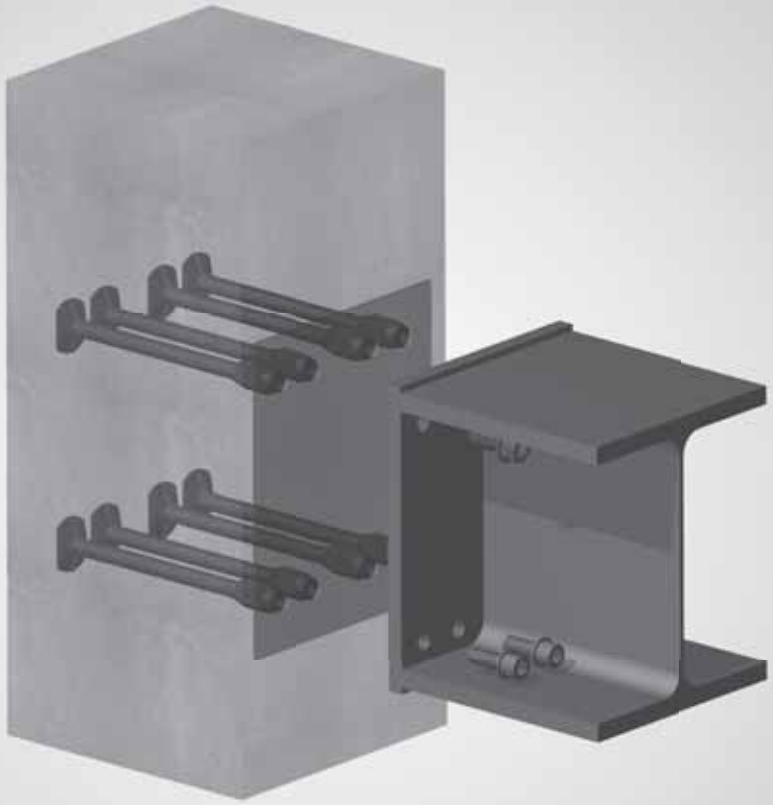
Leviat®
A CRH COMPANY

HALFEN

HALFEN HSC STUD CONNECTOR

Approval Z-21.8-1974



Z-HSC-B 01/20-E

HALFEN HSC-B STUD CONNECTOR
General Note

Use of third-party products

This approval only applies to original HALFEN products. The specifications in this approval are not transferable to other products. Users are fully liable for personal injuries and material damage caused by third-party products used instead of HALFEN products.

Deutsches Institut für Bautechnik

DIBt

Zulassungsstelle für Bauprodukte und Bauarten

Bautechnisches Prüfamt

Eine vom Bund und den Ländern gemeinsam getragene Anstalt des öffentlichen Rechts

Mitglied der EOTA, der UEAtc und der WFTAO

National technical approval / General construction technique permit

Date: 17 Jan 2020

Reference: I 24-1.21.8-21/19

Number:
Z-21.8-1974

Validity
from: **31 January 2020**
to: **31 January 2025**

Applicant:

Halfen GmbH
Liebigstraße 14
40764 Langenfeld, Germany

Subject of decision:

HALFEN Stud Connector type B (HSC-B)

The subject named above is herewith granted a national technical approval (*allgemeine bauaufsichtliche Zulassung*) / general construction technique permit (*allgemeine Bauartgenehmigung*).
This decision contains seven pages and three annexes with 12 pages.
The subject was granted the first national technical approval on 28 January 2010 under no. Z-1.6-284.

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 shall 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 therein 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.

8 The general construction technique permit included in this decision also serves as a national technical approval for the construction technique.

II SPECIAL PROVISIONS

1 Subject concerned and field of use and application

This approval covers 'Halfen Stud Connectors type B (HSC-B)' made of rebar B500B with a nominal diameter of 12, 14, 16, 20 or 25 mm combined with a one-sided or two-sided joint configuration with couplers in accordance with national technical approval no. Z-1.5-189 and subsequent supplementary provisions. The HSC-B with a nominal diameter of 12 or 14 mm may also consist of stainless reinforcing steel B500 NR, material no. 1.4571 or 1.4362.

Application examples are provided in Annex 1. In one-sided joint configurations, the coupling bars can be anchored using anchor heads in accordance with national technical approval no. Z-21.8-1973 or bent stud connectors type B in accordance with DIN EN 1992-1-1:2011-01.

The subject of the permit is the planning, design and execution of the load-bearing coupling elements 'Halfen Stud Connectors type B (HSC-B)' used to connect steel corbels or steel beams to reinforced concrete elements, under static, quasi-static as well as fatigue loads. Both one-sided and two-sided configurations are possible.

Halfen Stud Connectors type B (HSC-B) shall only be used in normal weight concrete. The concrete strength shall be at least C20/25 and not more than C70/85.

2 Provisions for the construction product

2.1.1 Material properties

The starting material of the coupling bars shall have the properties of a B500B in accordance with DIN 488-1 or B500 NR, material no. 1.4571 or 1.4362 in accordance with the national technical approval.

The requirements for the anchor heads in accordance with national technical approval no. Z-21.8-1973 shall be adhered to.

The couplers shall meet the requirements in accordance with national technical approval no. Z-1.5-189 and the information in the data sheet deposited with DIBt and the external surveillance body. The materials used for the connection parts are given in Annex 2, Table 2.

2.2 Manufacture, packaging, transport, storage and marking

2.2.1 Manufacture

The connecting bars of the Halfen Stud Connectors type B (HSC-B) are screwed into the couplers in the factory at one or both ends of the bars. On the connection side of the steel structure, screws in accordance with Annex 2, Table 2, are used depending on the nominal diameter of the HSC-B.

Only HSC anchors and couplers which are marked with the mark of the manufacturing plant shall be used in accordance with the national technical approvals specified under Section 2.1.1.

2.2.2 Packaging, transport and storage

The couplers, coupler threads and anchors shall be packed, transported and stored in such a way that they are protected against corrosion, mechanical damage and contamination until they are used at the construction site.

2.2.3 Marking

The manufacturer shall affix the national conformity mark (*Ü-Zeichen*) to the delivery note for the Halfen Stud Connectors type B (HSC-B) in accordance with the Conformity Marking Ordinances (*Übereinstimmungszeichen-Verordnungen*) of the federal states. The delivery note shall also contain the nominal diameter of the HSC-B. The mark shall only be applied if the requirements given in Section 2.3 are met.

2.3 Confirmation of conformity

2.3.1 General

The manufacturer shall confirm for each manufacturing plant that the construction product complies with the provisions of this decision 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 manufacturer 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.

A copy of the initial type-testing evaluation report shall also be sent 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 construction products manufactured satisfy the provisions of this decision. The factory production control shall at least include the following measures:

- Description and check of the starting material and the components:

  The manufacturer of the Halfen Stud Connector type B (HSC-B) shall ensure that the properties required for the reinforcing steel B500B in DIN 488-1 or B500 NR in accordance with the national technical approval, the properties required for the anchor heads in accordance with Z-21.8-1973 and those required for the couplers in accordance with Z-1.5-189 are verified through plant codes and national conformity marks.
- Factory production control shall be carried out for the couplers in accordance with Z-1.5-189, Section 2.3.2.

  The dimensions specified in the 'Halfen Stud Connectors type B (HSC-B)' data sheet shall be checked and the tolerances specified therein shall be complied with.

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,
- type of check or test,
- date of manufacture and testing of the construction product,
- result of the checks and tests and comparison with the requirements,
- signature of the person responsible for factory production control.

The records shall be kept for at least five years and submitted to the inspection body used for external surveillance. 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 once a year, by means of external surveillance at each manufacturing plant. Initial type-testing of the construction product shall be carried out within the scope of external surveillance. Samples for random testing shall also be taken. Sampling and testing shall be the responsibility of the recognised inspection body.

Samples for random testing shall also be taken as part of external surveillance. Sampling and testing shall be the responsibility of the recognised body. The analyses of the tensile tests as part of factory production control shall be checked. In case of doubt, the external surveillance body shall carry out their own tests.

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

For the planning, detailing, determination of the internal forces and moments and design, the following shall apply: 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, DIN EN 1993-1-4 in conjunction with DIN EN 1993-1-4/NA and DIN EN 1993-1-8 in conjunction with DIN EN 1993-1-8/NA as well as Annexes 2 and 3.

The fatigue verification shall be carried out in accordance with DIN EN 1992-1-1 and DIN EN 1992-1-1/NA, Clause 6.8. As a characteristic value of the fatigue strength for nominal diameters 12 to 20 mm a stress range of $\Delta\sigma_{Rsk} = 80$ N/mm² for $N = 2 \cdot 10^6$ load cycles and for nominal diameter 25 mm a stress range of $\Delta\sigma_{Rsk} = 70$ N/mm² for $N = 2 \cdot 10^6$ load cycles shall be assumed (see DIN EN 1992-1-1, Figure 6.30). The stress exponents for the S-N curve shall be taken as $k_1 = 3.5$ to $2 \cdot 10^6$ load cycles, $k_1 = 3$ from $2 \cdot 10^6$ to 10^7 load cycles as well as $k_2 = 5$.

3.2 Provisions for execution

The minimum spacings in accordance with Annex 2, Table 1, apply to the installation of the Halfen Stud Connectors type B (HSC-B) in the reinforced concrete member. Adherence to these minimum spacings shall be ensured.

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

- DIN 13-1:1999-11	ISO general purpose metric screw threads - Part 1: Nominal sizes for coarse pitch threads; nominal diameter from 1 mm to 68 mm
- DIN 488-1:2009-08	Reinforcing steels - Part 1: Grades, properties, marking
- DIN 6912:2009-06	Hexagon socket head cap screws with centre, with low head
- DIN 7984:2009-06	Hexagon socket head cap screws with low head
- DIN EN 1992–1–1:2011-01	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004+AC:2010 **and**
DIN EN 1992-1-1/NA:2013-04	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	Eurocode 3: Design of steel structures – Part 1-1: General design rules and rules for buildings; German version EN 1993-1-1:2005+AC:2009 **and**
DIN EN 1993-1-1/NA:2017-09	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures – Part 1–1: General design rules and rules for buildings
DIN EN 1993-1-4:2015-10	Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels in conjunction with DIN EN 1993-1-4:2006+A1:2015 **and**
DIN EN 1993-1-4/NA:2017-01	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
- DIN EN 1992-4:2019-04:	Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete; German version EN 1992-4:2018
- DIN EN 1993-1-8:2010-12	Eurocode 3: Design of steel structures - Part 1-8: Design of joints; German version EN 1993-8:2005+AC:2009 **and**
DIN EN 1993-1-8/NA:2010-12	National Annex - Nationally determined parameters - Eurocode 3: Design of steel structures - Part 1-8: Design of joints
- DIN EN 10277:2018-09	Bright steel products - Technical delivery conditions; German version EN 10277:2018
- DIN EN ISO 1461:2009-10	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461:2009); German version EN ISO 1461:2009
- DIN EN ISO 3506-1:2010-04	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs (ISO 3506-1:2009); German version EN ISO 3506-1:2011
- DIN EN ISO 4014:2011-06	Hexagon head bolts - Product grades A and B (ISO 4014:2011); German version EN ISO 4014:2011
- DIN EN ISO 4016:2011-06	Hexagon head bolts - Product grade C (ISO 4014:2011); German version EN ISO 4016:2011
- DIN EN ISO 4017:2015-05	Fasteners - Hexagon head screws - Product grades A and B (ISO 4017:2014); German version EN ISO 4017:2014
- DIN EN ISO 4018:2011-07	Hexagon head screws - Product grade C (ISO 4018:2011); German version EN ISO 4018:2011
- DIN EN ISO 4762:2004-06	Hexagon socket head cap screws (ISO 4762:2004); German version EN ISO 4762:2004

- DAfStb booklet 525:2003-09	Explanations to DIN 1045-1 including amendment 1:2005-05 (*Erläuterungen zur DIN 1045-1 einschließlich Berichtigung 1:2005-05*)
- DAfStb booklet 631:2019-05	Tools for the determination of internal forces and moments and special detail verification in reinforced concrete structures (*Hilfsmittel zur Schnittgrößenermittlung und zu besonderen Detailnachweisen bei Stahlbetontragwerken*)
- Z-1.5-189	Mechanical connection and anchoring of steel bars 'Halfen reinforcement screw connection type HBS-05' dated 29 October 2019
- Z-21.8-1973	Halfen Stud Connector HSC dated 1 March 2018
- Z-30.3-6	Products, structural components made and fasteners of stainless steels, dated 5 March 2018

- The data sheet is deposited with DIBt and the body used for external surveillance.

Beatrix Wittstock
Head of Section

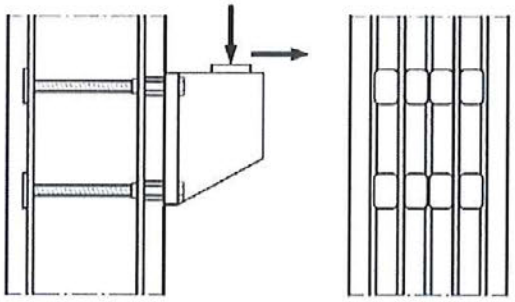
Drawn up by

Deutsches Institut für Bautechnik DIBt

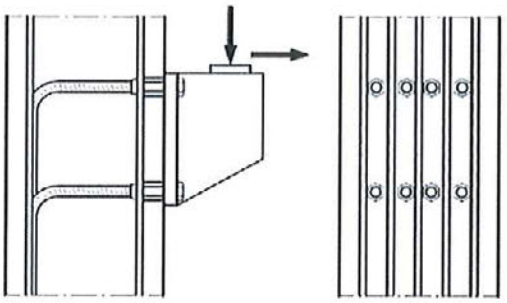
Steel corbel joints

One-sided joint configuration

HSC-B with anchor head

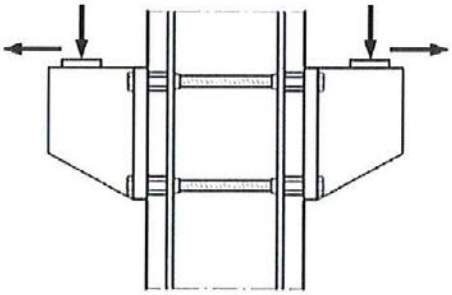


Bent HSC-B



Two-sided joint configuration

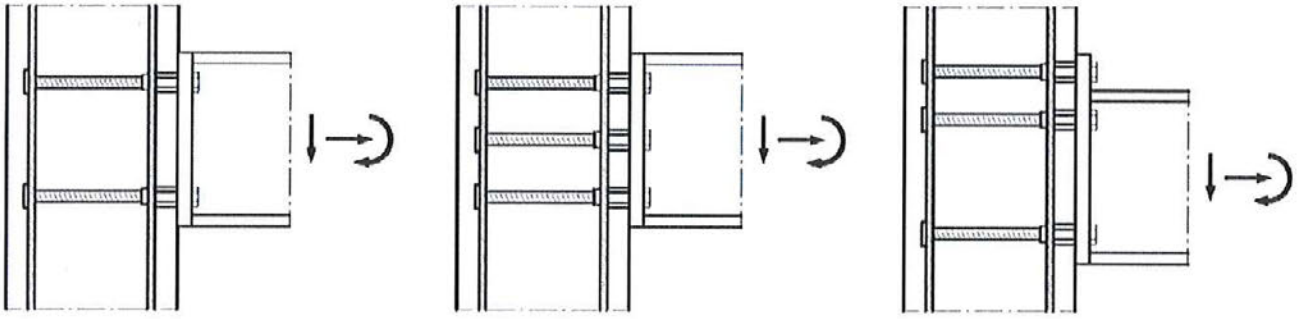
HSC-B with couplers screwed to both sides



Joints for optional steel members (end plate connection)

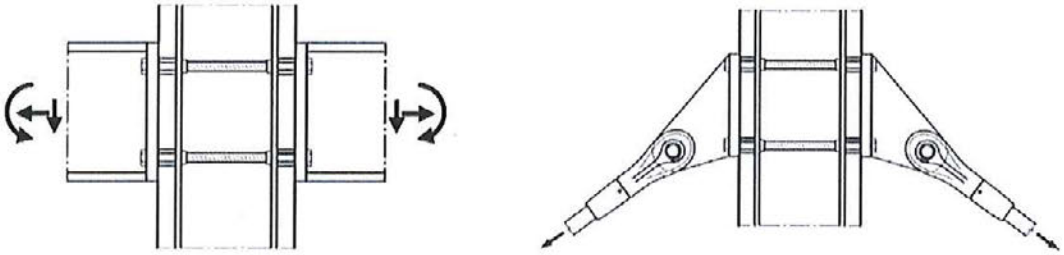
One-sided joint configuration

HSC-B with anchor head



Two-sided joint configuration

HSC-B with couplers screwed to both sides

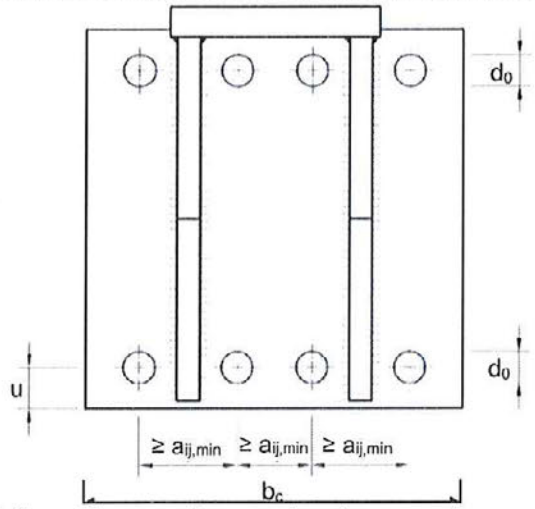


Halfen Stud Connector type B (HSC-B)	Annex 1
Application examples	

Deutsches Institut für Bautechnik DIBt

Design boundary conditions

End plate of steel member in accordance with DIN EN 1993-1-1 and DIN EN 1993-1-8 (e.g.: corbel, beam):



Bolted end plate joint with two or more bolt rows

Reinforced concrete member in accordance with DIN EN 1992-1-1 (e.g.: columns, walls, beams etc.):

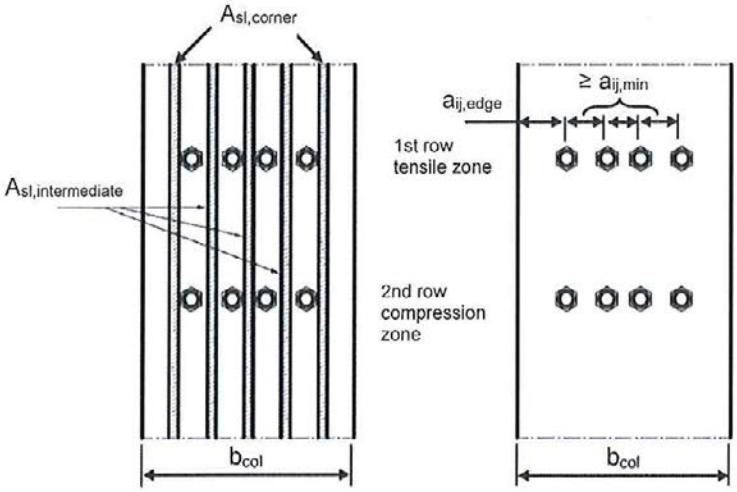


Table 1: Design boundary conditions for end plate and reinforced concrete member

HSC-B Ød_s	End plate of steel member			Reinforced concrete member[1)]			
	Maximum hole diameter d_0	Hole spacing ≥ $a_{ij,min}$	Edge distance u	Coupler spacing ≥ $a_{ij,min}$	Coupler edge spacing $a_{ij,edge}$	Bar diameter longitudinal reinforcement $A_{sl,corner}$	Bar diameter longitudinal reinforcement $A_{sl,intermediate}$
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
12	13.0	30	≥ 21	30	≥ 40	≥ ϕ12	≥ ϕ10
14	15.0	35	≥ 21	35	≥ 46	≥ ϕ12	≥ ϕ10
16	17.0	38	≥ 21	38	≥ 50	≥ ϕ12	≥ ϕ10
20	21.0	48	≥ 27	48	≥ 63	≥ ϕ12	≥ ϕ12
25	28.5	66	≥ 36	66	≥ 86	≥ ϕ12	≥ ϕ20

1) The longitudinal reinforcements $A_{sl,corner}$ and $A_{sl,intermediate}$ shall be anchored above and below the end plate in the reinforced concrete member in accordance with DIN EN 1992-1-1.

Halfen Stud Connector type B (HSC-B)

Design boundary conditions

Annex 2
Page 1/2

Table 2: Geometry, materials and design boundary conditions for coupler and bolt

HSC-B Ød$_s$	Threaded coupler[1]						Bolt[2]	
	Thread size[3]	Wrench size SW	Coupler length L_M	Maximum screw-in depth	Minimum screw-in depth	Maximum preload force[4]	Tensile stress area A_s	Tightening torque
[mm]	M	[mm]	[mm]	[mm]	[mm]	[kN]	[mm²]	[Nm]
12	M12 x 1.75	19	36	16.5	12	31.1	84.3	5)
14	M14 x 2	22	42	19.5	14	42.7	115	5)
16	M16 x 2	24	48	22.5	16	58.6	157	5)
20	M20 x 2.5	30	60	28.5	20	91.6	245	5)
25	M27 x 3.0	41	75	36	27	173.3	459	5)

1) Couplers in accordance with national technical approval no. Z-1.5-189, materials: 11SMn30+C (1.0715) in accordance with DIN EN 10277 as well as X6CrNiMoTi17-12-2 (1.4571) or X2CrNiMo17-12-2 (1.4404) with $R_{p,0.2} \geq 440$ N/mm² and $R_m \geq 500$ N/mm² in accordance with national technical approval no. Z-30.3-6

2) Bolts in accordance with DIN EN ISO 4014, DIN EN ISO 4016, DIN EN ISO 4017, DIN EN ISO 4018 or DIN EN 1993-1-8; hexagon socket screws in accordance with DIN EN ISO 4762, DIN 7984 or DIN 6912 as well as stainless steel bolts in accordance with DIN EN ISO 3506-1

3) Thread in accordance with DIN 13-1, tolerance range 6H

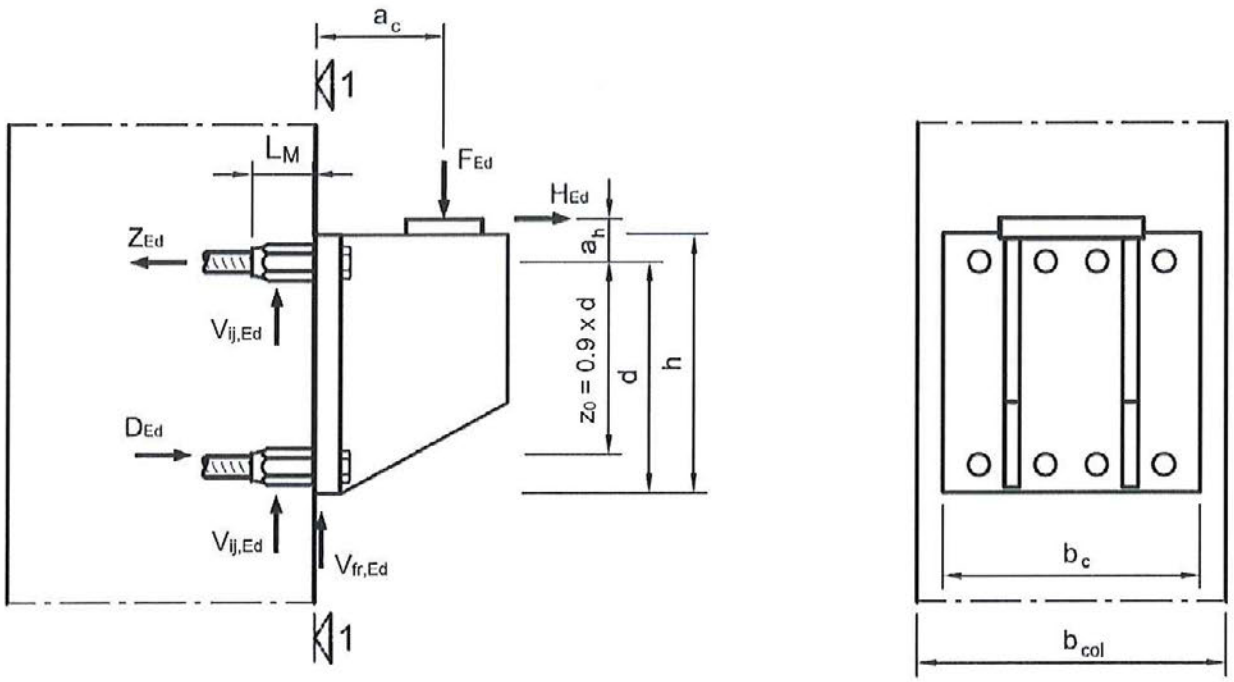
4) Preload force for couplers which were installed so they are recessed or not flush with the surface without washers for shimming

5) Tightening torques of bolts shall be determined in accordance with local conditions (coefficients of friction).

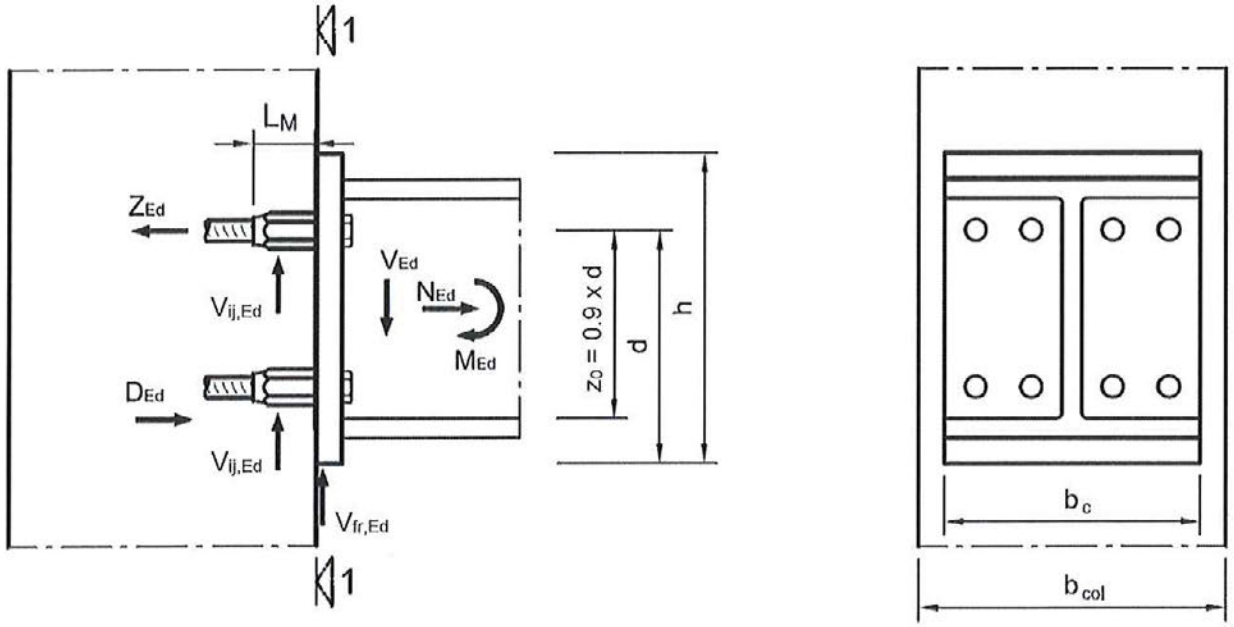
Deutsches Institut für Bautechnik DIBt

Planning and design in accordance with DIN EN 1992-1-1, DIN EN 1993-1-1 and DIN EN 1993-1-8

1. Geometry and designations



a) Corbel joint



b) Joint for optional steel member

Figure 1: Joint geometry, actions and static model

Halfen Stud Connector type B (HSC-B)	
Planning and design	**Annex 3** Page 1/9

2. Actions in design section 1-1

Corbel joint:

Design value of acting vertical force:

$$V_{Ed} = F_{Ed} \quad (1)$$

If friction forces of the bearings due to restrained deformations cannot be excluded, a horizontal force of:

$$H_{Ed} \geq 0.2 \cdot F_{Ed} \quad (2)$$

shall be applied.

Joint for optional steel member (e.g. beam or cantilever):

The design values of the acting internal forces and moments shall be determined in accordance with Figure 1b) in the joint between the reinforced concrete member and the end plate (section 1-1).

3. Determination of the tensile chord load Z_{Ed}

Corbel joint:

$$Z_{Ed} = V_{Ed} \cdot \frac{a_c}{z_0} + H_{Ed} \cdot \frac{a_h + z_0}{z_0} \quad (3a)$$

Where:

V_{Ed}	=	design value of vertical load
H_{Ed}	=	design value of horizontal load
a_c	=	distance of vertical load from column edge
a_h	=	distance of horizontal load from centre of gravity of tensile chord reinforcement
z_0	=	0.9·d (lever arm of internal forces)
d	=	distance of centre of gravity of tensile chord reinforcement to bottom edge of corbel end plate

Joint for optional steel member (e.g. beam or cantilever):

$$Z_{Ed} = \frac{M_{Ed}}{z_0} + N_{Ed} \cdot \frac{0.5 \cdot h - 0.1 \cdot d}{z_0} \quad (3b)$$

Where:

M_{Ed}	= design moment
N_{Ed}	= design value of axial force
Z_0	= 0.9·d (lever arm of internal forces)
d	= distance of centre of gravity of tensile chord reinforcement to bottom edge of end plate
h	= height of end plate

4. Determination of compression chord load D_{Ed} and friction component $V_{fr,Ed}$

Corbel joint:

$$D_{Ed} = V_{Ed} \cdot \frac{a_c}{z_o} \quad (4a)$$

Joint for optional steel member (e.g. beam or cantilever):

$$D_{Ed} = \frac{M_{Ed}}{z_o} - N_{Ed} \frac{d - 0.5 \cdot h}{z_o} \quad (4b)$$

Friction component $V_{fr,Ed,inf}$ for verification of bolts, couplers, local concrete blow-out failure:

$$V_{fr,Ed,inf} = D_{Ed} \cdot \mu_{inf} \quad (4c)$$

where: D_{Ed} = compression chord load in accordance with equation (4a) or (4b)
μ_{inf} = friction coefficient in accordance with Table 3

Friction component $V_{fr,Ed,sup}$ for verification of concrete edge failure:

$$V_{fr,Ed,sup} = D_{Ed} \cdot \mu_{sup} \quad (4d)$$

where: D_{Ed} = compression chord load in accordance with equation (4a) or (4b)
μ_{sup} = friction coefficient in accordance with Table 3

If the friction component is to be used for design and verification, corresponding on-site measures shall be used to ensure that friction forces between the corbel head plate or the end plate of the connected steel member and the positioning plate (steel/steel) can be transferred. The positioning plate is used to precisely position the HSC-B during concreting. If no positioning plate is used or the positioning plate is removed after concreting, the friction coefficients for the concrete/steel case shall be used.

Table 3: Friction coefficients for verifications of members in ULS

Friction coefficients	**Steel/steel**		**Concrete/steel**	
	μ_{inf}	μ_{sup}	μ_{inf}	μ_{sup}
Friction component which can be activated	0.1	0.2	0.2	0.45
Friction component which cannot be activated	0		0	

5. Design of steel corbel or steel member to be connected and positioning plate

The design of the steel corbel or the steel member to be connected is carried out in accordance with DIN EN 1993-1-1, taking into account the limit values for edge and hole spacings as well as the hole diameter in accordance with Annex 2, Page 1, Table 1. Hot-dip galvanisation in accordance with DIN EN ISO 1461 is used for permanent corrosion protection.
The positioning plate is not taken into account in the structural analysis. Temporary corrosion protection against rust streaks is achieved using galvanisation or Sendzimir galvanisation with a minimum thickness of ≥12 µm. Permanent corrosion protection using hot-dip galvanisation in accordance with DIN EN ISO 1461 is used for other applications. If ventilation is required for concreting, provision shall be made for an opening with d ≥ 4 mm in the centre of the positioning plate.

6. Design of bolts

Actions:

$N_{ij,Ed} = Z_{Ed}/n_{tensile\ chord}$ (5)

where:

$N_{ij,Ed}$	=	actual tensile force per bolt
Z_{Ed}	=	tensile chord load in accordance with equation (3a) or (3b)
$n_{tensile\ chord}$	=	number of fasteners in tensile chord

$V_{ij,Ed} = (V_{Ed} - V_{fr,Ed,inf})/n$ (6)

where:

$V_{ij,Ed}$	=	actual shear force per bolt
V_{Ed}	=	design value of acting vertical or shear force
$V_{fr,Ed,inf}$	=	friction component in accordance with equation (4c)
n	=	total number of fasteners

Strength of bolt under shear and/or tensile loads:

$$N_{ij,Rd} = k_2 \cdot \frac{f_{ub}}{\gamma_{M2}} \cdot A_s \quad (7)$$

where:

$N_{ij,Rd}$	=	tensile strength of bolt
k_2	=	0.9
f_{ub}	=	nominal value of tensile strength of bolt
A_s	=	stressed cross section of bolt
γ_{M2}	=	1.25 (partial safety factor)

$$V_{ij,Rd} = \alpha_v \cdot \frac{f_{ub}}{\gamma_{M2}} \cdot A_s \quad (8)$$

where:

$V_{ij,Rd}$	=	shear strength of bolt
α_v	=	0.60 for bolts of strength classes 4.6, 5.6, 8.8
α_v	=	0.50 for bolts of strength classes 4.8, 5.8, 6.8, 10.9
α_v	=	0.44 for bolts of strength class 12.9
α_v	=	0.75 for austenitic stainless steel bolts of strength class 50
α_v	=	0.68 for austenitic stainless steel bolts of strength classes 70, 80
α_v	=	0.50 for austenitic-ferritic stainless steel bolts of strength classes 50, 70 and 80

Verification:

$$\left(\frac{N_{ij,Ed}}{N_{ij,Rd}}\right)^2 + \left(\frac{V_{ij,Ed}}{V_{ij,Rd}}\right)^2 \leq 1.0 \quad (9)$$

7. Design of couplers

The couplers are designed in accordance with DIN EN 1993-1-1 using the elastic-plastic (E-P) verification procedure.

Actions:

$$N_{ij,Ed} = Z_{Ed}/n_{tensile\ chord} \quad (10)$$

where: $N_{ij,Ed}$ = actual tensile force per coupler
Z_{Ed} = tensile chord load in accordance with equation (3a) or (3b)
$n_{tensile\ chord}$ = number of fasteners in tensile chord

$$V_{ij,Ed} = (V_{Ed} - V_{fr,Ed,inf})/n \quad (11)$$

where: $V_{ij,Ed}$ = actual shear force per coupler
V_{Ed} = design value of acting vertical or shear force
$V_{fr,Ed,inf}$ = friction component in accordance with equation (4c)
n = total number of fasteners

Strength of a single coupler under shear and/or tensile loads:

The design values of strengths $N_{ij,Rd}$ and $V_{ij,Rd}$ are each displayed as limiting curves for the different nominal diameters of the HSC-Bs in interaction diagram 1.

Verification:

The value pair ($N_{ij,Ed}$, $V_{ij,Ed}$) of the acting internal forces and moments shall not be outside the respective limiting curves in interaction diagram 1.

8. Verification of local concrete blow-out failure

Action:

The acting shear force per coupler $V_{ij,Ed}$ is calculated in accordance with equation (11).

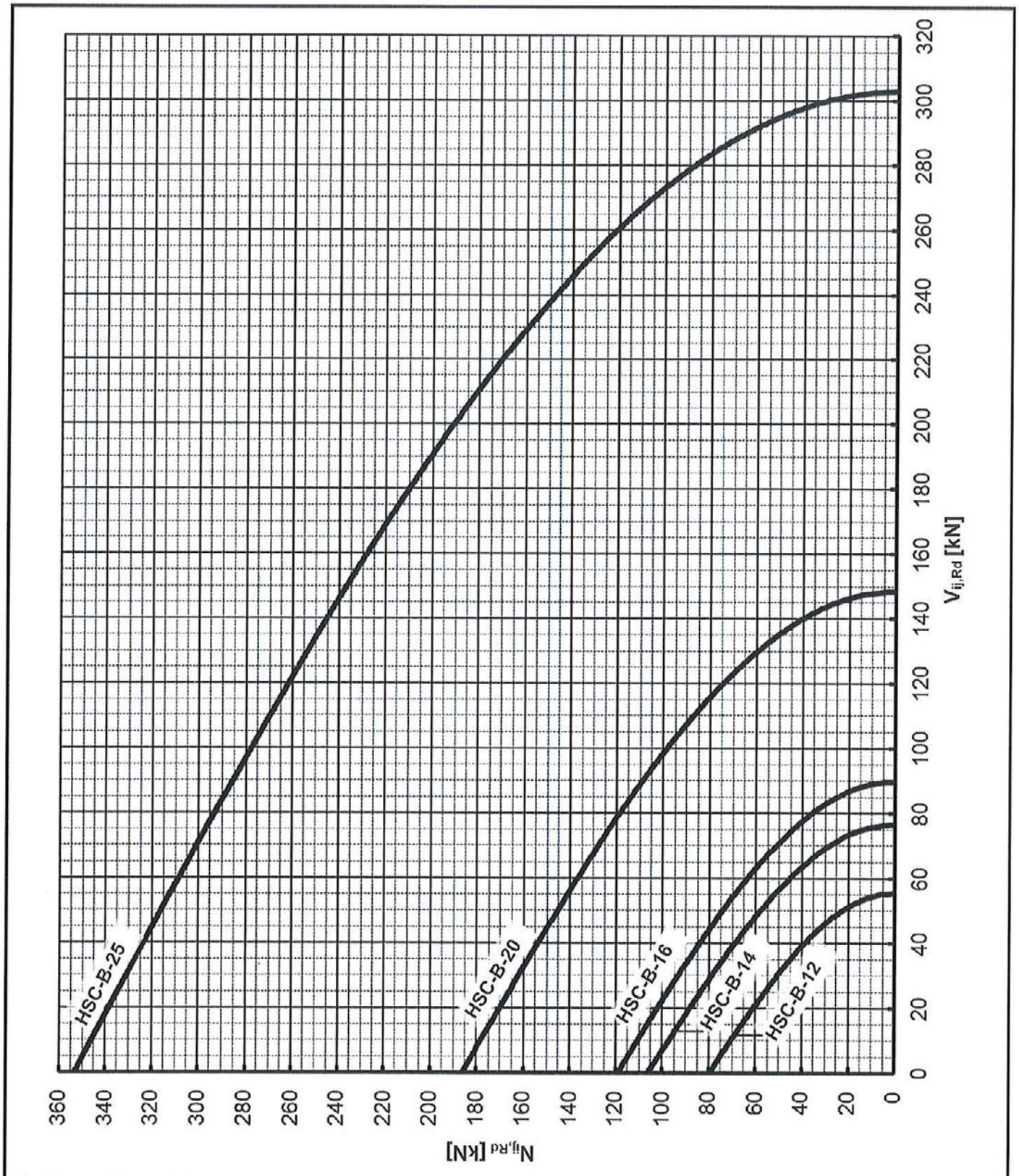
Design value of local shear resistance:

$$V_{ij,c,loc,Rd} = \frac{1.44}{\gamma_c} \cdot SW^2 (f_{ck} \cdot R_{p,0.2})^{0.5} \quad (12)$$

where: $V_{ij,c,loc,Rd}$ = local shear resistance per coupler
SW = wrench size of couplers in accordance with Annex 2, Page 2, Table 2
f_{ck} = characteristic cylinder compression strength of the concrete (for concrete with strength class > C50/60, f_{ck} = 50 N/mm² shall be applied)
$R_{p,0.2}$ = 440 N/mm² (characteristic yield strength of coupler material)
γ_c = 1.5 (partial safety factor in accordance with DIN EN 1992-1-1)

Verification:

$$\left(\frac{V_{ij,Ed}}{V_{ij,c,loc,Rd}}\right) \leq 1.0 \quad (13)$$



Interaction diagram 1: Design values of strengths $N_{ij,Rd}$ and $V_{ij,Rd}$ of a single coupler depending on HSC-B nominal diameter Ød_s

9. Verification of concrete edge failure

Action:

$$V_{concrete,Ed} = \frac{(V_{Ed} + V_{fr,Ed,sup})}{2} \quad (14)$$

where: $V_{concrete,Ed}$ = design value of shear force acting on concrete edge below end plate

v_{Ed} = design value of acting vertical or shear force

$V_{fr,Ed,sup}$ = friction component in accordance with equation (4d)

Design value of concrete edge resistance:

$$V_{concrete,Ed} = 15 \cdot \frac{\alpha}{\gamma_c} \cdot b_c \cdot L_M \cdot (f_{ck})^{0.25} \quad (15)$$

where: $V_{concrete,Ed}$ = concrete edge resistance below end plate in [N]

b_c = width of corbel head plate or end plate in [mm]

L_M = length of couplers in accordance with Annex 2, Page 2, Table 2 in [mm]

f_{ck} = characteristic cylinder compression strength of the concrete in [N/mm²]
(for concrete with strength class > C50/60, f_{ck} = 50 N/mm² shall be applied)

γ_c = 1.5 (partial safety factor in accordance with DIN EN 1992-1-1)

α = 0.85 (reduction coefficient to take sustained loads into account)

Verification:

$$\left(\frac{V_{concrete,Ed}}{V_{concrete,Rd}}\right) \leq 1.0 \quad (16)$$

When positioning a HSC-B at the lower edge of the member, loaded with a shear force perpendicular to the edge, the minimum edge distance of the end plate close to the edge shall be 15 · L_M, otherwise the following conditions shall be met:

(a) minimum edge distance of 20 cm for couplers close to the edge

(b) supporting reinforcement $A_{s,Auf} = V_{Ed} / f_{yd}$ for acting vertical load or shear load V_{Ed}. The supporting reinforcement in the form of links/stirrups or loops shall enclose the HSC-Bs with direct contact to the shaft and shall be positioned as closely as possible to the member to be connected. The tensile force of the supporting reinforcement shall be transferred to the reinforcement in the member using a corresponding lap.

10. Design of splitting tensile reinforcement

Splitting tensile reinforcements (links) shall be designed in accordance with DIN EN 1992-1-1 or based on DAfStb booklet 631 to take into consideration splitting tensile forces $Z_{s1,Ed}$ as well as $Z_{s2,Ed,tensile\ chord}$ or $Z_{s2,Ed,compression\ chord}$ below the rows of couplers. Existing reinforcements may also be taken into account for the cross sections.

Geometry, designations and design rules

The primary splitting tensile reinforcement $A_{SW,1}$ in accordance with equation (18) shall be positioned directly below the couplers. The secondary splitting tensile reinforcement $A_{SW,2,tensile\ chord}$ or $A_{SW,2,compression\ chord}$ in accordance with equation (22) or (23) shall be placed in area d_{s2} in accordance with equation (21), complying with the minimum design spacings in accordance with Figure 2 as well as the minimum link diameter in accordance with Table 4.

Table 4: Minimum link diameter

HSC-B Ød_s	Minimum link diameter of splitting tensile reinforcement $A_{sw,1}$ / $A_{sw,2,...}$
[mm]	[mm]
12	6
14	6
16	6
20	8
25	12

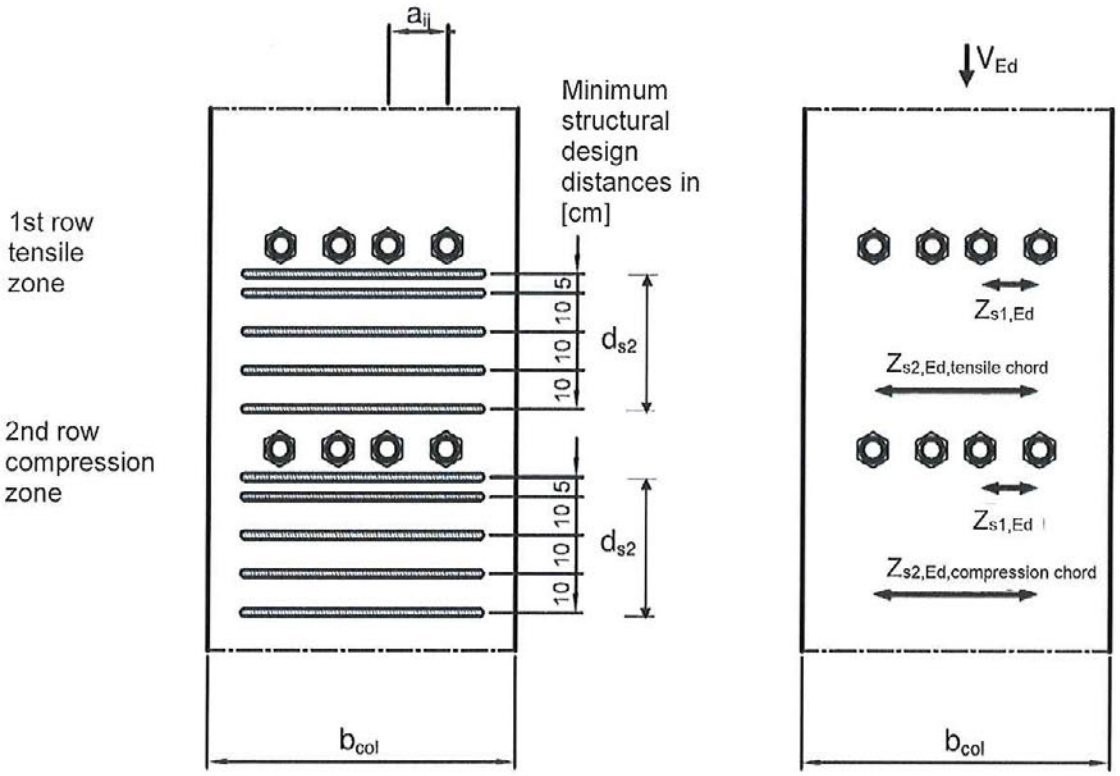


Figure 2: Splitting tensile forces and splitting tensile reinforcement

Primary splitting tensile reinforcement directly below couplers

$$Z_{s1,Ed} = 0.25 \cdot V_{ij,Ed} \left(1 - \frac{SW}{a_{ij,max}}\right) \quad (17)$$

where: $Z_{s1,Ed}$ = design value of primary splitting tensile force

$V_{ij,Ed}$ = V_{Ed} / n

V_{Ed} = design value of acting vertical or shear force

n = total number of fasteners

SW = wrench size of couplers in accordance with Annex 2, Page 2, Table 2

$a_{ij,max}$ = maximum spacing of two couplers in a row

$$A_{SW,1} = \frac{Z_{s1,Ed}}{f_{yd}} \quad (18)$$

where: $A_{SW,1}$ = primary splitting tensile reinforcement per row of couplers
f_{yd} = f_{yk} / γ_s (design value of yield strength for B500A)
f_{yk} = 500 N/mm² (characteristic value of yield strength for B500A)
γ_s = 1.15 (partial safety factor in accordance with DIN EN 1992-1-1)

Secondary splitting tensile reinforcement in area d_{s2} below the tensile or compression chord

$$Z_{s2,Ed,tensile\ chord} = 0.25 \cdot \frac{V_{Ed}}{2} \cdot \left(1 - \frac{\sum a_{ij}}{b_{col}}\right) \quad (19)$$

$$Z_{s2,Ed,compression\ chord} = 0.25 \cdot V_{concrete,Ed} \cdot \left(1 - \frac{\sum a_{ij}}{b_{col}}\right) \quad (20)$$

where:
$Z_{s2,Ed,tensile\ chord}$ = design value of secondary splitting tensile force below tension chord
$Z_{s2,Ed,compression\ chord}$ = design value of secondary splitting tensile force below compression flange
V_{Ed} = design value of acting vertical or shear force
$V_{concrete,Ed}$ = design value of shear force of concrete edge in accordance with equation (14)
b_{col} = width of column with $b_{col} \leq 3 \cdot \sum a_{ij}$
a_{ij} = maximum spacing of two couplers in a row, in accordance with Figure 2

$$d_{s2} = 2/3 \cdot b_c \quad (21)$$

where: d_{S2} = area below couplers with secondary splitting tensile reinforcement
b_c = width of corbel head plate or end plate

$$A_{SW,2,tensile\ chord} = \frac{Z_{s2,Ed,tensile\ chord}}{f_{yd}} \quad (22)$$

$$A_{SW,2,compression\ chord} = \frac{Z_{s2,Ed,compression\ chord}}{f_{yd}} \quad (23)$$

where: $A_{SW,2,tensile\ chord}$ = Secondary splitting tensile reinforcement below the tensile chord
$A_{SW,2,compression\ chord}$ = Secondary splitting tensile reinforcement below the compression chord
f_{yd} = f_{yk} / γ_s (design value of yield strength for B500A)
f_{yk} = 500 N/mm² (characteristic value of yield strength for B500A)
γ_s = 1.15 (partial safety factor in accordance with DIN EN 1992-1-1)

Verification of anchoring of tensile chord reinforcement

For the one-sided joint configuration of a corbel or a steel member to be connected, the anchoring of the tensile chord reinforcement shall be carried out and verified in accordance with DIN EN 1992-1-1 and DAfStb booklet 525. In the case of anchor heads, anchoring shall be carried out and verified in accordance with national technical approval Z-21.8-1973 (HALFEN Stud Connector HSC).

Leviat®
A CRH COMPANY

For more information on the products featured here, please contact Leviat:

Australia
Leviat
98 Kurrajong Avenue,
Mount Druitt Sydney, NSW 2770
Tel: +61 - 2 8808 3100
Email: info.au@leviat.com

Austria
Leviat
Leonard-Bernstein-Str. 10
Saturn Tower, 1220 Wien
Tel: +43 - 1 - 259 6770
Email: info.at@leviat.com

Belgium
Leviat
Borkelstraat 131
2900 Schoten
Tel: +32 - 3 - 658 07 20
Email: info.be@leviat.com

China
Leviat
Room 601 Tower D, Vantone Centre
No. A6 Chao Yang Men Wai Street
Chaoyang District
Beijing · P.R. China 100020
Tel: +86 - 10 5907 3200
Email: info.cn@leviat.com

Czech Republic
Leviat
Business Center Šafránkova
Šafránkova 1238/1
155 00 Praha 5
Tel: +420 - 311 - 690 060
Email: info.cz@leviat.com

Finland
Leviat
Vädursgatan 5
412 50 Göteborg / Sweden
Tel: +358 (0)10 6338781
Email: info.fi@leviat.com

France
Leviat
18, rue Goubet
75019 Paris
Tel: +33 - 1 - 44 52 31 00
Email: info.fr@leviat.com

Germany
Leviat
Liebigstrasse 14
40764 Langenfeld
Tel: +49 - 2173 - 970 - 0
Email: info.de@leviat.com

India
Leviat
309, 3rd Floor, Orion Business Park
Ghodbunder Road, Kapurbawdi,
Thane West, Thane,
Maharashtra 400607
Tel: +91 - 22 2589 2032
Email: info.in@leviat.com

Italy
Leviat
Via F.lli Bronzetti 28
24124 Bergamo
Tel: +39 - 035 - 0760711
Email: info.it@leviat.com

Malaysia
Leviat
28 Jalan Anggerik Mokara 31/59
Kota Kemuning, 40460 Shah Alam
Selangor
Tel: +603 - 5122 4182
Email: info.my@leviat.com

Netherlands
Leviat
Oostermaat 3
7623 CS Borne
Tel: +31 - 74 - 267 14 49
Email: info.nl@leviat.com

New Zealand
Leviat
2/19 Nuttall Drive, Hillsborough,
Christchurch 8022
Tel: +64 - 3 376 5205
Email: info.nz@leviat.com

Norway
Leviat
Vestre Svanholmen 5
4313 Sandnes
Tel: +47 - 51 82 34 00
Email: info.no@leviat.com

Philippines
Leviat
2933 Regus, Joy Nostalg,
ADB Avenue
Ortigas Center
Pasig City
Tel: +63 - 2 7957 6381
Email: info.ph@leviat.com

Poland
Leviat
Ul. Obornicka 287
60-691 Poznan
Tel: +48 - 61 - 622 14 14
Email: info.pl@leviat.com

Singapore
Leviat
14 Benoi Crescent
Singapore 629977
Tel: +65 - 6266 6802
Email: info.sg@leviat.com

Spain
Leviat
Polígono Industrial Santa Ana
c/ Ignacio Zuloaga, 20
28522 Rivas-Vaciamadrid
Tel: +34 - 91 632 18 40
Email: info.es@leviat.com

Sweden
Leviat
Vädursgatan 5
412 50 Göteborg
Tel: +46 - 31 - 98 58 00
Email: info.se@leviat.com

Switzerland
Leviat
Hertistrasse 25
8304 Wallisellen
Tel: +41 - 44 - 849 78 78
Email: info.ch@leviat.com

United Kingdom
Leviat
A1/A2 Portland Close
Houghton Regis LU5 5AW
Tel: +44 - 1582 - 470 300
Email: info.uk@leviat.com

United States of America
Leviat
6467 S Falkenburg Rd.
Riverview, FL 33578
Tel: (800) 423-9140
Email: info.us@leviat.us

For countries not listed
Email: info@leviat.com

Leviat.com **Halfen.com**

For information on certified management systems and standards, see www.halfen.com

Imagine. Model. Make.

© 2020 R-264-E – 02/20 PDF 10/20