with compliant products. After the defect has been remedied, the relevant test shall be repeated immediately - where technically feasible and necessary to show that the defect has been eliminated.

2.3.3 External surveillance

The plant and the factory production control system shall be inspected regularly, i.e. at least twice a year, by means of external surveillance at each manufacturing plant. Initial type-testing of the construction product Halfen Iso-ElemenT HIT-HP PI connection shall be carried out within the scope of external surveillance and samples for random testing shall also be taken. Sampling and testing shall be the responsibility of the recognised inspection body.

Within the scope of review of factory production control, tests shall be carried out in accordance with the test plans and the results shall be evaluated and compared with the requirements contained therein.

The results of certification and external surveillance shall be kept for at least five years. They shall be presented by the certification or inspection body to DIBt and the competent supreme building authority upon request.

3 Provisions for planning, design and execution

3.1 Planning and design

DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA, DIN EN 1993-1-1 in conjunction with DIN EN 1993-1-1/NA and DIN EN 1993-1-4 in conjunction with DIN EN 1993-1-4/NA as well as the following provisions shall apply to planning and design.

3.1.1 General

Depending on the type, Halfen Iso-ElemenT HIT-HP PI connections may be used to transfer bending moments and / or shear forces. The minimum strength class of the reinforced normal weight concrete members to be connected shall be C20/25 (C25/30 for external members).

The connected reinforced concrete structure shall be divided by joints that are to be arranged in accordance with Section 3.2.2 to decrease thermal stress.

The stresses occurring in the reinforced concrete structure are transferred locally via the tensile and compression members in the joint and are transmitted into the connected slabs via a load introduction area. Structural verification of the transmission of the forces shall be carried out. Verification of the force transmission between the compression bar with anchor plate and the adjacent concrete shall be carried out in accordance with Annex 7, pages 3 and 4.

At least two Halfen Iso-ElemenT HIT-HP PI connection elements shall be applied for every construction to be connected. The design rules in accordance with Annex 9 shall be complied with. Loading of the connections due to local torsion moments shall be excluded.

3.1.2 Resistance to fire

This decision does not verify the fitness for use of the Halfen Iso-ElemenT HIT-HP PI connection in members for which fire resistance requirements apply.

3.1.3 Durability and corrosion protection

The requirements for durability are specified in DIN EN 1992-1-1, Section 4. The minimum concrete strength classes as well as the minimum concrete cover depending on the respective environmental conditions shall be complied with in accordance with DIN EN 1992-1-1. Corrosion protection is ensured by compliance with the concrete cover of the on-site reinforcement in accordance with DIN EN 1992-1-1 and by using the materials in accordance with this decision as well as the materials used on-site.

3.1.4 Design

3.1.4.1 General

Structural verification shall be performed for each individual case. For this purpose, type-tested design tables may be used.

The truss model in accordance with Annex 7 shall be taken as a basis for determining the internal forces and the placement of the reinforcement. The internal forces M_{Ed} and V_{Ed} shall be applied in the design section in accordance with Annex 7 to design the Halfen Iso-ElemenT HIT-HP PI connection.

The internal forces shall only be calculated through the linear-elastic analysis. Analysis with redistribution, a plastic approach to analysis and non-linear analysis shall not be used.

DIN EN 1992-1-1, supplemented by the provisions contained in this decision, shall apply in the introduction area of the tensile bars into the concrete and the adjacent reinforced concrete area.

The tensile bars and compression bars shall be designed for the forces calculated in accordance with the design model for Halfen Iso-ElemenT HIT-HP PI in accordance with Annex 7.

The connected reinforced concrete slab shall be designed in accordance with DIN EN 1992-1-1 and DIN EN 1992-1-1/NA for the internal forces M_{Ed} and V_{Ed}.

The connected steel parts shall be designed in accordance with DIN EN 1993-1-1 and DIN EN 1993-1-1/NA for the internal forces M_{Ed} and V_{Ed}.

3.1.4.2 Specifications for the insulation joint and the load introduction area for ultimate limit states

3.1.4.2.1 Verification of the tensile bars

The verification shall be performed in accordance with Annex 7. The strengths and partial safety factors given in Table 1 shall be used as a basis for the design. Higher values shall not be applied, even if steels of higher strength classes are used.

Table 1: Yield strengths and partial safety factors for the bars used

Bar made from:	Calculated value of the characteristic yield strength in [N/mm²]	Partial safety factor
B500B	500	1.15
B500B NR	500	1.15
Stainless round steel in accordance with Z-30.3-6 or data sheet (S690)	690	1.10

3.1.4.2.2 Verification of compression bars

The verification of the compressive load which the compression bars can resist as well as the verification for the introduction of the compressive stresses into the adjacent concrete shall be performed using the design model for Halfen Iso-ElemenT HIT-HP PI specified in Annex 7. The splitting forces in the load introduction area of the adjacent slab shall be verified in the longitudinal direction and transverse direction as a result of partially loaded areas, and a corresponding reinforcement shall be designed.

Verification of tensile and fatigue strength for axial forces and bending of bars, resulting from deformation due to temperature differences of the members to be connected in terms of Section 3.1 of national technical approval Z-30.3-6 do not need to be provided. These verifications are deemed to have been provided within the approval procedure by limiting the joint spacings in the external members in accordance with Section 3.2.2.

3.1.4.2.3 Anchorage lengths and lap joints of the bars leading through the insulation layer

The tensile and compression bars shall be connected with the tensile and compression bars of adjacent reinforced concrete members.

The shear bars shall be overlapped with $l_0 = 1.3\ l_{bd} \geq 1.3\ l_{b,min}$ in accordance with DIN EN 1992-1-1 and DIN EN 1992-1-1/NA, equation (8.4) (see Annex 5) with the tensile reinforcement of the reinforced concrete members to be connected, unless higher values result from DIN EN 1992-1-1 and DIN EN 1992-1-1/NA, equation (8.10).

3.1.4.3 Specifications for the insulation joint and the load introduction area for serviceability limit states

For crack width control, DIN EN 1992-1-1 and DIN EN 1992-1-1/NA, Clause 7.3.1, shall apply. An additional verification does not need to be provided at the frontal side of the joint or in the load introduction area if the provisions of this decision are complied with.

In the calculation of the vertical deformations at the leading edge of the steel construction, the deformations resulting from the torsion in the Halfen Iso-ElemenT HIT-HP PI connection shall be considered for the cantilever connection. The verification of the deformations shall be provided under the quasi-permanent combination of actions in accordance with Annex 8.

3.2 Execution

3.2.1 General

The Halfen Iso-ElemenT HIT-HP PI connections shall be installed in accordance with the installation instructions supplied by the manufacturer.

The Halfen Iso-ElemenT HIT-HP PI connections shall be protected against moisture penetration during storage, assembly and installation.

The executing company shall provide a declaration of conformity in accordance with Section 16a(5) in conjunction with Section 21(2) of the Model Building Code to confirm conformity of the construction technique with the general construction technique permit included in this decision.

3.2.2 Spacings and joint spacings

The spacings and edge distances of the bars in accordance with Annex 9 shall be observed.

Expansion joints in accordance with Annex 9, Table A7, shall be placed at a right angle to the insulation layer in the external reinforced concrete members to limit thermal stress.

3.2.3 Detailing

In the reinforced concrete slabs, the minimum concrete cover in accordance with DIN EN 1992-1-1 shall be complied with. This applies to tensile and compression bars, the transverse reinforcement or, if present, the installation reinforcement.

The reinforcement of the connected concrete structures shall be placed as closely to the insulation layer as possible but in consideration of the required concrete cover in accordance with DIN EN 1992-1-1.

The following standards, approvals and references are referred to in this decision:

– DIN 488-1:2009-08 Reinforcing steels – Part 1: Grades, properties, marking

– DIN EN 1992-1-1:2011-01 + A1:2015-03
Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004+A1:2014 **and**

DIN EN 1992-1-1/NA:2013-04+A1:2015-12
National Annex – Nationally determined parameters – Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings

– DIN EN 1993-1-1:2010-12 + A1:2014-07
Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2005+A1:2014 **and**
DIN EN 1993-1-1/NA:2018-12 National Annex – Nationally determined parameters – Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings
– DIN EN 1993-1-4:2015-10 + A2:2021-02
Eurocode 3: Design of steel structures – Part 1-4: General rules – Supplementary rules for stainless steels; German version EN 1992-1-1:2006+A2:2020 **and**
DIN EN 1993-1-4/NA:2020-11 National Annex – Nationally determined parameters – Eurocode 3: Design of steel structures – Part 1-4: General rules – Supplementary rules for stainless steels
– DIN EN 10088-5:2009-07 Stainless steels – Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes; German version EN 10088-5:2009
– DIN EN 13162:2015-04 Thermal insulation products for buildings – Factory made mineral wool (MW) products – Specification; German version EN 13162:2012+A1:2015
– DIN EN ISO 3506-1:2020-08 Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs with specified grades and property classes (ISO 3506-1:2009); German version EN ISO 3506-1:2020
– DIN EN ISO 3506-2:2020-08 Mechanical properties of corrosion-resistant stainless steel fasteners – Part 2: Nuts with specified grades and property classes (ISO 3506-2:2009); German version EN ISO 3506-2:2020
– DIN EN ISO 17660-1:2006-12 Welding – Welding of reinforcing steel – Part 1: Load-bearing welded joints (ISO 15660-1:2006); German version EN ISO 17660-1:2006
– Approval No. Z-30.3-6 Products, structural components and fasteners made of stainless steels, dated 20 April 2022
– The test plan is deposited with DIBt and the body used for external surveillance.
– The data sheet is deposited with DIBt and the body used for external surveillance.

Dipl.-Ing. Beatrix Wittstock
Head of Section

Drawn up by
Kisan

Type HIT-HP PI

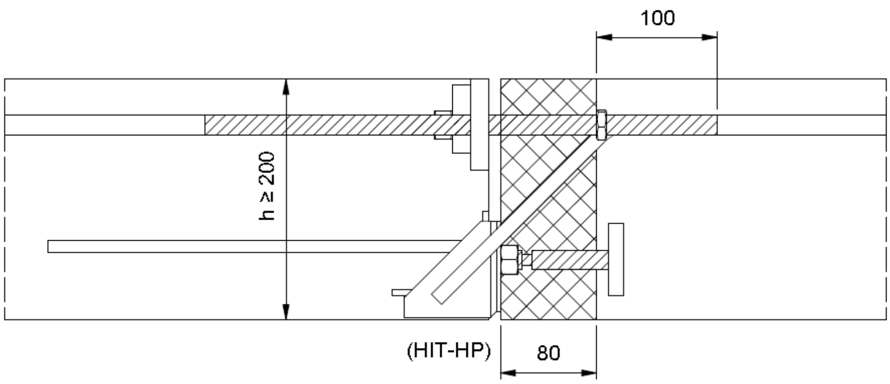


Fig. 1: Halfen Iso-ElemenT **HIT-HP PI** with compression bearing
Connection for torque and / or shear force

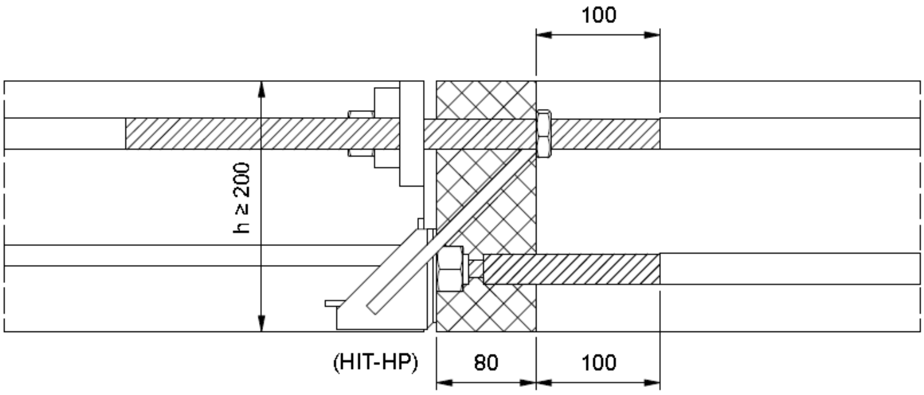


Fig. 2: Halfen Iso-ElemenT **HIT-HP PI** with compression bar
Connection for torque and / or shear force

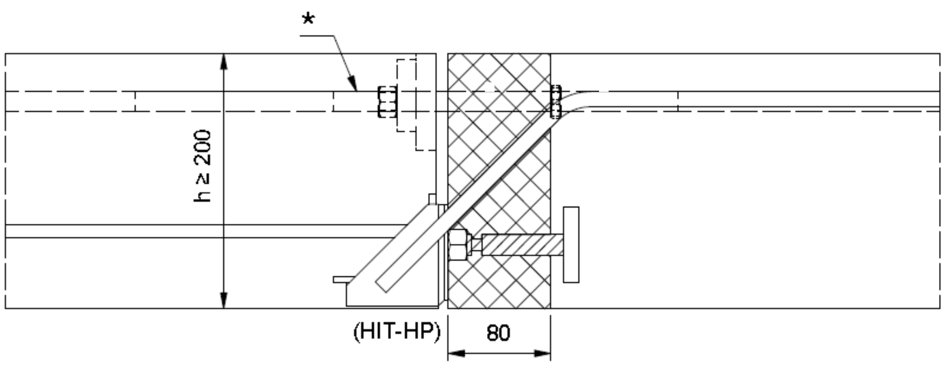


Fig. 3: Halfen Iso-ElemenT **HIT-HP PI** with compression bearing
Connection for shear force
*) Structurally, two securing points in the tension area per balcony element

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	**Annex 1**
Installed condition	**Page 1 / 1**

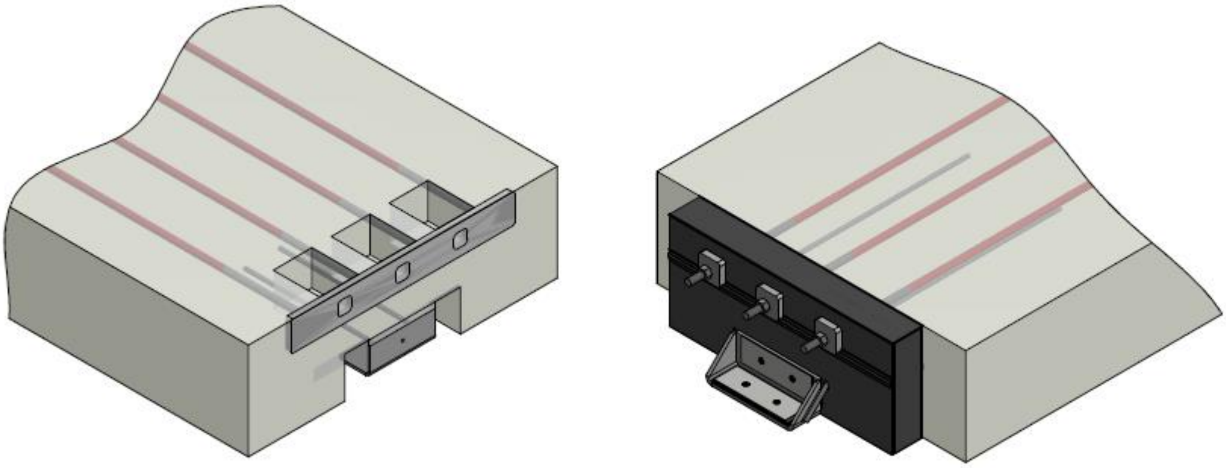


Fig. 4: Halfen Iso-ElemenT **HIT-HP PI**, balcony-side installation

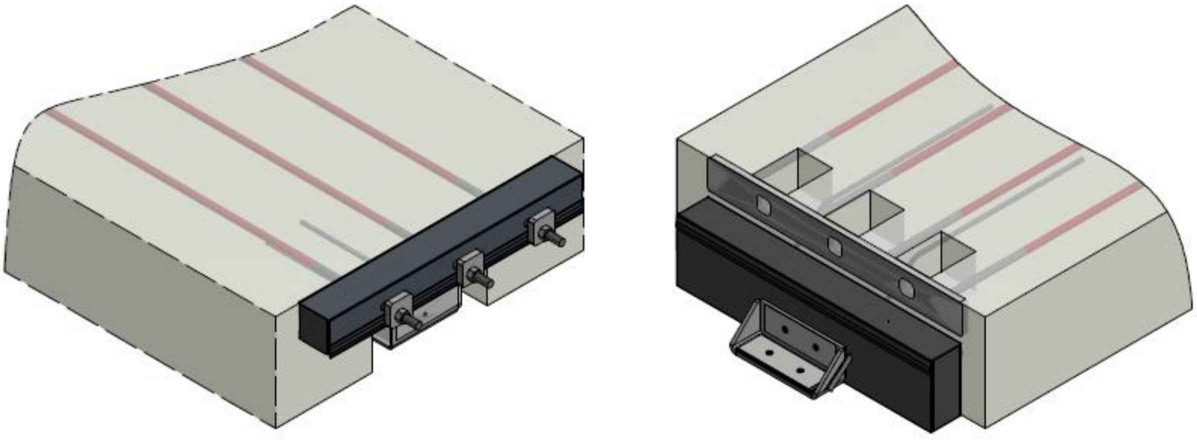


Fig. 5: Halfen Iso-ElemenT **HIT-HP PI**, slab-side installation

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	**Annex 2**
Installation variants	**Page 1 / 3**

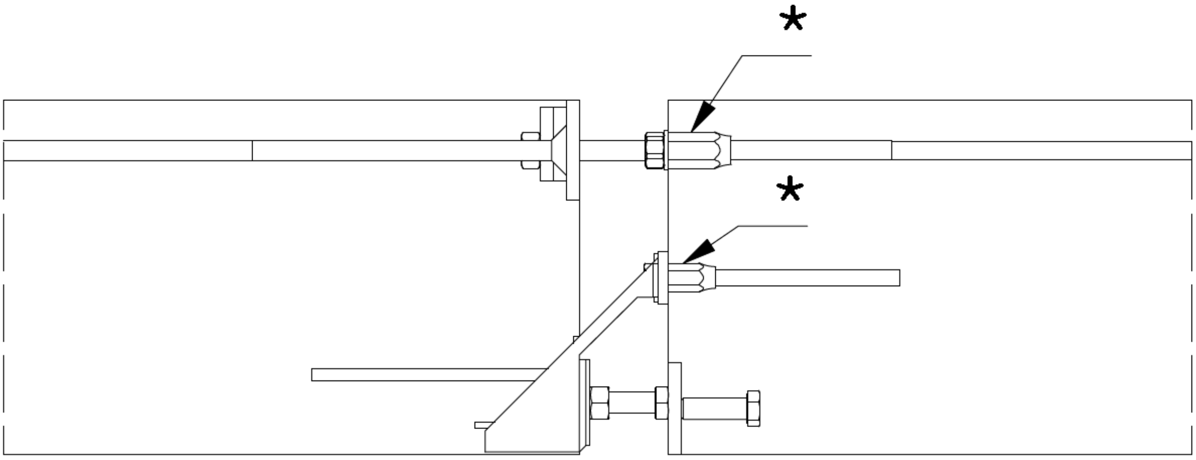


Fig. 6: Halfen Iso-ElemenT **HIT-HP PI,** variant with couplers
*) Couplers in accordance with approval Z-21.8-1974

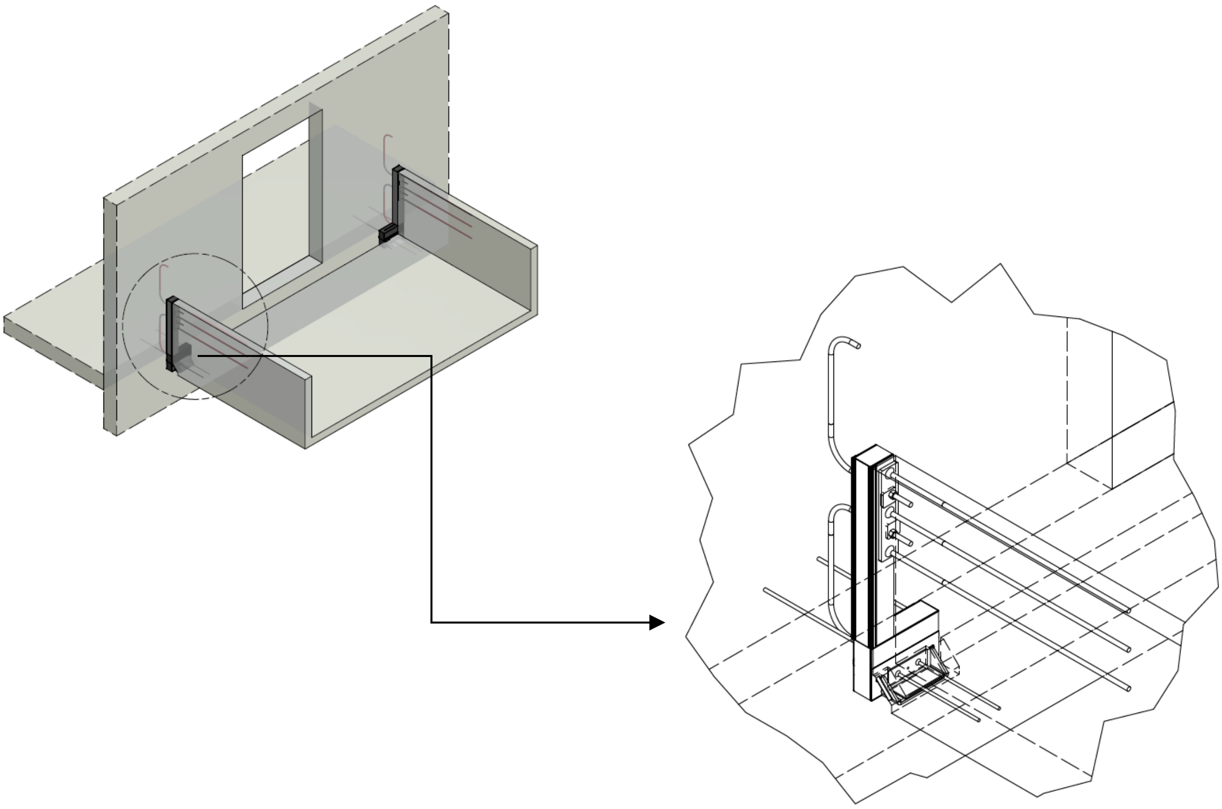


Fig. 7: Halfen Iso-ElemenT **HIT-HP PI,** arrangement in balcony troughs

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	**Annex 2**
Installation variants	**Page 2 / 3**

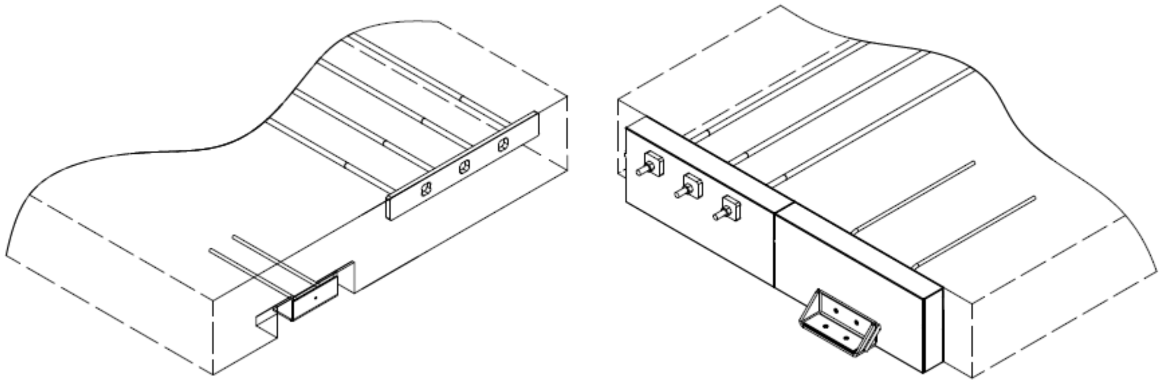


Fig. 8: Halfen Iso-ElemenT **HIT-HP PI** with compression bearings, longitudinally offset pressure and tension areas

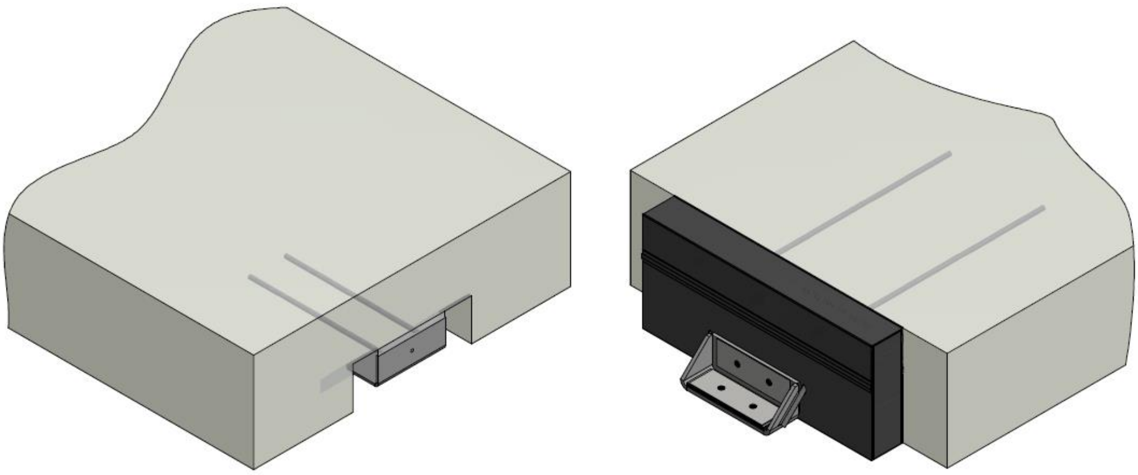


Fig. 9: Halfen Iso-ElemenT **HIT-HP PI** – shear force connection

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	**Annex 2**
Installation variants	**Page 3 / 3**

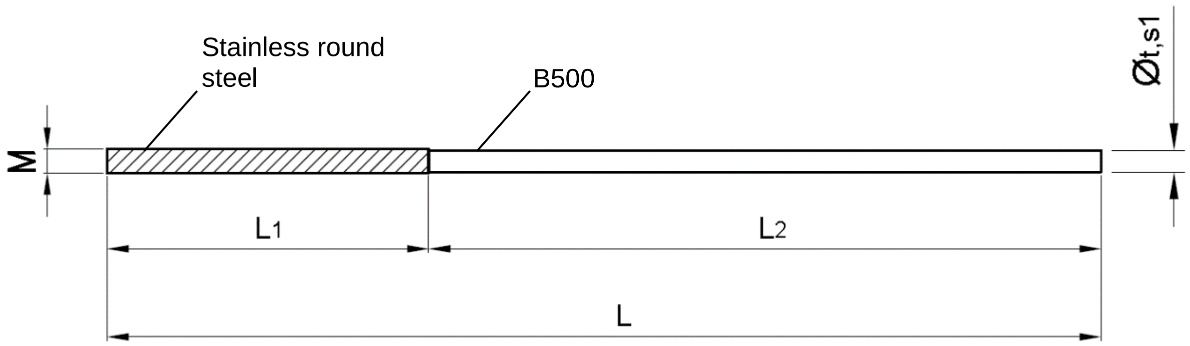


Fig. 10: Standard design made of stainless round steel S690 or A4-80 (L_1 as partial thread or full thread) with B500

Stainless round steel S690 or A4-80	Reinforcing steel B500 $Ø_{t,s1}$ [mm]
M12	12
M14	14
M16	16
M20	20
M24	25

Table A1: Diameter combinations HIT-HP PI tensile bar

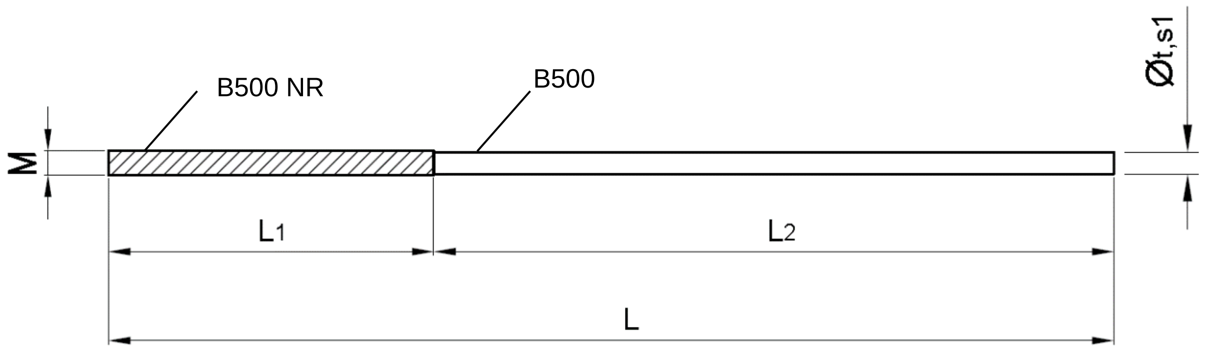


Fig. 11: Variant made of B500 NR (L_1 as partial thread or full thread) with B500 with $Ø_{t,s1}$ for both parts

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	Annex 3
Tensile bar variants	Page 1 / 1

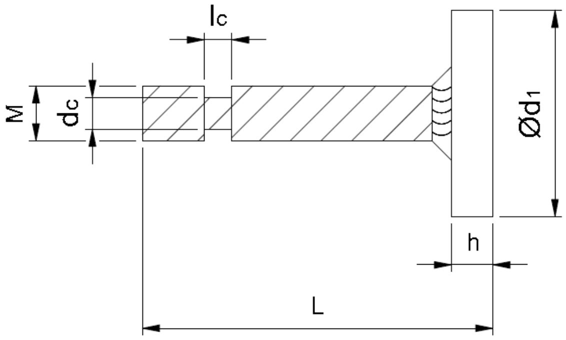


Fig. 12: Standard design for compression bearing made of stainless round steel S690 or A4-80 or B500 NR, each with partial thread or full thread with welded-on anchor plate S235

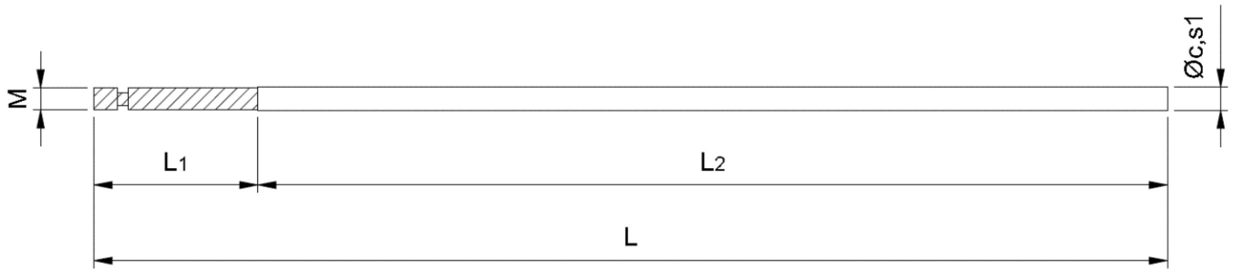


Fig. 13: Compression bar made of stainless round steel S690 or A4-80 or B500 NR (L_1 as partial thread or full thread) with B500

Stainless round steel S690 or A4-80	Reinforcing steel B500 $Ø_{c,s1}$ [mm]
M16	16
M20	20

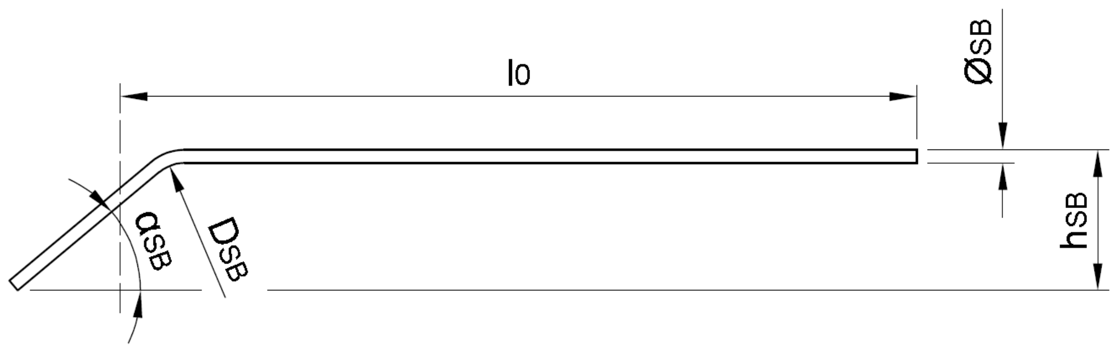
Table A2: Diameter combinations HIT-HP PI compression bar

Halfen Iso-ElementT HIT-HP PI for the post-installed connection of reinforced concrete slabs

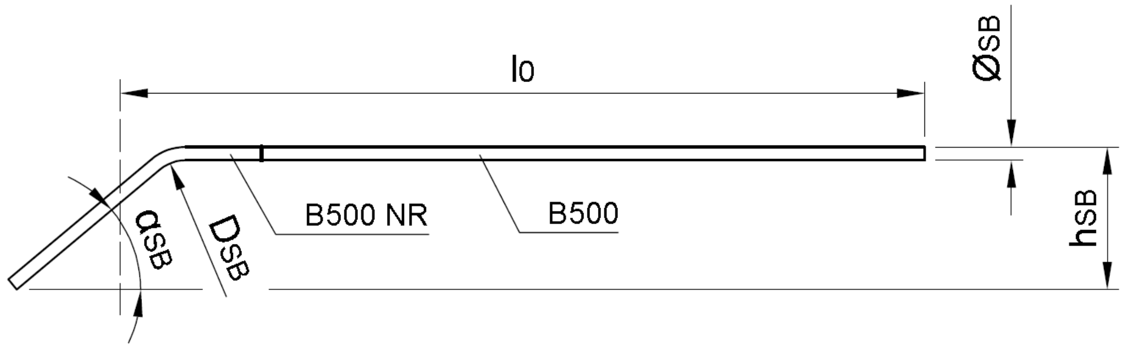
Compression bar and compression bearing variants

Annex 4

Page 1 / 1



a) Stainless reinforcing steel B500 NR design



b) Stainless reinforcing steel B500 NR with B500 design

Fig. 14: Halfen-Iso-ElemenT HIT-HP/SP shear bar variants

$Ø_{SB}$ **(B500B, B500 NR)**	**D_{SB} Mandrel diameter**	**α_{SB} [°]**
6 mm – 14 mm	3.5 $Ø_{SB}$	30 – 60

Table A3: HIT-HP PI shear bar variants

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	**Annex 5**
Shear bar variants	**Page 1 / 1**

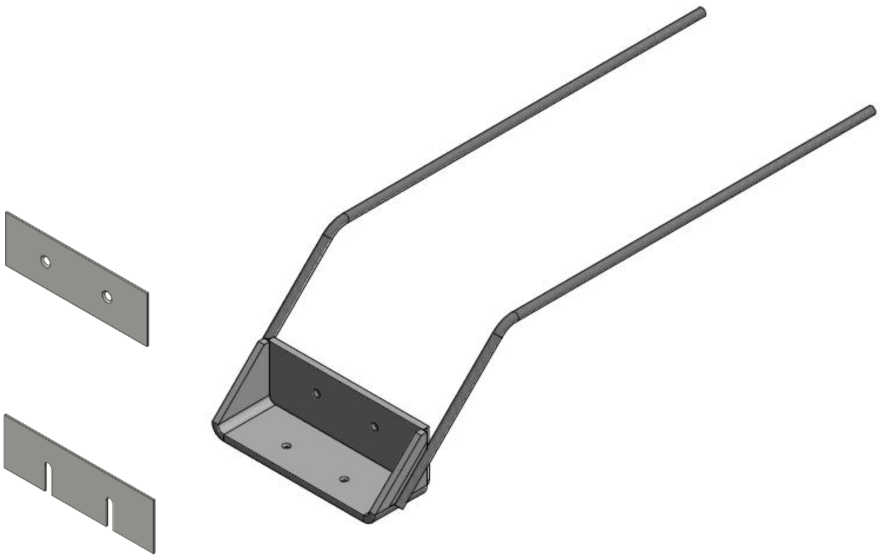


Fig. 15: Steel bracket, slab side with associated tolerance plates

Fig. 16: Tensile bar plate with tensile bars

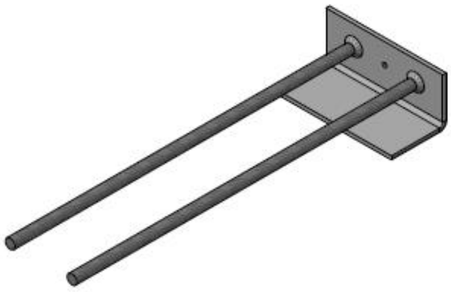


Fig. 17: Support bracket in balcony

Halfen Iso-ElemenT HIT-HP PI for the post-installed connection of reinforced concrete slabs	Annex 6
Schematic representation of embedded steel elements	Page 1 / 1

Deutsches Institut für Bautechnik DIBt

Halfen Iso-Element HIT-PI truss model

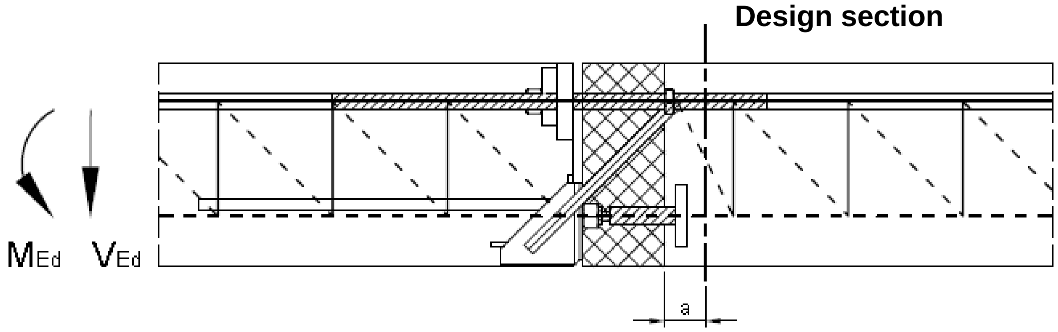


Fig. 18: **HIT-HP PI** truss model

Determining the actions for HIT-HP PI

$$E_d = \gamma_G \cdot E_{Gk} + \gamma_Q \cdot E_{Qk}$$

Determining the internal forces

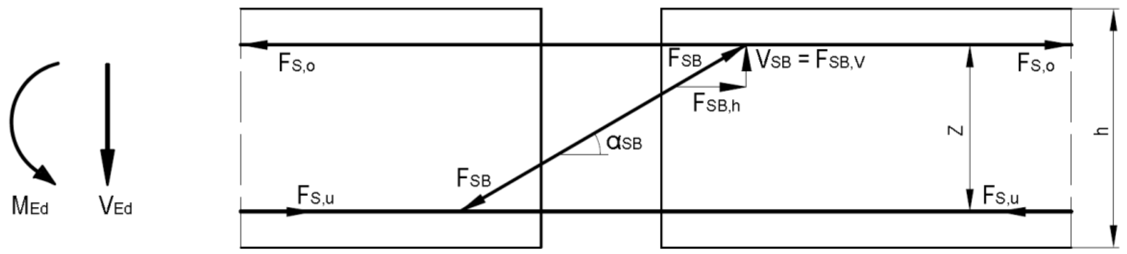


Fig. 19: Internal forces for **HIT-HP PI**

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Verification of ultimate limit state for HIT-HP PI

Tensile / compressive load in upper chord / lower chord:

$$F_{sd,u} = \frac{M_{Ed}}{z}$$

$$F_{sd,o} = \frac{M_{Ed}}{z} - F_{SB,h}$$

$$F_{SB,h} = \frac{V_{Ed}}{\tan \alpha_{SB}}$$

where: $z = h - c_{nom,o} - c_{nom,u} - \varnothing_{t,s1}/2 - \varnothing_{c,s1}/2$

DETERMINING THE REQUIRED TENSILE BAR REINFORCEMENT:

$$A_{s,rqd} = \frac{F_{sd,o}}{f_{y,d}} \leq A_{s,act}$$

VERIFICATION OF THE COMPRESSION MEMBERS:

$$F_{sd,u} \leq n \cdot F_{s,Rd}$$

where: $F_{s,Rd}$ in accordance with Table A4
n (number of compression members)

DESIGN VALUES $F_{s,Rd}$ FOR BUCKLING LOADS FROM COMPRESSION BARS IN THE JOINT

Bar diameter [mm] or thread	Material [-]	$F_{s,Rd}$ [kN per bar/bearing]
M16	Stainless round steel S690 or A4-80	87.4
M20	Stainless round steel S690 or A4-80	136.6

Table A4: Buckling loads for pressure elements depending on the material

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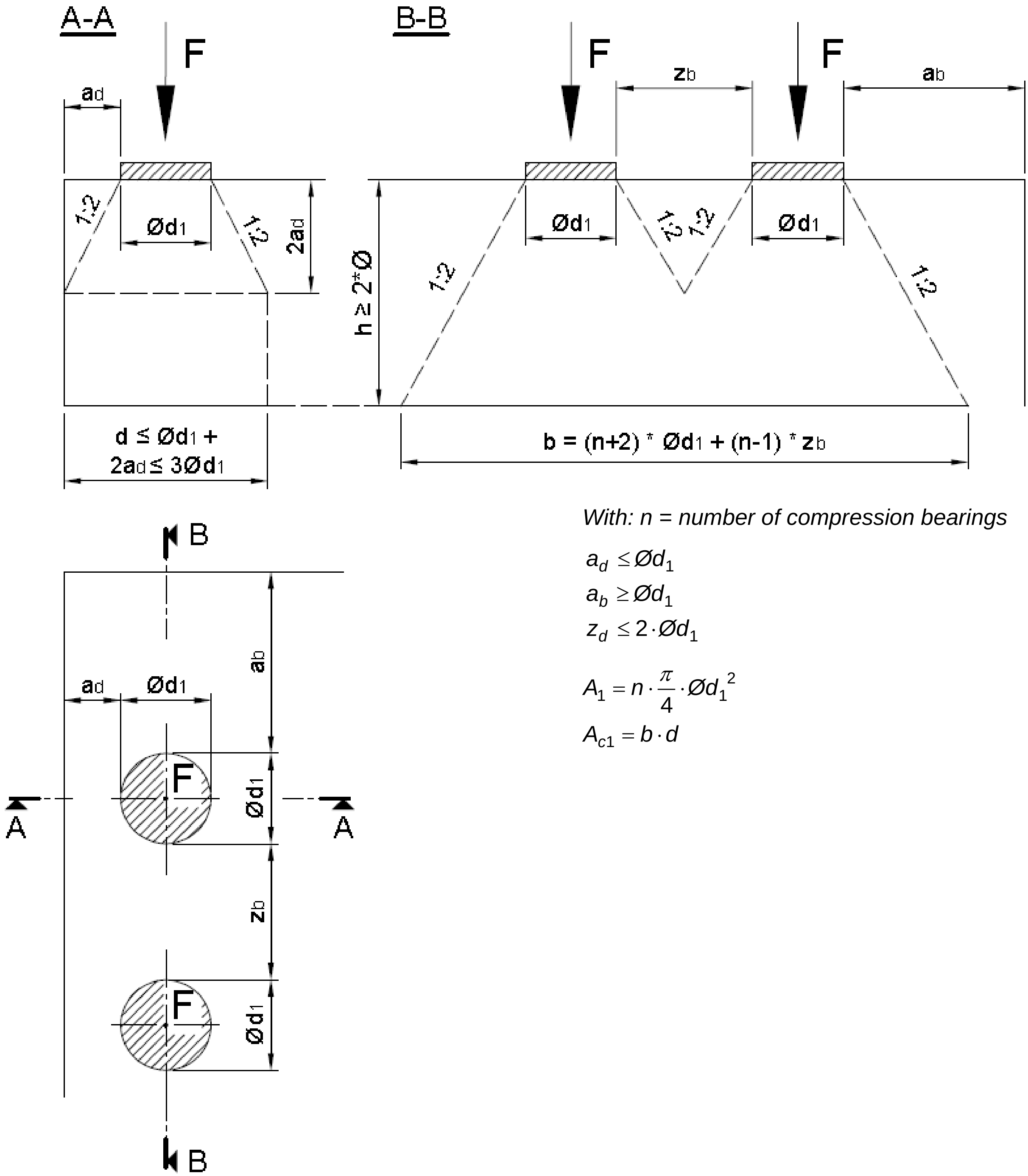
VERIFICATION OF CONCRETE COMPRESSION WITH LOADING POINT VIA ANCHOR BOLT OR ANCHOR PLATE

The verification of concrete compression with loading point via anchor bolt or anchor plate with determination of the design distribution area A_{c1} in accordance with Fig. 20.



With: n = number of compression bearings

$a_d \leq Ød_1$

$a_b \geq Ød_1$

$z_d \leq 2 \cdot Ød_1$

$A_1 = n \cdot \frac{\pi}{4} \cdot Ød_1^2$

$A_{c1} = b \cdot d$

Fig. 20: Determination of the design distribution area A_{c1} according to Leonhardt (lecture on solid construction – Part 2: Special design cases in reinforced concrete construction)

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$$F_{c,Rd} = 8.7 \cdot (f_{ck})^{\frac{1}{4}} \cdot A_1 \cdot \sqrt{\frac{A_{c1}}{A_1}} \leq 26 \cdot A_1 \cdot (f_{ck})^{\frac{1}{4}}$$

With: f_{ck} Concrete compressive strength in accordance with DIN EN 1992-1-1

$$F_{s,ud} \leq F_{c,Rd}$$

SHEAR STRESS:

$$F_{SB,d} = \frac{V_{Ed}}{\sin \alpha_{SB}}$$

With: α_{SB} Angle of the shear bars ($30° \leq \alpha_{SB} \leq 60°$)

DETERMINING THE REQUIRED REINFORCEMENT:

$$A_{s,SB,rqd} = \frac{F_{SB,d}}{f_{y,d}}$$

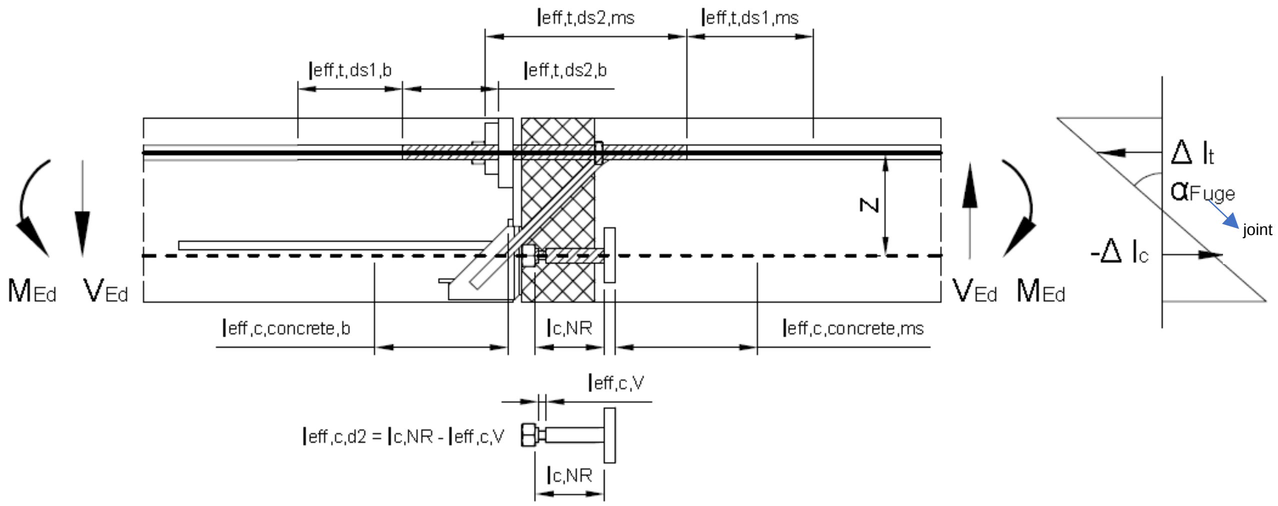

Fig. 21: Model for determining the bending deformations in the joint (German: Fuge)

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

Determining the elongation lengths

Member	l_{eff}
Tensile bar: Stainless round steel S690 or A4-80 with B500	$l_{eff,t,TB} = l_{eff,t,ds2,ms} + l_{eff,t,ds1,ms}$ $l_{eff,t,ds2,ms}$ (see Fig. 21) $l_{eff,t,ds1,ms} = l_{eff,B500} = 10*Ø_{t,s1}$
Tensile bars on tensile-bar plate: B500 NR with B500	$l_{eff,t,TBP} = l_{eff,t,ds2,b} + l_{eff,t,ds1,b}$ $l_{eff,t,ds2,b}$ (see Fig. 21) $l_{eff,t,ds1,b} = l_{eff,B500} = 10*Ø_{t,s1}$
Compression bearing:	$l_{eff,c} = l_{eff,c,d2} + l_{eff,c.V}$ $l_{eff,c,d2} = l_{c,NR} - l_{eff,c,V}$
Compression bar: Stainless round steel S690 or A4-80 with B500	$l_{eff,c} = l_{eff,c,d2} + l_{eff,c.V} + l_{eff,d,ds1}$ $l_{eff,c,d2} = l_{c,NR} - l_{eff,c,V}$ $l_{eff,c,ds1} = l_{eff,B500} = 10*Ø_{c,s1}$

Table A5: l_{eff} for tensile bar / compression bar variants

Determining bending in the tensile-bar plate:
Elongation of the tensile bars and bending of the tensile-bar plate shall be accounted for. Bending of the tensile-bar plate can be determined analytically or with FE programmes. It is assumed that bending within the free length between the tensile bars is decisive.

$\Delta l_{t,plate} = w_{TBP,centre}$

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Tension zone elongation:

$$\Delta l_t = \Delta l_{t,NR,b} + \Delta l_{t,B500,b} + \Delta l_{t,NR,ms} + \Delta l_{t,B500,ms} + \Delta l_{t,plate}$$

$$= \frac{\sigma_{s,t,ds2,b}}{E_{s,ds2,b}} \cdot l_{eff,t,ds2,b} + \frac{\sigma_{s,t,ds1,b}}{E_{s,ds1,b}} \cdot l_{eff,t,ds1,b} + \frac{\sigma_{s,t,ds2,ms}}{E_{s,ds2,ms}} \cdot l_{eff,t,ds2,ms} + \frac{\sigma_{s,t,ds1,ms}}{E_{s,ds1,ms}} \cdot l_{eff,t,ds1,ms} + w_{TBP,centre}$$

With: E_s = 200,000 N/mm² for B500

E_s = 170,000 N/mm² for S690 or A4-80

E_s = 160,000 N/mm² for B500 NR

Compression zone strain (when using compression bearings):

$$\Delta l_c = \Delta l_{c,concrete,b} + \Delta l_{c,concrete,ms} + \Delta l_{c,NR} + \Delta l_{c,v}$$

$$= F \cdot \left(\frac{1}{\beta_b} + \frac{1}{\beta_{ms} \cdot A_1}\right) + \frac{\sigma_{s,c,d2}}{E_{s,d2}} \cdot l_{eff,c,d2} + \frac{\sigma_{s,c,V}}{E_{s,V}} \cdot l_{eff,c,V}$$

With : F= M_{Ed}/z (per element)

A_1 in accordance with Annex 7, Fig. 20

β_b and β_{ms} in accordance with Table A6

Concrete strength class	C20/25	C25/30	C30/37	C35/45	C40/50
β_b [N/mm] (balcony)	1581000	1633700	1739100	1791800	1844500
β_{ms} [N/mm³] (floor slab)	150	155	165	170	175

Table A6: Coefficients β_b and β_{ms} for the deformation calculation, depending on the concrete quality

Compression zone strain (when using compression bars):

$$\Delta l_c = \Delta l_{c,concrete,b} + \Delta l_{c,NR} + \Delta l_{c,v} + \Delta l_{c,B500ms}$$

$$= F \cdot \left(\frac{1}{\beta_b}\right) + \frac{\sigma_{s,c,d2}}{E_{s,d2}} \cdot l_{eff,c,d2} + \frac{\sigma_{s,c,V}}{E_{s,V}} \cdot l_{eff,c,V} + \frac{\sigma_{s,c,ds1}}{E_{s,ds1}} \cdot l_{eff,c,ds1}$$

With : F= M_{Ed}/z (per element)

β_b in accordance with Table A6

Design rules

Element height	$200 \leq h \leq 500$ mm
Spacing of tensile bars and compression bars from member edge or from the expansion joint	≥ 50 mm
Number of tensile bars / compression bearings per element	$n_{TB/CB} \geq 2$ (for elements subjected to moments)
Diameter of the tensile bars / compression bearings	$Ø_{TB/CB} \leq$ M24 (Ø25 mm)
Number of shear bars per element	$n_{SB} \geq 2$
Diameter of the shear bars	$Ø_{SB} \leq 14$ mm

Mandrel diameter; axial edge distance; axial spacing of the shear bars

$D_{mandrel,SB} \geq 3.5\ Ø_{SB}$; $a_{edge} \geq 12\ Ø_{SB}$; $a_M \geq 17\ Ø_{SB}$	for all $Ø_{SB}$ and concrete quality ratings
$D_{mandrel,SB} \geq 6\ Ø_{SB}$; $a_{edge} \geq 6\ Ø_{SB}$; $a_M \geq 12\ Ø_{SB}$	$Ø_{SB} \leq 12$mm (≥ C20/25); $Ø_{SB} = 14$mm (≥ C25/30)
$D_{mandrel,SB} \geq 6\ Ø_{SB}$; $a_{edge} \geq 6\ Ø_{SB}$; $a_M \geq 12\ Ø_{SB}$	$Ø_{SB} = 14$mm (C20/25) with $f_{y,d,SB,red} = 0.95\ f_{y,d,SB}$

Angle of the shear bars:	$30° \leq \alpha_{SB} \leq 60°$
Beginning of shear bar bending in the concrete	$0.9\ Ø_{SB}$
Vertical offset between shear bars and longitudinal reinforcement	$s_{SB} \leq 100$ mm

Maximum element spacing for limiting thermal stress

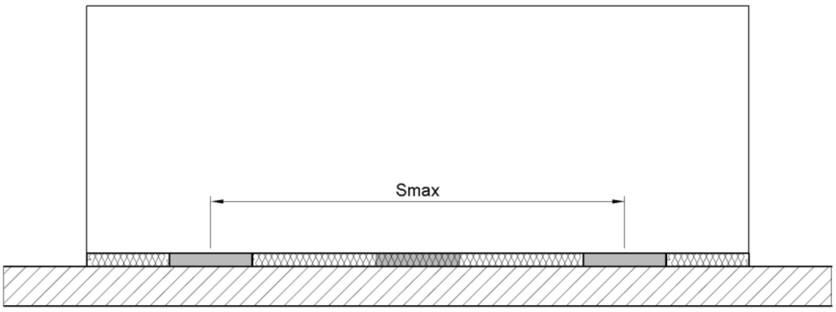

Fig. 22: Element spacing s_{max} **HIT-HP PI**

To limit thermal stress, the maximum element spacing between the external elements of a member as specified in Table A7 shall be maintained in the external concrete members.

Thickness of the insulation joint	Tensile bar diameter in the joint [mm]				
	M12	M14	M16	M20	M24
HIT-HP	10.8	10.4	9.8	8.5	7.0

Table A7: Element spacing s_{max} [m]

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