HALFEN BRICKWORK SUPPORT
Design Guide

PFM 21-EN

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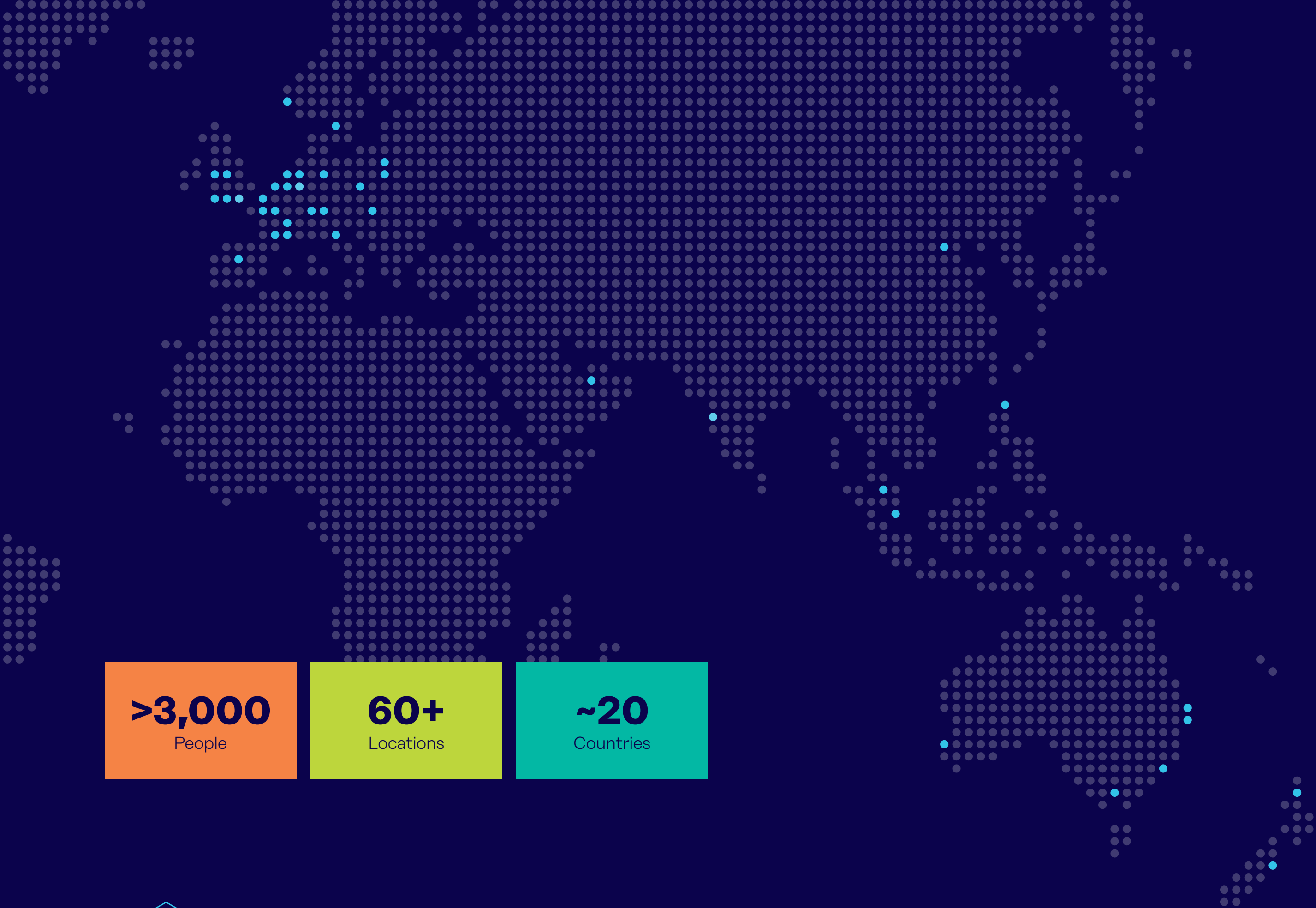
We provide technical design assistance at every stage of a project, from initial planning to installation and beyond.

Our technical support services range from simple product selection through to the development of a fully customised project-specific design solution.

Every promise we make locally, has the commitment and dedication of our global team behind it. We employ almost 3,000 people at 60 locations across North America, Europe and Asia-Pacific, providing an agile and responsive service worldwide.



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60+ Locations

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- Windposts
- Lintels
- Brick Slip Systems
- Wall Ties & Restraints
- Masonry Reinforcement
- Natural Stone Façade Systems
- Cavity Trays
- Sandwich Panel anchor
- Suspended concrete façade
- Masonry Repair

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  Installation instructions, type tests, approvals/ assessments, certificates and product declarations provide the required reliability for design and realization of all your projects.

This brochure provides extensive support for your projects when using our HALFEN HK5 Support brackets.

If you have questions about the HALFEN HK5 Support bracket or would like information on our cross-brand range of products, please contact your regional Leviat support team.

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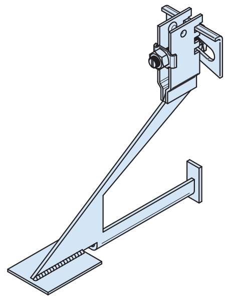

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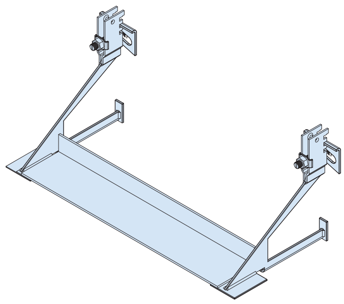

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1. Introduction

1.1 Material — corrosion resistant steel

In Germany, stainless steel, corrosion resistance class CRC III, designed in line with current applicable standards , is mandatory for support of masonry veneers.Once constructed, the space behind brick veneer façades is no longer accessible and cannot be monitored. All other corrosion protection methods must be regarded as non-durable. Damage to corrosion protection cannot be avoided during installation, cannot be controlled and, for the most part, cannot be subsequently replaced.
The statement above is further supported in the following DIN standards, approvals, and reports:

a.) DIN 18 516 - 3 (March 2018) - (ventilated) veneer systems for exterior walls. Section 5.2.
Fixings must be made of stainless steels that comply at least with resistance group III according to approval Z-30.3-6.

b.) The *DiBt Berlin, the supreme building authority in Germany (Obersten Bauaufsicht) reaffirmed that stainless steels (i.e. A4/L4) should be used as standard for support systems in double-leaf masonry.

***DiBt = German Institute of Construction Engineering**
(Deutsches Insitut für Bautechnik)

1.2 Application

The following components used in the support of double-leaf masonry are made of stainless steel material, of at least corrosion resistance class CRC III:

- HK5 Brickwork support bracket
- HK5-S Single support bracket for precast lintels
- FSW Precast lintel bracket with bar
- KW, KWL Bolt-on angles
- HW Support angle
- KM Grout-in bracket
- Suspension loops
- HAV Parapet support bracket
- HGA Scaffold anchors
- Brickwork connection cast-in channel
- Wall anchor
- Cavity-tie anchors
- HALFEN HTA Cast-in channels
- HALFEN HS Bolts
- HALFEN Bolts and dowels

2. Calculation basis

2.1 Load assumption

The calculation weight for walls is defined in DIN EN 1991-1-1.

Masonry, including mortar, no plaster.
The calculation value γ [kN/m³] is based on the gross density of the bricks. See abbreviation for the relevant brick density:

DIN 20000-401 - VMz - 20 - 1.6 - NF - 115

- DIN 20000-401: Brick standard
- VMz: Masonry type
- 20: compressive strength class
- 1.6: density class
- NF: Format
- 115: required wall thickness in mm

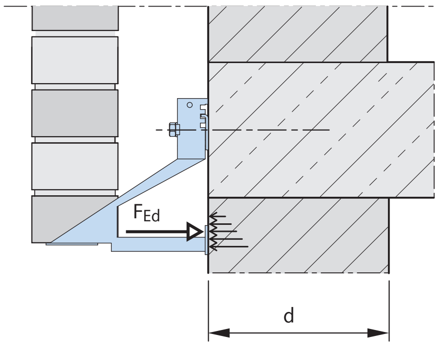
Table 1: Load assumption

Density class	calculation value γ	Wall thickness		
		11.5	17.5	24.0
[kg/dm³]	[kN/m³]	[kN/m²]	[kN/m²]	[kN/m²]
0.6	8.0	0.92	1.40	1.92
0.7	9.0	1.035	1.58	2.16
0.8	10.0	1.15	1.75	2.4
0.9	11.0	1.265	1.93	2.64
1.0	12.0	1.38	2.10	2.88
1.2	14.0	1.61	2.45	3.36
1.4	16.0	1.84	2.80	3.84
1.6	16.0	1.84	2.80	3.84
1.8	18.0	2.07	3.15	4.32
2.0	20.0	2.3	3.50	4.8
2.2	22.0	2.53	3.85	5.28

= Standard value

Calculation basis

Load transfer
Loads perpendicular to the wall



Design value; load-bearing capacity for bearing pressure =

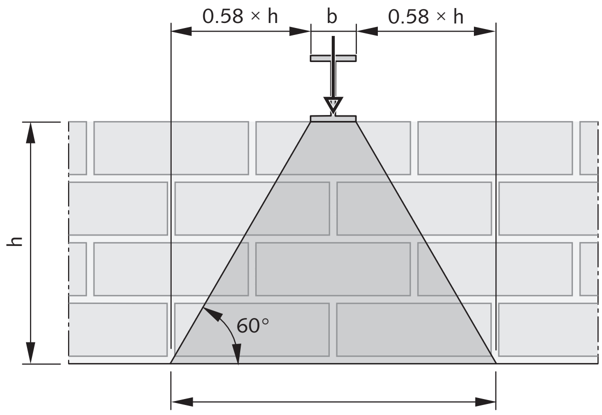
$F_{Rd} = 1.3 \times A_b \times f_{vd}$ [DIN EN 1996-1-1/NA, 6.1.3]

with
A_b Area subjected to load
f_{vd} Design value for shear resistance of masonry

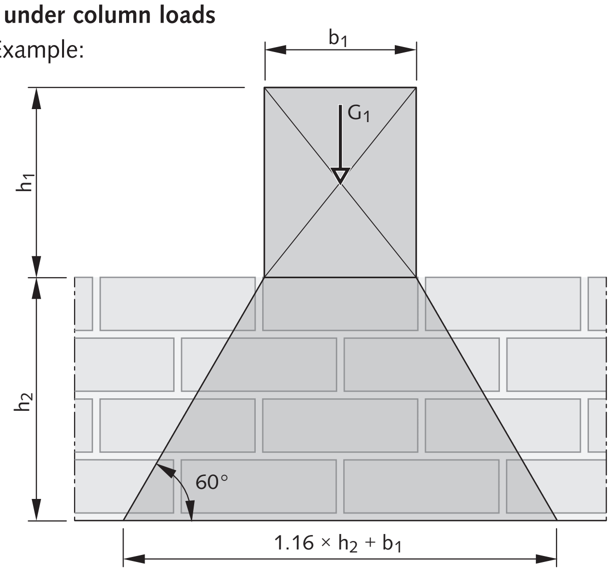
In addition, for horizontal loads $F_{Ed} > 4.0\,kN$, the shear capacity in the bedding joints of the masonry subjected to load must also be verified.

Perforated and hollow construction blocks; the pressure plate must transfer compression loads over at least 2 webs. (Not verifiable in refurbishment and post-install projects; therefore always use larger pressure plate in these cases).

Load transfer
- point loads
load distribution of 60° may be assumed:



- under column loads
Example:



γ = 18.0 kN/m³
d = 0.115 m
b_1 = 0.365 m
h_1 = 1.50 m
h_2 = 1.25 m
G_1 = 0.365 × 1.50 × 0.115 × 18.0 = 1.13 kN

$$g_1 = \frac{1.13}{1.16 \times 1.25 + 0,365} = 0.62\,kN/m$$

g_2 = 1.25 × 0.115 × 18.0 = 2.59 kN/m
$\sum g$ = 0.62 + 2.59 = 3.21 kN/m

Calculation basis

2.2 Deformation

Brickwork façades are subject to considerable fluctuating stresses. Constant variation in temperature and humidity causes movement in external façades.
In contrast, the main supporting structure is subjected to less fluctuations, but it also deforms under the effect of loads and contraction (contraction caused by drying and hardening/curing).
Brickwork façades and main supporting structures deform differently. Therefore, all connecting elements must be meticulously designed and executed (brick-tie anchors, doors, and window connections).

Stresses

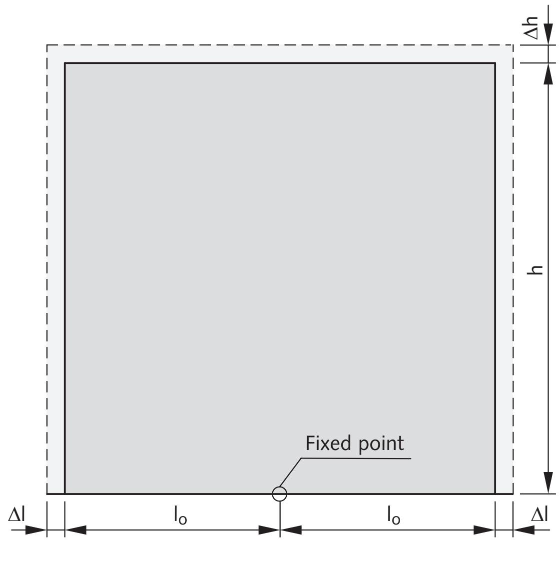
for masonry façades:

- Temperature expansion
- Shrinkage and swelling

for supporting structure/brickwork/blockwork:

- Flexural tension under load
- Creep deformation under load
- Shrinkage

Temperature expansion



$\Delta l = \Delta_t \times \alpha_t \times lo$
$\Delta h = \Delta_t \times \alpha_t \times h$

Δl = Temperature expansion from a reference value (Fixed point) in the masonry façade.

Reference values according to DIN 18516-1:
Reference temperature 10° C
Temperature in Winter −20° C
Temperature in Summer + 80° C (in the façade)
→ $\Delta_t = -30°C$ / $+70°C$

Table 2: Thermal expansion coefficient for masonry α_t

Brick type	α_t (10^{-6}/K)
Masonry brick	6
Calcium-silicate brick	8
Concrete block, light-weight concrete block	10
Aerated concrete block	8

Shrinkage and swelling

Shrinkage shortens, swelling lengthens a wall.

Table 3: Ultimate value of moisture expansion (shrinkage and swelling)

Brick type	[mm/m]
Masonry brick	0
Calcium-silicate brick	−0.2
Concrete block	−0.2
Light-weight concrete block	−0.5
Aerated concrete block	−0.1

Calculation basis

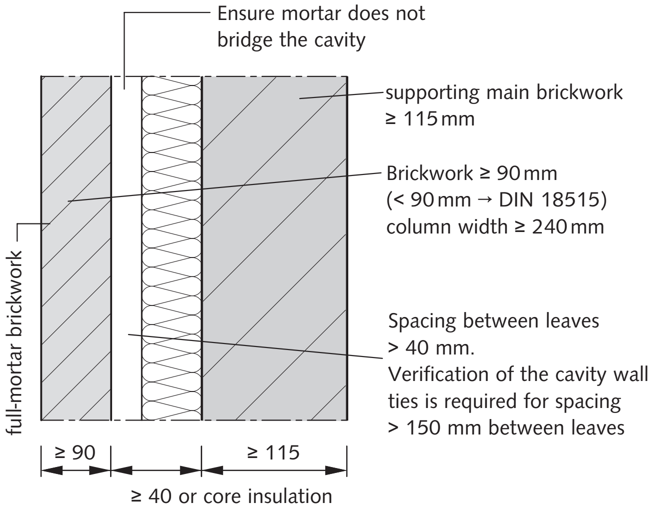
2.3 Brickwork façades

Construction type

double-leaf external wall

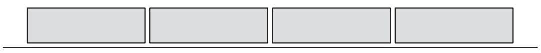
- with cavity
- with cavity and thermal insulation
- with core insulation
- with plaster

Dimensions

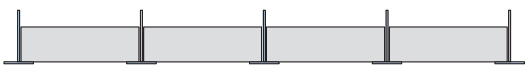


Support

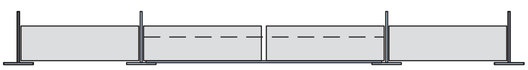
supported over the entire length.

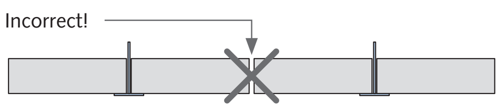


both sides on support brackets.



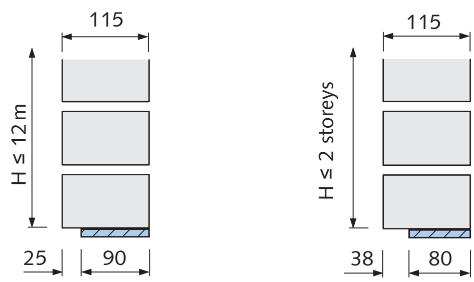
supported by angle brackets





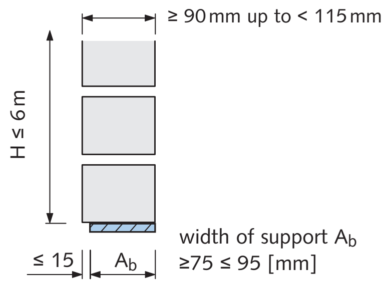
Support heights, support surface in acc. with DIN EN 1996-2

- for 115 mm thick brick leaves



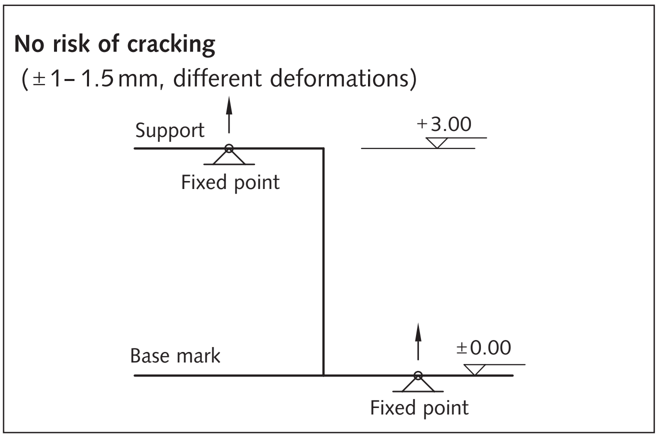
The external brickwork can protrude beyond the support by up to 38 mm if it is not higher than 2 storeys or it is supported every two storeys.

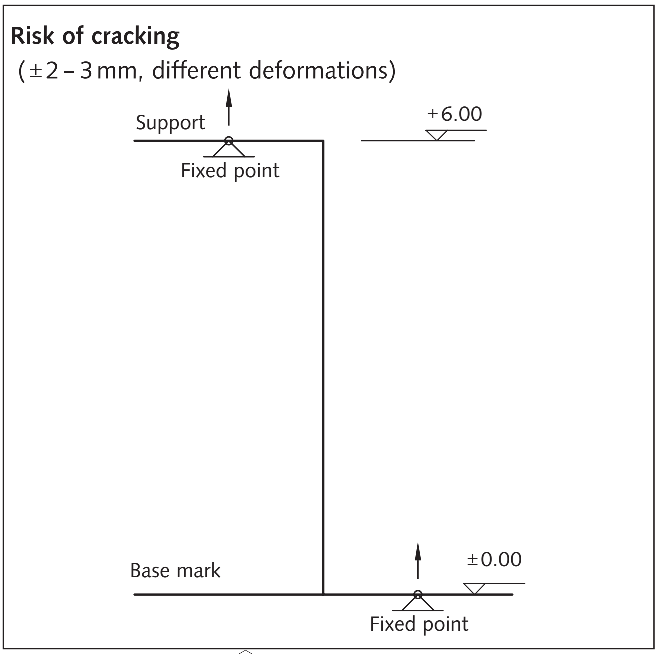
- for brickwork ≥ 90 mm to < 115 mm thick

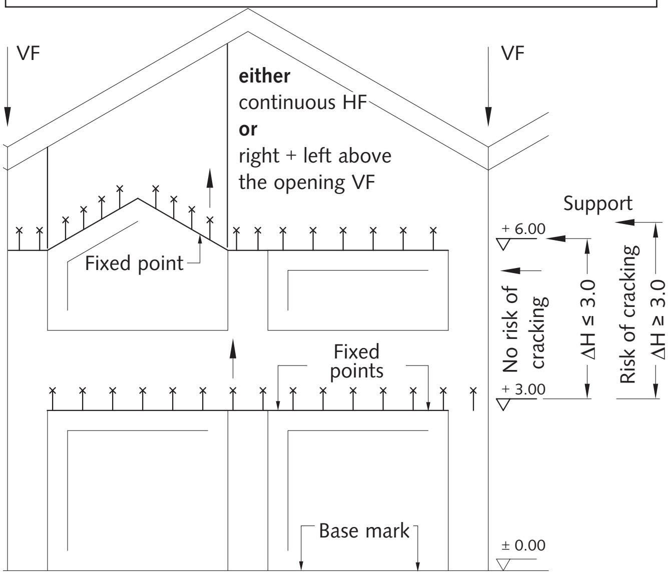


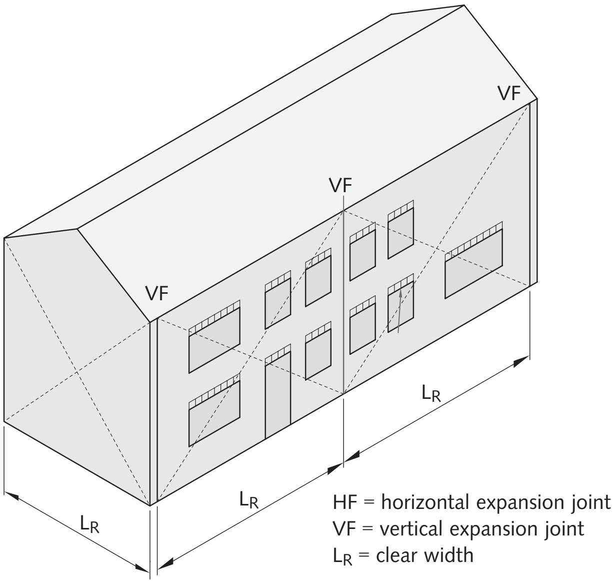
Calculation basis

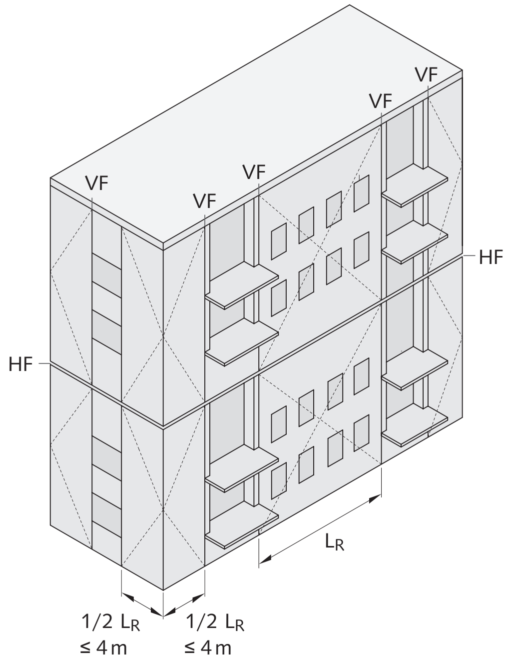
2.4 Expansion joint spacings











The values (see table below) for expansion joint spacings in external masonry façade in accordance with DIN EN 1996-2 can be used as a guideline.

Table 4: maximum distance between vertical expansion joints	
Masonry type	max L_R
Brick masonry	12.0 m
Calcium-silicate masonry	8.0 m
Concrete masonry (with admixures) and concrete cast stone	6.0 m
Aerated concrete block masonry	6.0 m
Natural stone masonry	12.0 m

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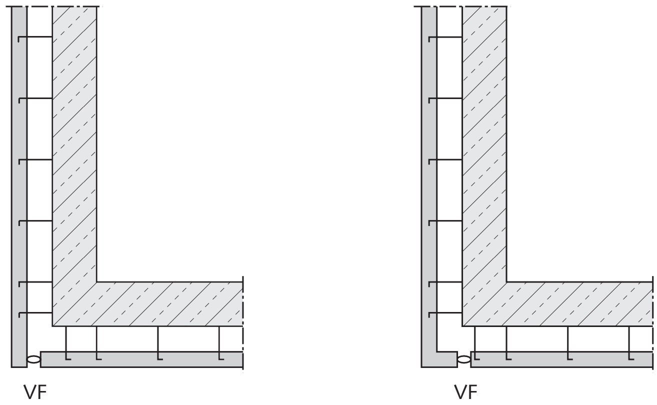
Calculation basis

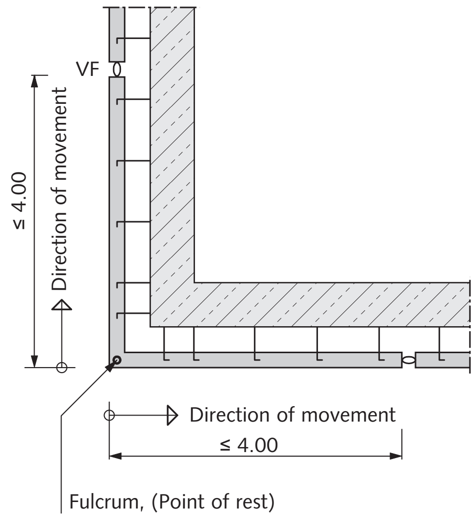
To prevent damage to the masonry, vertical and horizontal expansion joints must be planned to counter the effects of creep, deflection, thermal and moisture, and the possible effects of internal stresses caused by vertical or lateral loading. Expansion joints should be dimensioned and positioned taking the following points into account:

- Type of brick/blockwork
- Geometry/dimensions of the buildings structure taking openings into account
- Scale of deformation constraints
- Performance of the masonry under short-term or permanent loads
- Performance of the masonry under thermal and climatic conditions
- Fire resistance requirements
- Noise and thermal insulation requirements

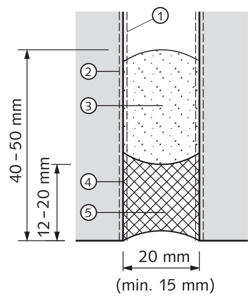
Ensure the brick façade is also free to expand vertically. Parapet masonry must be separated from the other vertically expanding veneer with expansion joints if the lintels are rigidly fixed to the main supporting structure e.g. using HK5 Support brackets. Expansion joints must be properly and permanently sealed using suitable material.



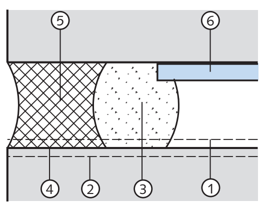
Symmetrical corner layout with expansion joints



Vertical expansion joint



Horizontal expansion joint under support brackets



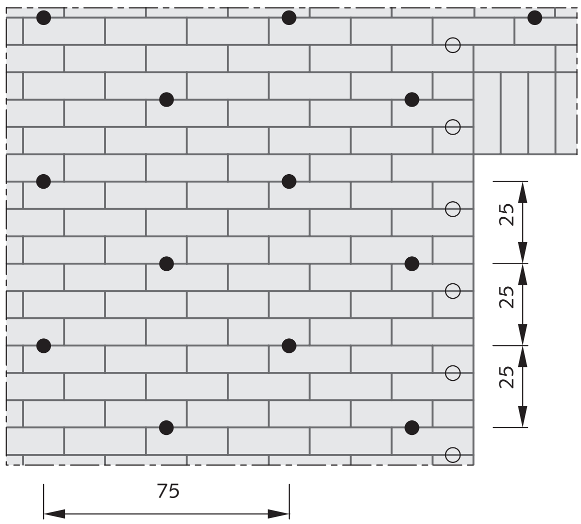
Example; detail of expansion joint, recommended by the German Society for Masonry Construction (Deutsche Gesellschaft für Mauerwerksbau).
① joint compressed
② joint expanded
③ closed-cell foam profile
④ bonding primer
⑤ elastoplastic joint sealing compound
⑥ HALFEN HK5 Support brackets

Calculation basis

2.5 Thermal insulation

Fasten insulation (batts or boards) evenly to the inner main load bearing wall, install with tight fitting butt joint or use rabbet or tongue and groove joints.

2.6 Cavity wall ties



An additional 3 cavity wall ties per linear metre must be used along all edges (building corners, openings, along expansion joints and the uppermost edges of the façade).

Horizontal anchoring of masonry façade in accordance with DIN EN 1996-2

The National annex to DIN EN 1996-2 defines a basic cavity wall tie. No approval is needed for stainless steel cavity wall ties that corresponds to the illustration and boundary conditions:

For designs other than shown in the illustration and for cavity spacings >150 mm the cavity wall ties must be verified in accordance with EN 845-1 and need a National Technical Approval or a General Construction Technique Permit:

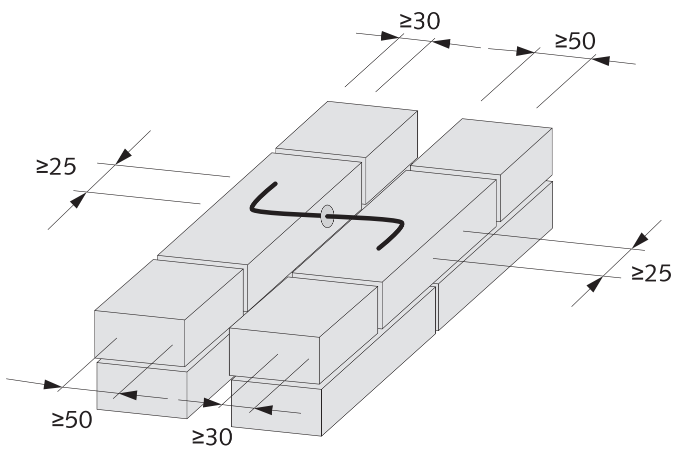
- Vertical spacing: must not exceed 500 mm; horizontal spacing: must not exceed 750 mm
- Clearance between the brick/block work must not exceed 150 mm
- Diameter: 4 mm
- Minimal number: see table 5

Table 5: Minimum number of cavity wall ties for m² of wall

Building height	Wind zone 1-3 Wind zone 4 inland	Wind zone 4 North-sea and Baltic coast, Baltic Islands	Wind zone 4 North-sea Islands
h ≤ 10 m	7 ①	7	8
10 m < h ≤ 18 m	7 ②	8	9
18 m < h ≤ 25 m	7	8 ③	

① in wind zone 1 and wind zone 2 inland/non-costal areas: 5 anchors/m²
② in wind zone 1: 5 anchors/m²
③ for a building length, in plan smaller than h/4: 9 anchors/m²

Apart from their structural effectiveness, cavity wall ties must also be designed to ensure they do not conduct moisture from the external brickwork façade to the inner main structure (e.g. by fitting a drip disc).



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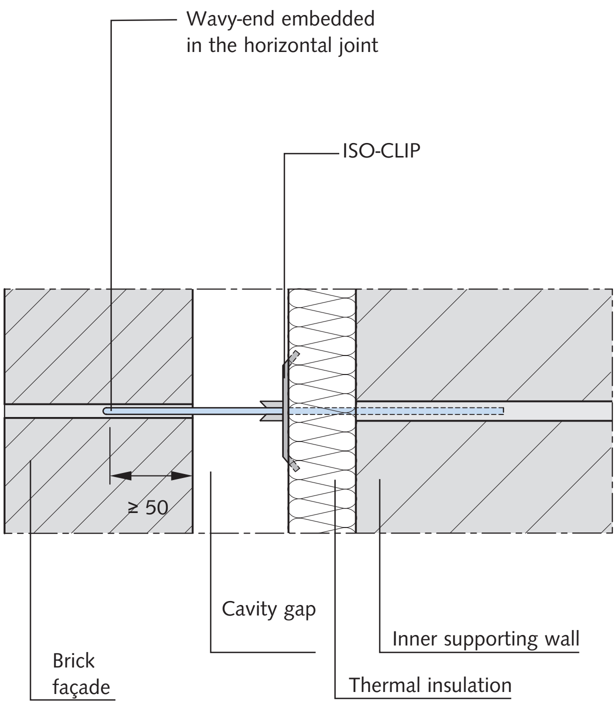
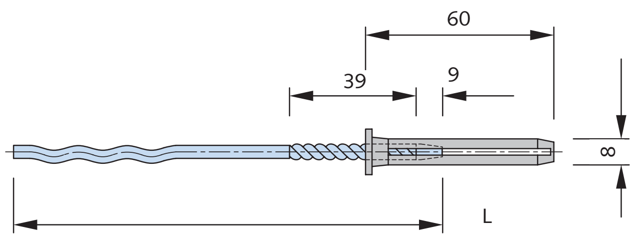
Calculation basis

Cavity wall tie systems with national technical approval or general construction technique permit

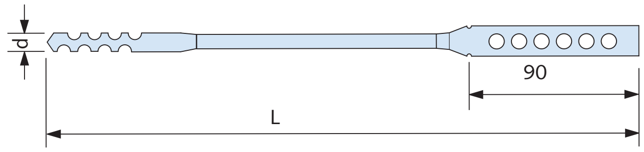
Anchoring with cavity wall ties, detailed illustration:



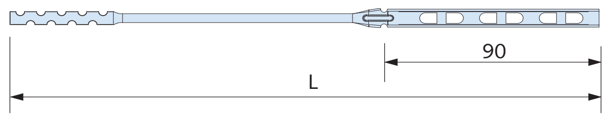
LSA-DW Cavity wall tie
In acc. with national technical approval Z-21.2-1009, Z-17.1-825 and Z-17.1-1138
For anchoring in brickwork or concrete including pre-fitted plug,



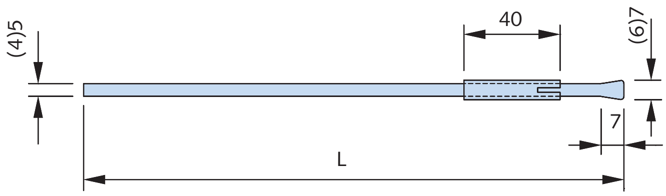
LSA-F Cavity wall tie
In accordance with national technical approval Z-17.1-888 and Z-17.1155 for anchoring in masonry



LSA-FS Cavity wall tie
In accordance with national technical approval Z-17.1-633 for anchoring in masonry

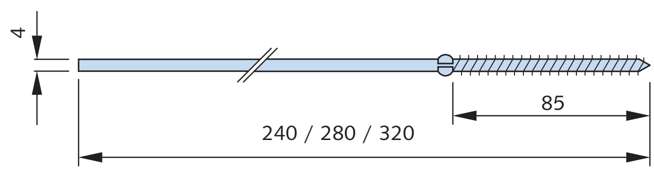


HEA Cavity wall tie
In accordance with national technical approval Z-21.1-910 for anchoring in concrete



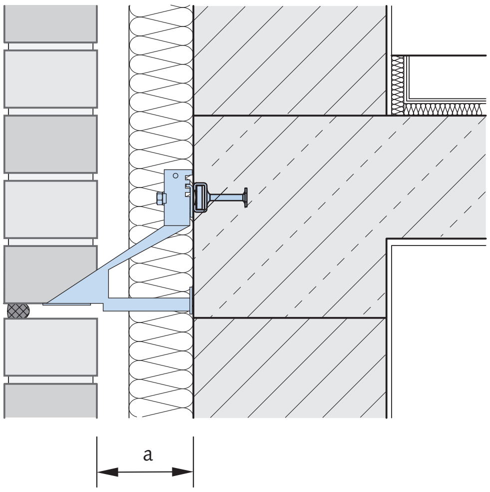
Cavity wall tie system, no national technical approval or type approval

HPV Cavity wall tie
for anchoring in aerated concrete blockwork



HALFEN SUPPORT BRACKETS – DESIGN GUIDE
Calculation basis

2.7 HALFEN HK5 Support brackets

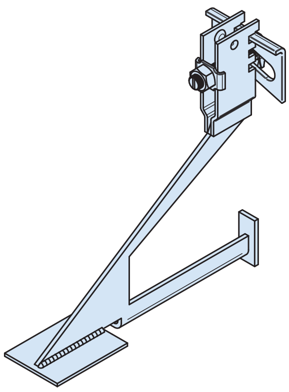


HALFEN HK5 Support brackets provide reliable and adjustable anchoring of brick façades to HALFEN Cast-in channels or to suitable anchors.
Material: Stainless steel L4 / A4

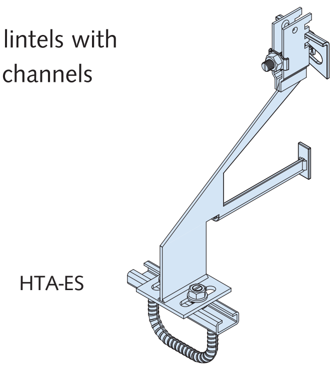
Charateristics:

- Freely height adjustable: Range ±20 mm
- Load groups: 4.0 – 8.0 – 12.0 kN (max. vertical load for each fixing)
- Type tested system – national technical approval Z-21.8-1922 for the bracket heads
- Standard bracket for cavity spacings a = 40 / 260 mm (other cavity spacings possible with custom brackets)
- Various types for a wide range of applications.

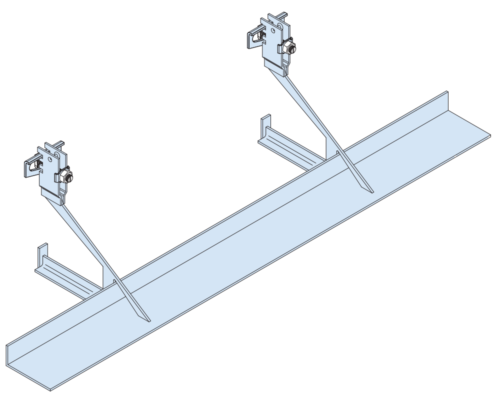
HK5-U
Standard type for continuous wall areas



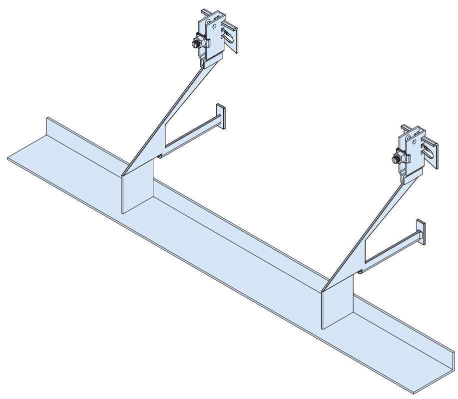
HK5-S
for anchoring of precast lintels with HALFEN HTA-ES Cast-in channels



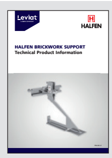
HK5-F
Angle support bracket for support above openings.
The stainless steel angle is visible from below.



HK5-FV
Offset angle support bracket for window rebate/recess.
The stainless steel angle is visible from below.



More information about available products and further technical information can be found in our Technical Product Information: "HALFEN FM Brickwork support" and the HK5 Support bracket type test. Go to www.halfen.com ► Product ranges ► Brickwork support systems

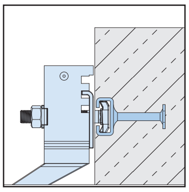


Calculation basis

2.8 Fixing material

2.8.1 Fixing material - Concrete

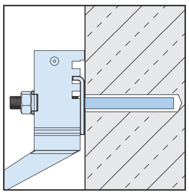
HALFEN Cast-in channel



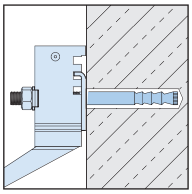
Fixing to
HALFEN **HTA-CE Cast-in channels**

Please see our Technical Product Information: "HALFEN Cast-in channels" for more details
www.halfen.de ► Product ranges ► Fixing systems

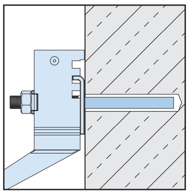
Chemical anchor bolt systems



Fixing with
HB-V HALFEN Chemical anchors
only for non-cracked concrete

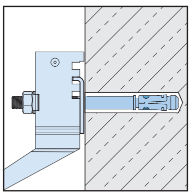


Fixing with
HALFEN **HB-VMZ** Injection system
for cracked and non-cracked concrete

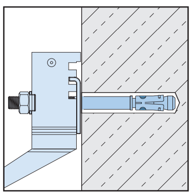


Fixing with
HALFEN **HB-VMU plus** Injection anchor system for cracked and non-cracked concrete

Mechanical heavy duty anchor bolt

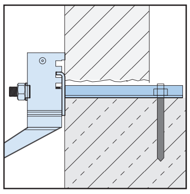


Fixing with
HALFEN **HB-BZ** Wedge anchor
for cracked and non-cracked concrete



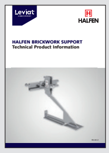
Fixing with
HALFEN **HB-B** Wedge anchor
for non-cracked concrete

Fixing to slabs

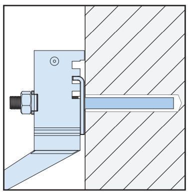


HK-DA Slab anchor
for fixing of HALFEN Support brackets to the edge of minimal thickness slabs

Please see our Technical Product Information: "HALFEN FM Brick-work support" for more details
www.halfen.de ► Product ranges ► Brickwork support systems

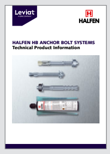


2.8.2 Fixing material - Masonry



Fixing with
HALFEN **HB-VMU plus** Injection anchor system for masonry

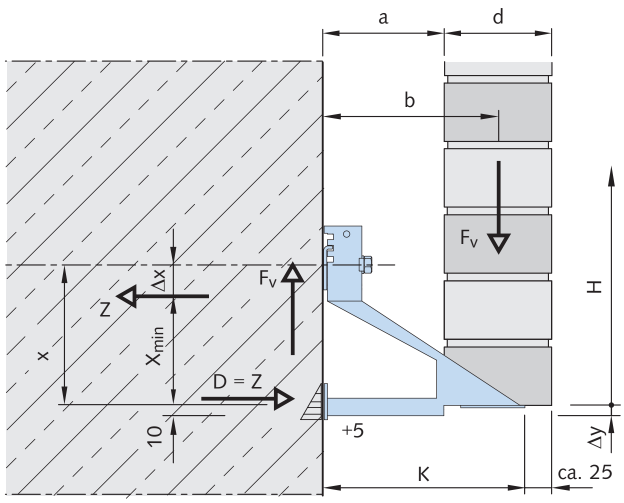
Please see our Technical Product Information: "HALFEN HB Anchor bolt systems" for more details
www.halfen.com ► Product ranges ► Accessories



Calculation basis

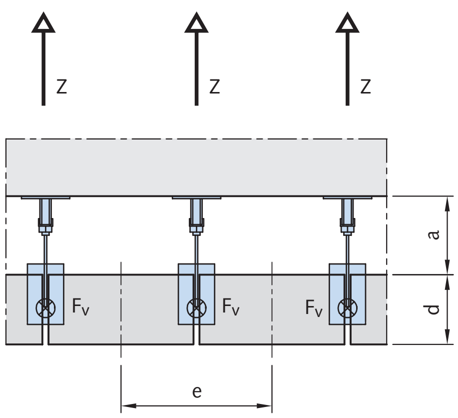
2.9 Method for selecting a support bracket and fixing

Section



$X_{min} = x - \Delta x$

Plan



Load verification for a support bracket:

H = Load height
γ = MW – gross density, masonry
a = Wall spacing
b = a + d / 2 + Tolerance range [mm]
Tolerance range = 15 [mm]
d = thickness of brick
e = Width of load influence
F_V = Vertical load for each fixing point $F_V = H \times e \times d \times \gamma$

Selecting the support bracket

(see FM catalogue)
max F_V = Load group → x = [mm]
(from the tables in the FM catalogue)

Connection loads

Tension/compression load max Z = – D = Fv × b / (X_{min}+Δy – (45/3–5))

$X_{min} = X - \Delta X$

Δx → height adjustable = ± 20 mm

Resulting force $R = \sqrt{Z^2 + F_V^{\ 2}}$

Selecting the fixing components
in non-cracked concrete
- HALFEN Chemical anchor bolt

in cracked and non-cracked concrete
- HTA-CE – Channel with HS-bolt
- HALFEN Injection anchor
- HALFEN Wedge anchor
- HALFEN HK-DA Slab anchor

Static calculation of the support brackets
(see the type test for the HALFEN HK5 Support brackets)

Further verification for special brackets
(as required)

Calculation basis

2.10 Arching-effect above a lintel

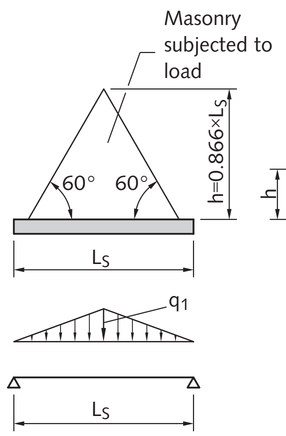
A precondition for using this section is that arching-action can develop next to and above the support lintel/beam as well as in the adjacent load surfaces, and that there are no disruptive openings so arching loads can be absorbed. (see below "**Arching-action**"). In the case of lintel or support beams under supporting walls, only the dead load of the wall section in an equilateral triangle above the beam needs to be considered as load. (see Fig 1). Evenly distributed slab loads above the load triangle are not considered in the lintel verification.

Slab loads that act on the masonry within the load triangle as an evenly distributed load are only applied for the section in which they are in the load triangle (for example; floor slabs and beam floor slab with beam spacing ≤ 1.25 m).

Arching-action above a lintel

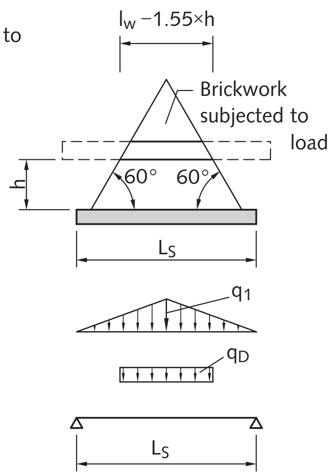
Rough evaluation for the dimensions required to accommodate the arching-action in the masonry adjacent to and above openings → see fig. 3 and the table.

Fig. 1



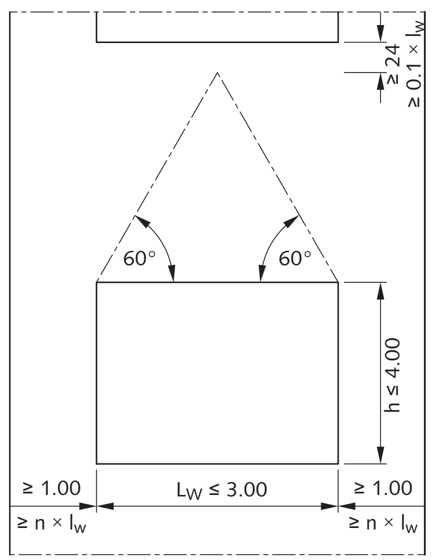
$q_1 = \gamma_{mw} \times 0.866 \times L_s \times d$

Fig. 2



$q_1 = \gamma_{mw} \times 0.866 \times L_s \times d$
q_D = max. support load from slab
$L_s = L_W \times 1.05$ [m]
L_W = clear width

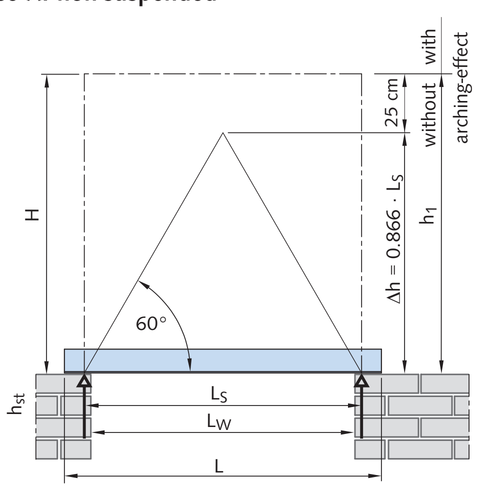
Fig. 3 Minimal wall area with arching-action



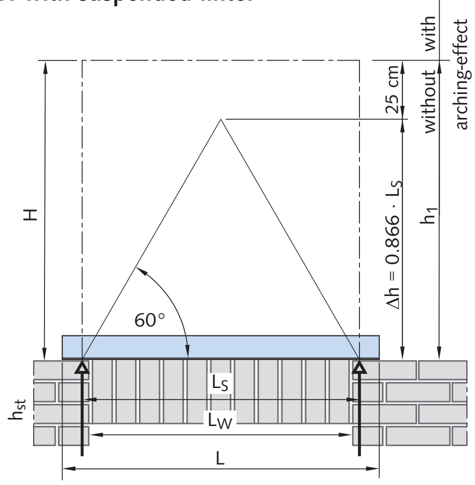
h/lw	0.85	1.2	1.6	2.0	2.5	3.0	3.6
n	0.4	0.5	0.6	0.7	0.8	0.9	1.0

Support angle

Case A: non-suspended

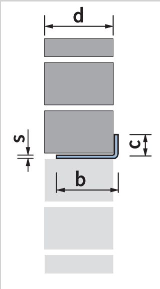


Case B: with suspended lintel



Calculation basis

Table 6: Case A – HW non-suspended lintel

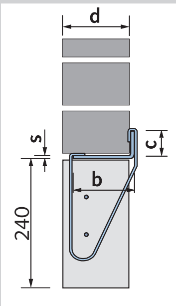


Dimensions in mm

Clear width L_W	Support angle length L	≤ 1.00	≤ 1.25	≤ 1.50	≤ 1.75	≤ 2.00	≤ 2.25	≥ 2.25	Δh [m]
		Load height H [m] with d ≤ 11.5 cm, γ ≤ 18kN/m³ – Angle dimensions **b** × **c** × **s** [mm]							
510	700	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	0.497
760	950	90 × 60 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	0.713
1.010	1.200	90 × 60 × 4	90 × 60 × 4	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	0.930
1.260	1.450	90 × 60 × 5	90 × 60 × 5	90 × 70 × 5	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	1.146
1.510	1.700	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	90 × 90 × 5	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	1.363
1.760	1.950	90 × 90 × 5	90 × 90 × 5	90 × 90 × 6	90 × 90 × 8	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	1.579
2.010	2.200	90 × 90 × 8	90 × 100 × 8	90 × 100 × 8	SK	SK	SK	90 × 90 × 8	1.796

= with arching-effect
= without arching-effect
SK = special bracket incl. static verification

Table 7: Case B – HW with suspended lintel



Dimensions in mm

Clear width L_W	Support angle length L	≤ 1.00	≤ 1.25	≤ 1.50	≤ 1.75	≤ 2.00	≤ 2.25	≥ 2.5	Δh [m]
		Load height H [m] with d ≤ 11.5 cm, γ ≤ 18kN/m³ – Angle dimensions **b** × **c** × **s** [mm]							
510	700	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	0.497
760	950	90 × 60 × 4	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	0.713
1.010	1.200	90 × 60 × 4	90 × 60 × 5	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	0.930
1.260	1.450	90 × 90 × 4	90 × 90 × 5	90 × 90 × 5	90 × 60 × 4	90 × 60 × 4	90 × 60 × 4	90 × 60 × 4	1.146
1.510	1.700	90 × 90 × 5	90 × 90 × 5	90 × 90 × 6	90 × 90 × 6	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	1.363
1.760	1.950	90 × 90 × 5	90 × 90 × 6	90 × 90 × 8	90 × 90 × 8	90 × 90 × 5	90 × 90 × 5	90 × 90 × 5	1.579
2.010	2.200	90 × 100 × 8	90 × 100 × 8	90 × 110 × 8	SK	SK	SK	90 × 100 × 8	1.796

= with arching-effect
= without arching-effect
SK = special bracket incl. static verification

Explanation

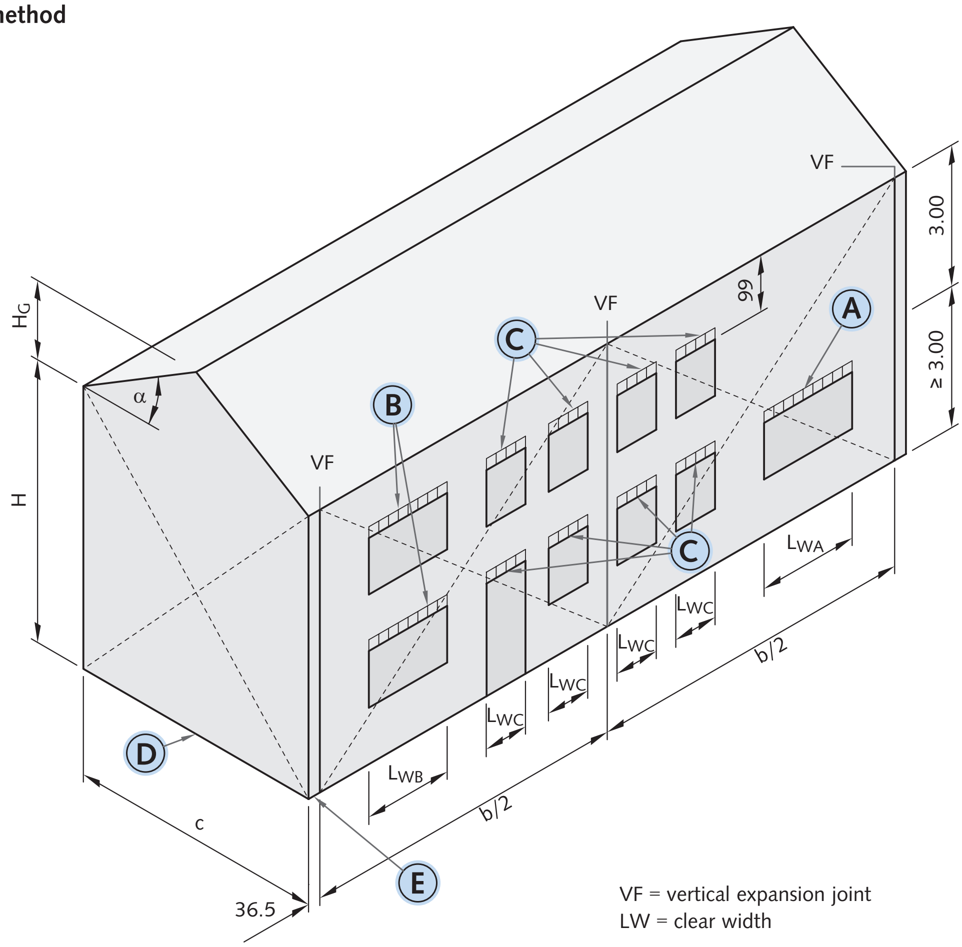
without arching-effect
Assumption:
1. Load height $H \leq h_1$ (m)

with arching-effect
Assumption:
1. Load height $H \geq h_1$ (m)
2. No openings in arching-area
3. No point-load in arching-area
4. Space available at sides to transfer shear forces

Arching-triangle height $\Delta h = 0.866 \times L_S$
Arching height $h_1 = \Delta h + 0.25$ (m)
L_W = Clear width
Support length A_l = 95 mm
Bracket length = $L_W + 2 \times A_l$
Static width $L_S = L_W + 2 \times A_l/3$

3.1 Calculation method

House 1:
Position A – E



VF = vertical expansion joint
LW = clear width

Dimensions and specifications:

b	= < 20.0 m	L_{WA}	= 6.01 m
c	= 11.99 m	L_{WB}	= 3.01 m
H	= 6.00 m	L_{WC}	= 1.01 m
H_G	= 1.50 m		
α	= 14°		

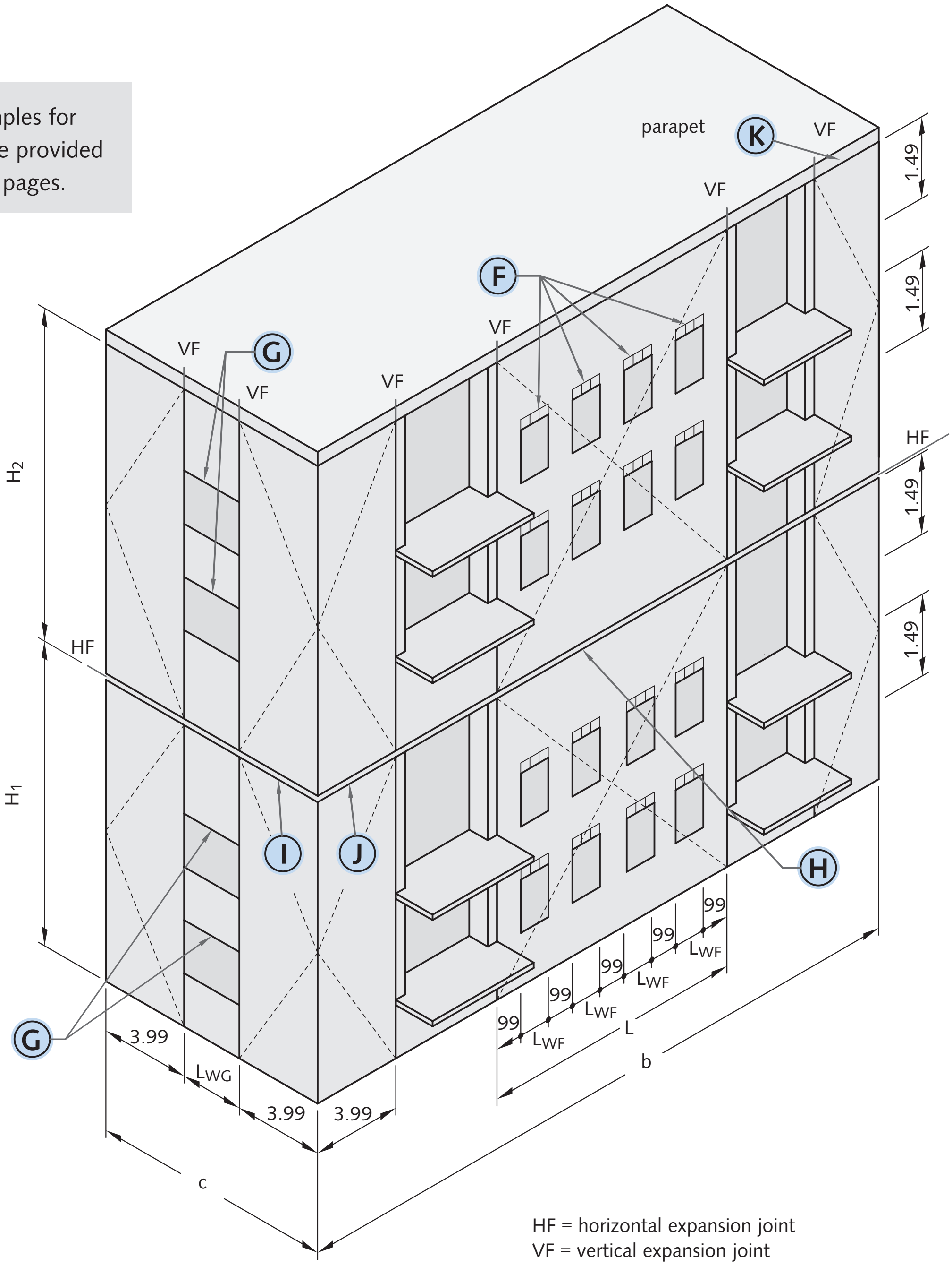
Calculation examples for positions A – E are provided on the following pages.

Brick: γ = 18.0 kN/m^3
Brick format: NF (240 × 115 × 71 [mm]),
Wall spacing: a = 100 mm,
Invisible support above window openings,
Expansion joint/damp proof course is required at the foot of the masonry,
Main supporting wall: concrete,
HTA-CE Channels with corner elements installed at the building corners.

Design examples

House 2:
Position F – K

Calculation examples for positions F – K are provided on the following pages.



HF = horizontal expansion joint
VF = vertical expansion joint
LW = clear width

Dimensions and specifications:

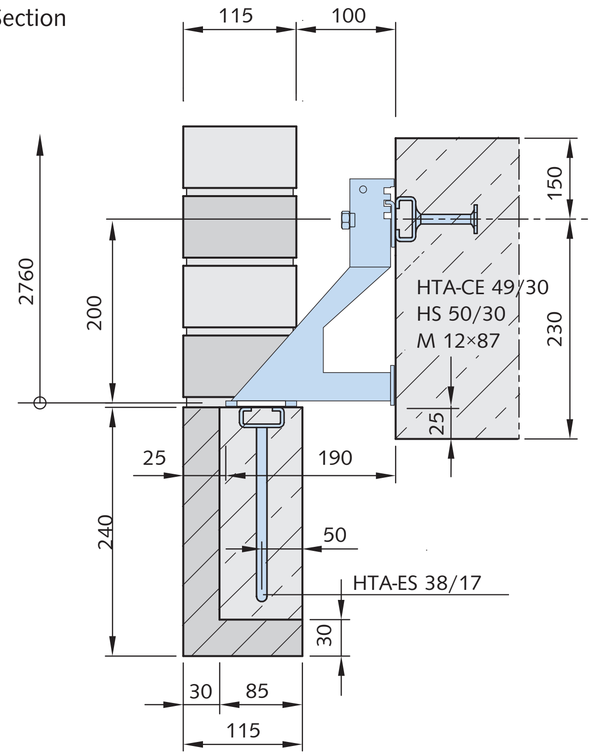
L	= 8.99 m	L_{WG}	= 3.01 m
H_1	= 6.00 m	c	= 10.99 m
H_2	= 7.00 m	b	= 22.99 m
L_{WF}	= 1.01 m		

Concrete block: γ = 22.0 kN/m^3
Block format: (240 × 115 × 113 [mm]), (Concrete – Façade blocks),
Wall spacing: a = 140 mm,
visible support angle under the lintel of the window opening. The brickwork is placed on top of the angle bracket.
Main supporting wall: concrete, no cast-in HTA-CE Channels: construction system is connected using anchor bolts.

HALFEN SUPPORT BRACKETS – DESIGN GUIDE

3.2 Position A, House 1: Suspension of precast lintels

Section



cf; approximate calculation with average weight of 21 kN/m³:

g_{FT} = 0.24 × 0.115 × 21.0 = 0.58 kN/m

g_H = 2.76 × 0.115 × 21.0 = 5.71 kN/m

$\sum g$ = 0.62 + 5.71 = 6.33 kN/m

→ F_{V1} = 6.33 × 6.01 / 6 = 6.35 kN

→ F_{V1d} = 1.35 × F_{V1} = 8.57 kN

Selecting the support bracket:
Selected:
3 × precast element;
2 × suspension elements for each precast element
HK5-S - 8.0 - 190
(see FM catalogue) → × = 200 mm
Characteristic connection loads:

Calculation:
(for each suspension point)
precise calculation:

g_{FT} = (0.24 × 0.115 − 0.085 × 0.21) · 18.0
+ 0.085 × 0.21 × 25.0 ≈ 0.62 kN/m

g_H = 2.76 × 0.115 × 18.0 ≈ 5.71 kN/m

$\sum g$ = 0.62 + 5.71 = 6.33 kN/m

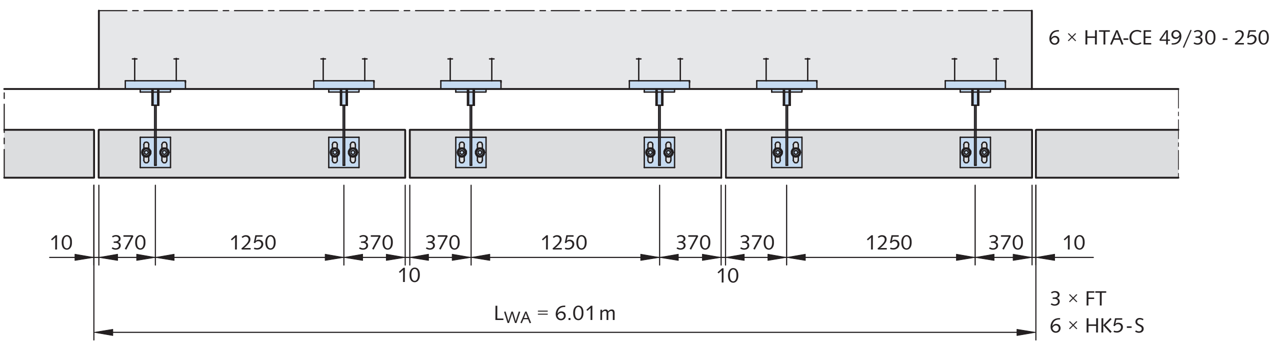
→ F_{V1} = 6.33 × 6.01 / 6 = 6.35 kN

→ F_{V1d} = 1.35 × F_{V1} = 8.57 kN

Fixing material:
Main support wall:
Selected:
6 × HTA-CE 49/30 - 250 standard length,
HS 50/30, M12 × 87

Precast element:
Selected:
HTA-ES 38/17 - 150,
2 × HS 38/17, M 10 × 30 each suspension element
(see FM catalogue).

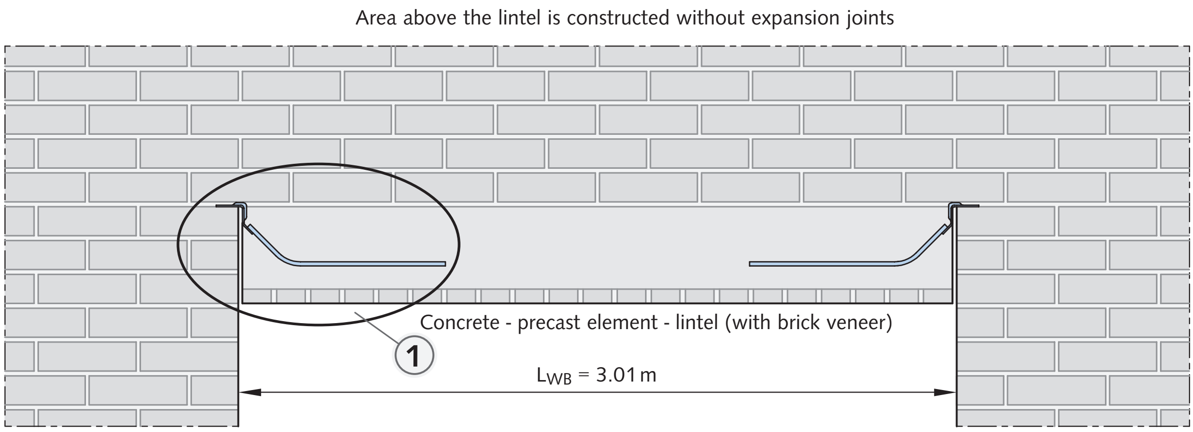
Plan



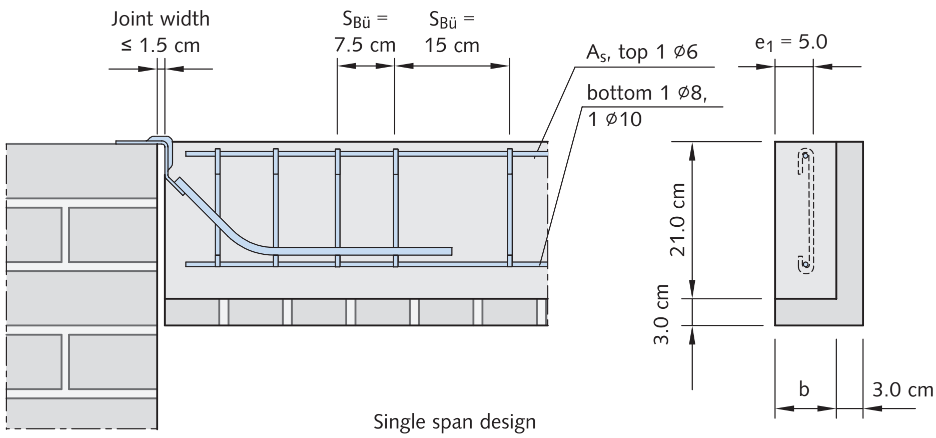
HALFEN SUPPORT BRACKETS – DESIGN GUIDE

3.3 Position B, House 1: Precast lintel – FSW Precast lintel bracket with bar

Precast lintel – FSW Precast lintel bracket with bar
(Position B, House 1)



Detail 1



Load calculation:

g_{FT} = (0.24 × 0.115 - 0.085 × 0.21) × 18.0
+ 0.085 × 0.21 × 25.0 = 0.62 kN/m

g_H = (0.99 − 0.24) × 0.115 × 18.0 = 1.55 kN/m

$\sum g$ = 0.62 + 1.55 = 2.17 kN/m

→ F_{V1} = 2.17 × 3.01 / 2 = 3.27 kN ≤ 3.5 kN

Selecting the precast lintel bracket:

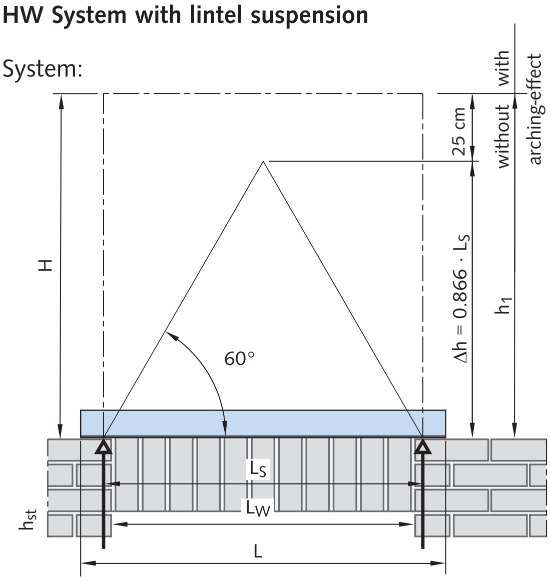
Selected:
1 × Precast element
2 × Precast lintel brackets for each precast element
FSW - 3.5 - 80

FSW Precast lintel bracket with bar						
	Allowable load per bracket [kN]					
	F_V = **3.5** (F_{Rd} = **4.7**)	F_V = **2.6** (F_{Rd} = **3.5**)	F_V = **3.9** (F_{Rd} = **5.3**)	F_V = **5.1** (F_{Rd} = **6.9**)	F_V = **5.3** (F_{Rd} = **7.2**)	F_V = **6.8** (F_{Rd} = **9.2**)
Precast lintel bracket	**FSW - 3.5 - 80**	**FSW - 2.6 - 60**	**FSW - 3.9 - 60**	**FSW - 5.1 - 60**	**FSW - 5.3 - 80**	**FSW - 6.8 - 80**
Material:	Rebar material: B500		Angle bracket: W 1.4404 or 1.4571 (A4) or duplex 1.4062, 1.4162, 1.4362 (L4)			

3.4 Position C, House 1: Support angle for suspended soldier course: Hidden support

HW System with lintel suspension

System:



Determining the arching-effect (with/without)

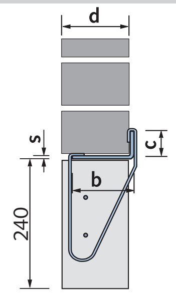
Load height	H	$= 0.74\,m$
Clear width	L_W	$= 1.01\,m$
Angle length	L	$= 1.20\,m$
Static width	L_S	$= 1.07\,m$
Arching-triangle height	Δh	$= 0.866 \cdot 1.07 = 0.93\,m$
Arching height	h_1	$= 0.93 + 0.25 = 1.18\,m$

$H < h1 \rightarrow$ without arching-effect

Selecting the support angle

see table 07, → page 18, case B

Table 8: Case B — HW with lintel suspension

 Dimensions in mm	Clear width L_W	Support angle length L	Load height H [m] with d ≤ 11,5 cm, γ ≤ 18kN/m³ ≤ 1.00	≤ 1.25	≤ 1.50	≤ 1.75	≤ 2.00	≤ 2.25	≥ 2.5	Δh [m]
			Angle dimensions **b** × **c** × **s** [mm]							
	510	700	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	0.497
	760	950	90 × 60 × 4	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	0.713
	1.010	1.200	90 × 60 × 4	90 × 60 × 5	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	0.930
	1.260	1.450	90 × 90 × 4	90 × 90 × 5	90 × 90 × 5	90 × 60 × 4	90 × 60 × 4	90 × 60 × 4	90 × 60 × 4	1.146
	1.510	1.700	90 × 90 × 5	90 × 90 × 5	90 × 90 × 6	90 × 90 × 6	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	1.363
	1.760	1.950	90 × 90 × 5	90 × 90 × 6	90 × 90 × 8	90 × 90 × 8	90 × 90 × 5	90 × 90 × 5	90 × 90 × 5	1.579
	2.010	2.200	90 × 100 × 8	90 × 100 × 8	90 × 110 × 8	SK	SK	SK	90 × 100 × 8	1.796

= with arching-effect
= without arching-effect
SK = special bracket incl. static verification

Selected: HW 90 × 60 × 4

HSL-W Suspension loop in every 3rd perpendicular joint

Note:
To minimize angle deflection, all support brackets and loose support angles must be temporarily supported from below until the mortar in the masonry above an opening has sufficiently cured (plate effect).

HALFEN SUPPORT BRACKETS – DESIGN GUIDE

3.5 Position D, House 1: Support at base of wall (damp proof course considered)

Load calculation:

$\sum F_V = 11.99 \times (6.0 + 0.5 \times 1.5) \times 0.115 \times 18.0 = 167.53\,\text{kN}$

$g = 167.53 / 11.99 = 13.97\,\text{kN/m}$

bracket spacing $e = 0.50\,\text{m}$

$F_V = 6.99\,\text{kN}$

Selecting the support bracket:

Selected:

Single support bracket HK5-UV - 8.0 - 190 - SK in spacings of e = 0.50 m with non-fixed support angles HW 95 × 20 × 2 – 480 [mm];

given: $F_V = 6.99\,\text{kN} <$ allow. $F_V = 8.0\,\text{kN}$

→ x = 200 mm (see FM catalogue)

offset dimension (depends on the height of the damp proof course)

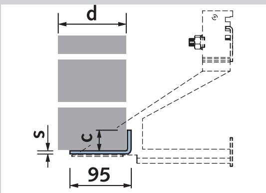
assumed: v = 150 mm

Characteristic connection loads:

$$Z = -D = \frac{6.99 \times \left(100 + \frac{115}{2} + 15\right)}{200 - 20 - 10} \approx 7.09\,\text{kN}$$

$$R = \sqrt{6.99^2 + 7.09^2} = 9.95\,\text{kN}$$

Table 9



Dimensions in mm	Spacing between 2 support brackets e	Angle length L	Support angle dimensions b × c × s
	500	**480**	95 × 20 × 2
	750	**730**	95 × 30 × 3
	1000	**980**	95 × 40 × 4

Note: Support angles HW with 80 mm support width are available for brick thickness d = 90 mm.

Fixing material:

Selected:

HTA-CE 49/30, HS 50/30, M12 × 87

Statical calculation for the support bracket

(see HALFEN HK5 Support bracket type test)

Additional verification:

Connection: Offset web to web plate

Width of the offset plate bv = 60 mm

Material thickness t = 4 mm

$A_{1\text{-}1} = 4 \times 60 = 240\,\text{mm}^2$

$W_{1\text{-}1} = 4 \times 60^2 / 6 = 2400\,\text{mm}^3$

$N_d = F_{vd} = 9431\ \text{N}$

$e_a = 100 + 115 / 2 + 15 - (190 - 10 - 60 / 2) = 22.5\,\text{mm}$

$M_d = N_d \times e_a = 212207\ \text{Nmm}$

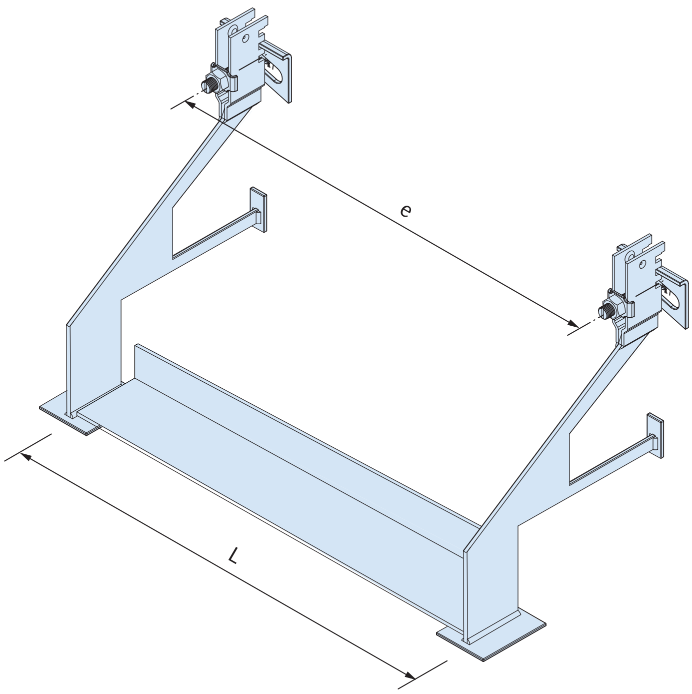
$\sigma_d = N_d / A_{1\text{-}1} + M_d / W_{1\text{-}1} = 127.72\ \text{N/mm}^2$

Verification: $\sigma_d / (f_{yk} / \gamma_{M0}) = 0.31 \le 1$

Verification of the support angle

Selected:

HW 95 × 20 × 2 - 480



3.6 Position E, House 1: Support at external corners

Load calculation:
The effect of continuity is not possible
as the angle bracket cannot deform upwards.
The wall has a greater stiffness.

$g = 6.00 \times 0.115 \times 18{,}0 = 12.42\,\text{kN/m}$
$A = B = 0.307 / 2 \times 12.42 \approx 1.91\,\text{kN}$
$C = (0.25 / 2 + 0.257) \times 12.42 + 1.91 \approx 6.65\,\text{kN} \leq 8.0\,\text{kN}$
$D = (0.25 + 0.375) \times 0.5 \times 12.42 = 3.88\,\text{kN}$

$\max F_V = C = 6.65\,\text{kN} < 8.00\,\text{kN}$
$\max F_{Vd} = 1.35 \times Fv = 8.98\,\text{kN}$

Selecting the support bracket:
Selected:
Angle support bracket
HK5-FR - 8.0 - 190 - 790/ 315 SK
3 × support brackets (see FM catalogue)
→ x = 200 mm, v = 150 mm

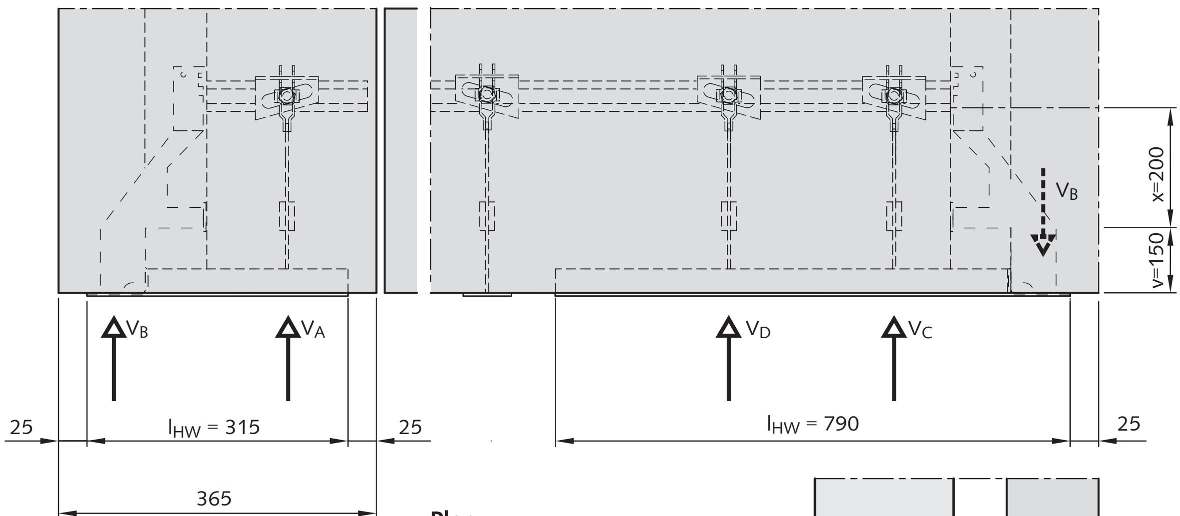
Characteristic connection loads:

$$Z = -D = \frac{6.65 \times (100 + \frac{115}{2} + 15)}{200 - 20 - 10} \approx 6.75\,\text{kN}$$

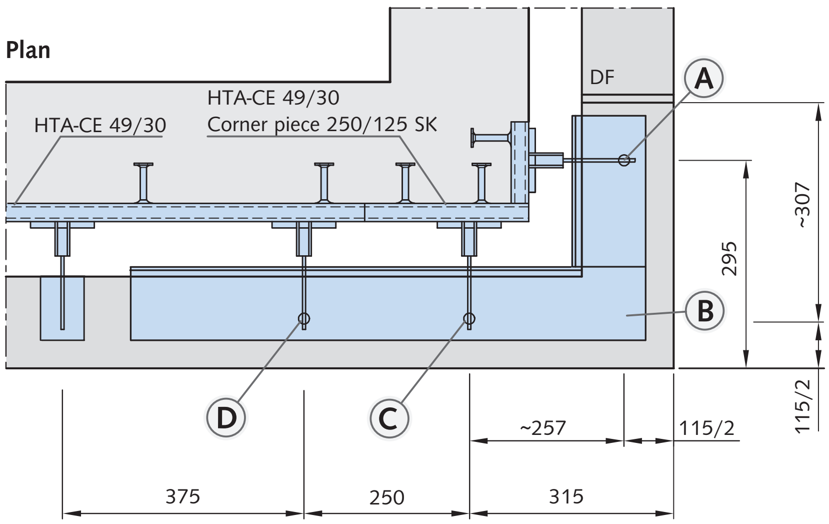
$$R = \sqrt{6.65^2 + 6.75^2} = 9.48\,\text{kN}$$

Fixing material:
Selected:
HTA-CE 49/30, HS 50/30, M12×87

View from front



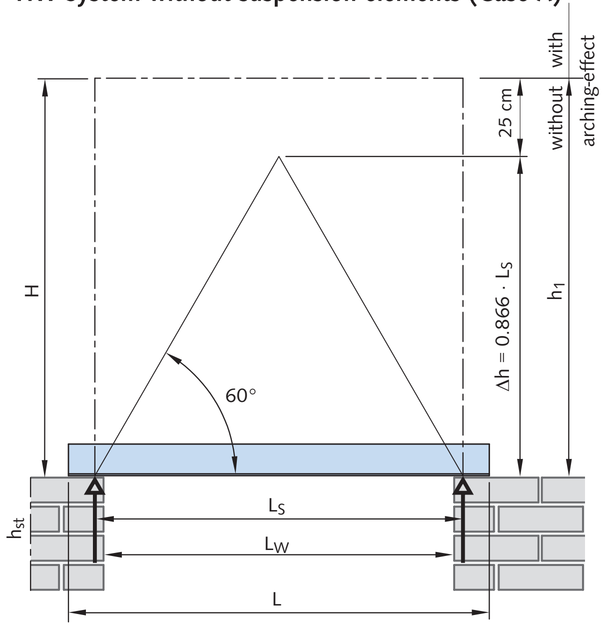
Plan



HALFEN SUPPORT BRACKETS – DESIGN GUIDE

3.7 Position F, House 2: Support angle above openings: Visible support

HW System without suspension elements (Case A)



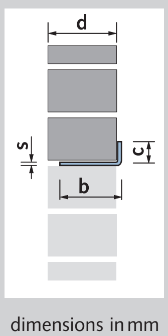
Verification of the arching-effect (with/without)

Load height H = 1.49 m
Clear width L_W = 1.01 m
Angle length L = 1.20 m
Span L_S = 1.07 m
Arching-triangle height $\triangle h = 0.866 \cdot 1.07 = 0.93$ m
Arching height $h_1 = 0.93 + 0.25 = 1.18$ m
$H > h_1 \rightarrow$ with arching-action

Selecting the support angle

see table 06, → page 18, case A

Table 10: Case A – HW without suspension elements



Clear width L_W	Support angle length L	Load height H [m] bei d ≤ 11.5 cm, γ ≤ 18kN/m³ ≤ 1.00	≤ 1.25	≤ 1.50	≤ 1.75	≤ 2.00	≤ 2.25	≥ 2.25	Δh [m]
		Angle dimensions **b** × **c** × **s** [mm]							
510	700	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	0.497
760	950	90 × 60 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	90 × 30 × 3	0.713
1.010	1.200	90 × 60 × 4	90 × 60 × 4	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	90 × 45 × 3	0.930
1.260	1.450	90 × 60 × 5	90 × 60 × 5	90 × 70 × 5	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	90 × 60 × 3	1.146
1.510	1.700	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	90 × 90 × 5	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	1.363
1.760	1.950	90 × 90 × 5	90 × 90 × 5	90 × 90 × 6	90 × 90 × 8	90 × 90 × 4	90 × 90 × 4	90 × 90 × 4	1.579
2.010	2.200	90 × 90 × 8	90 × 100 × 8	90 × 100 × 8	SK	SK	SK	90 × 90 × 8	1.796

= with arching-effect
= without arching-effect
SK = Special angle including static verification

Selected: HW 90 × 45 × 3

Note:
To minimize angle deflection, all angle support brackets and non-fixed angles must be temporarily supported from below until the mortar in the masonry above an opening has sufficiently cured (plate effect).

3.8 Position G, House 2: Support above openings: Visible support, Expansion joint

Load calculation:
$L_{WG} = 3.01\,m$
$g = 1.49 \times 0.115 \times 22.0 = 3.77\,kN/m$
Bracket spacing → $e = 0.75\,m$

$F_v = 0.75 \times 3.77 = 2.83\,kN \leq 4.0\,kN$

Selecting the support brackets:
Selected:
Support bracket HK5-FV - 4.0 - 230 - 1500 SK with
2 support brackets
given, $F_v = 2.83\,kN \leq$ allow. $F_v = 4.0\,kN$
given, $F_{vd} = 1.35 \times F_v = 3.82\,kN$
$x = 175\,mm$ (see FM catalogue), $v = 90\,mm$

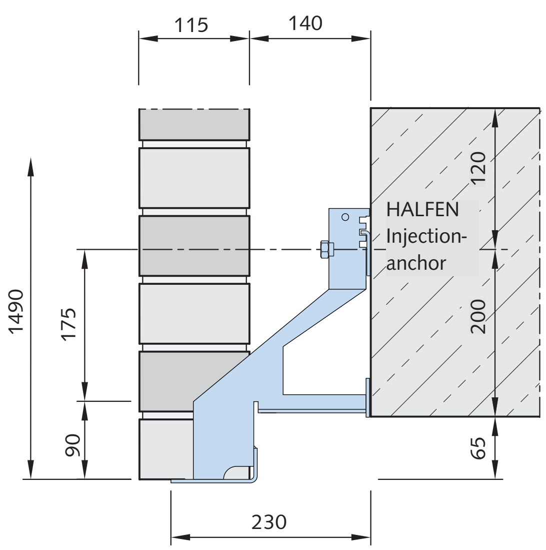
Characteristic connection loads:

$$Z = -D = \frac{2.83 \times (140 + \frac{115}{2} + 15)}{175 + 13 - 20 - 10} \approx 3.80\,kN$$

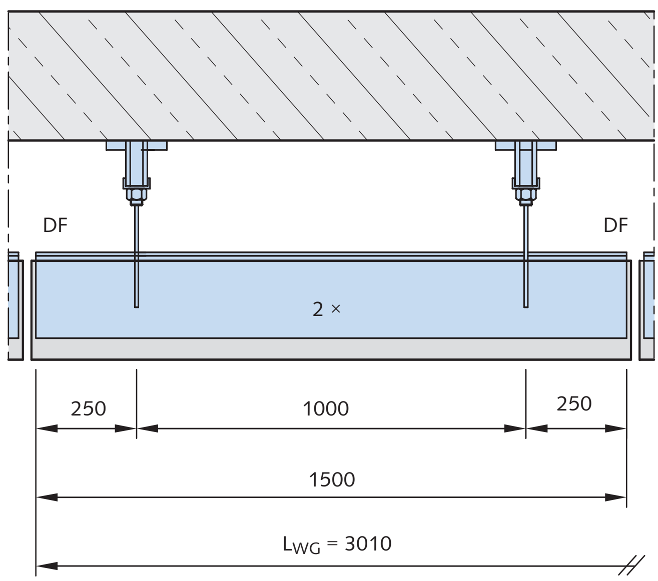
$$R = \sqrt{2.83^2 + 3.80^2} = 4.74\,kN$$

Fixing material
(in accordance with the structural engineer's specifications:
Tension zone, cracked concrete, reinforced concrete lintel)
Selected:
HALFEN Injection anchor
HB-VMZ-A60 M10-60/135-A4
see ETA - 07/0256 approval

Section



Plan



3.9 Position H, House 2: Intermediate support — continuous wall with window opening(s)

Load calculation:
$B_1 = 0.99 + 1.01 = 2.00\,m$
$H_2 = 7.00\,m$
$\Sigma Fv = (7.00 \times 2.00 - 2 \times 1.51 \times 1.01) \times 0.115 \times 22 = 27.70\,kN$

Selecting the support brackets:
Selected:
4 × single support brackets
HK5-U - 8.0 - 230 with (non-fixed) support angle bracket above the window opening(s)
HW 95 × 60 × 4 -1230
given, $F_{v1} = \Sigma F_v / 4 = 27.7 / 4 = 6.93\,kN \le 8.0\,kN$
$F_{v1d} = 1.35 * F_{v1} = 9.35\,kN$
→ x = 250 mm (see FM catalogue)

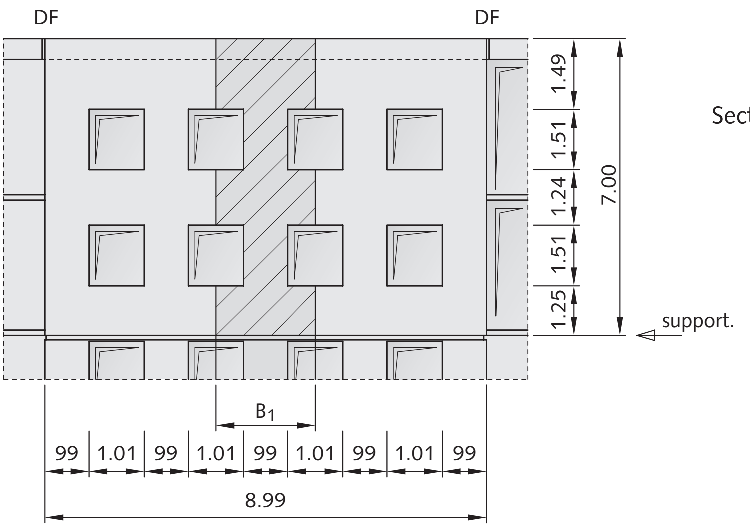
Characteristic connection loads:

$$Z = -D = \frac{6.93 \times (140 + \frac{115}{2} + 15)}{250 + 13 - 20 - 10} \approx 6.32\,kN$$

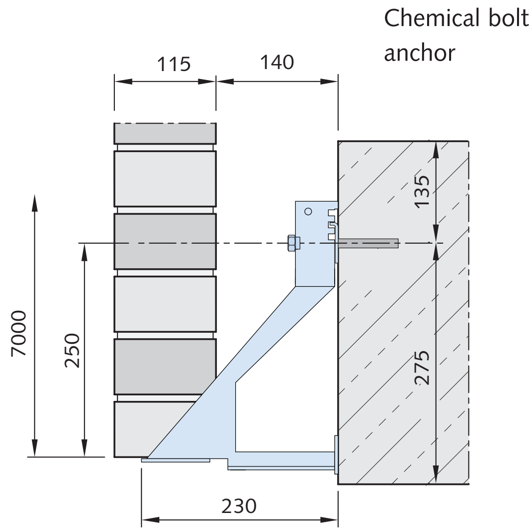
$$R = \sqrt{6.93^2 + 6.32^2} = 9.37\,kN$$

Fixing material:
(in accordance with the static engineer's specifications: verified pressure zone (non-cracked concrete) in reinforced concrete column)
Selected:
HALFEN Chemical bolt anchor
see ETA - 07/0257 approval
HB -V-A 16-65/210 A4

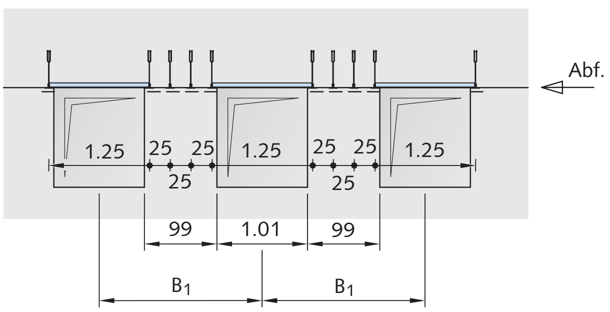
Load verification (Position H)



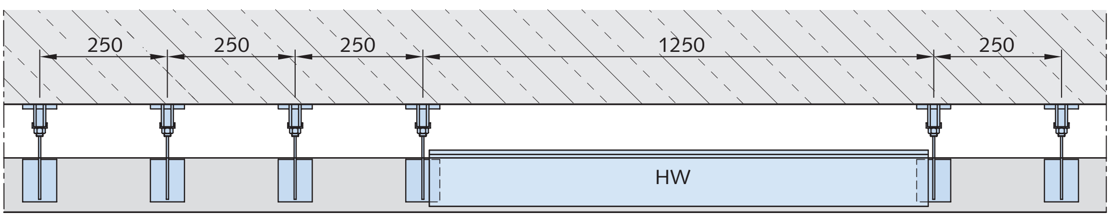
Section



Position(s) of the support brackets



Section



3.10 Position I, House 2: Intermediate support — in a continuous wall

Load calculation:
H2 = 7.00 m
g = 7.0 × 0.115 × 22.0 = 17.71 kN/m
e = 0.25 / 0.50 / 0.25 ... = 0.375 m
Fv = 17.71 × 0.375 = 6.64 kN

Selecting the support brackets:
Selected:
single support brackets
HK5-U - 8.0 - 230 in spacings
e = 0.25 / 0.50 / 0.25 ... [m] with (non-fixed) angle bracket

HW 95 × 20 × 2 -480
given, Fv = 6.64 kN ≤ 8.0 kN
Fv1d = 1.35 × Fv1 = 8.97 kN
→ x = 250 mm (see FM catalogue)

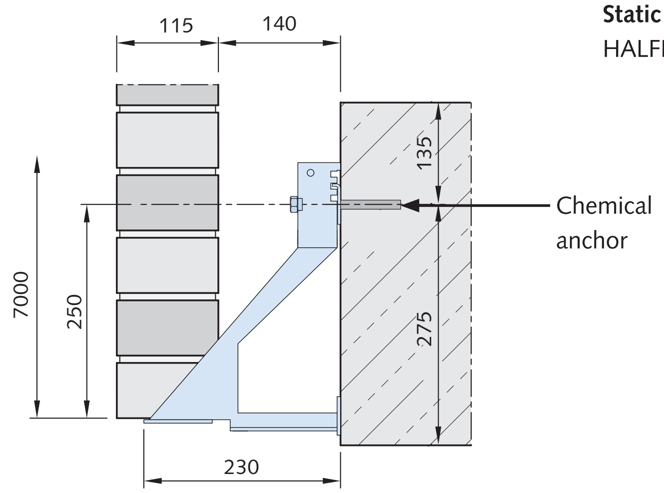
Characteristic connection loads:

$$Z = -Dd = \frac{6.64 \times (140 + \frac{115}{2} + 15)}{250 + 13 - 20 - 10} \approx 6.06\,\text{kN}$$

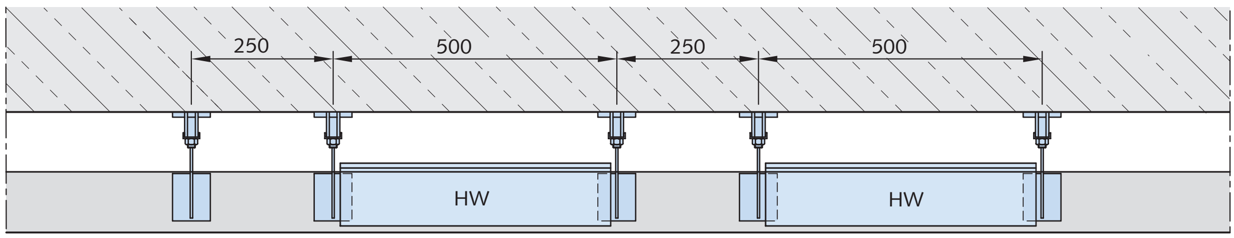
$$R = \sqrt{6.64^2 + 6.06^2} = 8.99\,\text{kN}$$

Fixing material:
(In accordance with the static engineer's specifications: verified pressure zone (non-cracked concrete) in reinforced concrete wall)
Selected:
HALFEN Chemical anchor
HB -V-A 12-65/190 A4
see ETA - 07/0257 approval

Section



Static calculation of the angle bracket:
HALFEN HK5 Support bracket (see type test)



3.11 Position J, House 2: Supports at external corners — without HTA-CE Cast-in channels

Load verification:
H_2 = 7.00 m
α = 55.0°
g = 7.0 × 0.115 × 22.0 = 17.71 kN/m
e_1 = 0.245 + 0.375 / 2 = 0.433 m
F_{v1} = 17.71 × 0.433 = 7.66 kN < 8.0 kN
F_{v1d} = 1.35 × F_{v1} = 10.34 kN
e_2 = 0.375 m
F_{v2} = 17.71 × 0.375 = 6.64 kN < 8.0 kN
F_{v2d} = 1.35 × F_{v2} = 8.97 kN

Selecting the wall bracket:
Selected:
Pos. J-1: Angle support bracket
HK5-F - 8.0 - 230 - 825 SK
1 × bracket + 1 × Lateral lug anchor
Pos. J-2: Angle support bracket
HK5-F/FV - 8.0 - 230–825 SK
2 × brackets = 250 mm, v = 70 mm

Characteristic connection loads:
zu Pos. J-1: back of bracket A
S = F_{v1} / sin α = 9.35 kN
D = F_{v1} / tan α = 5.35 kN
for Pos. J-2: back of bracket B

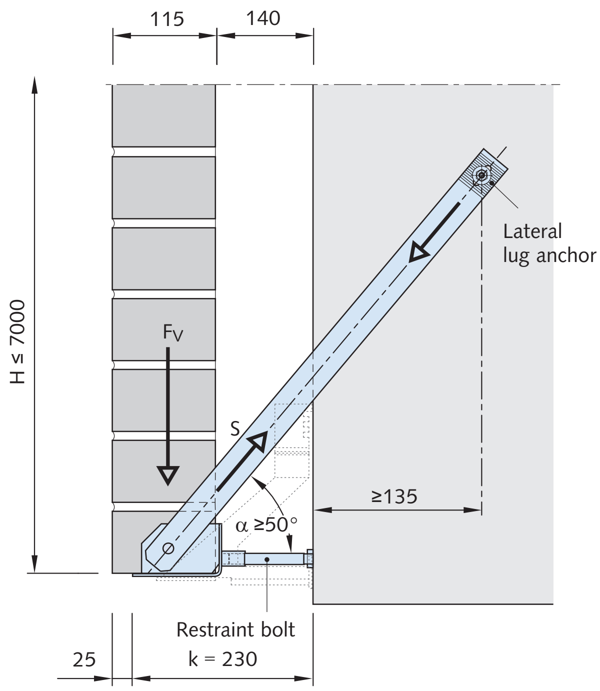
$$Z = -D = \frac{6.64 \times (140 + \frac{115}{2} + 15)}{250 + 13 - 20 - 10} \approx 6.06\,\text{kN}$$

$$R = \sqrt{6.64^2 + 6.06^2} = 8.99\,\text{kN}$$

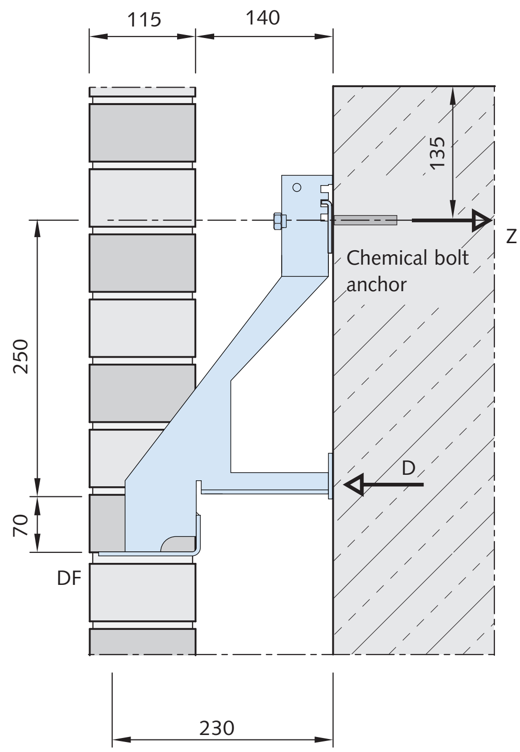
Fixing material:
(in acc. with the static engineer‘s specifications: verified pressure zone (non-cracked concrete) in reinforced concrete wall)
for Pos. J-1 (back of bracket) and J-2 selected:
HALFEN Chemical bolt anchor
HB -V-A 12-65/190 A4
see ETA - 07/0257 approval
for Pos. J-1 (Lateral lug anchor) selected:
HALFEN Chemical bolt anchor
HB -V-A 16-65/210 A4
see ETA - 07/0257 approval

Static calculation of the support brackets:
see HALFEN HK5 support bracket (type test)

Section Pos. J-1, back of bracket A



Section Pos. J-2, back of bracket B + C



3.11 Position J, House 2: Supports at external corners — without HTA-CE Cast-in channels

Additional verification:
for Pos. J-1 (Lateral lug anchor)

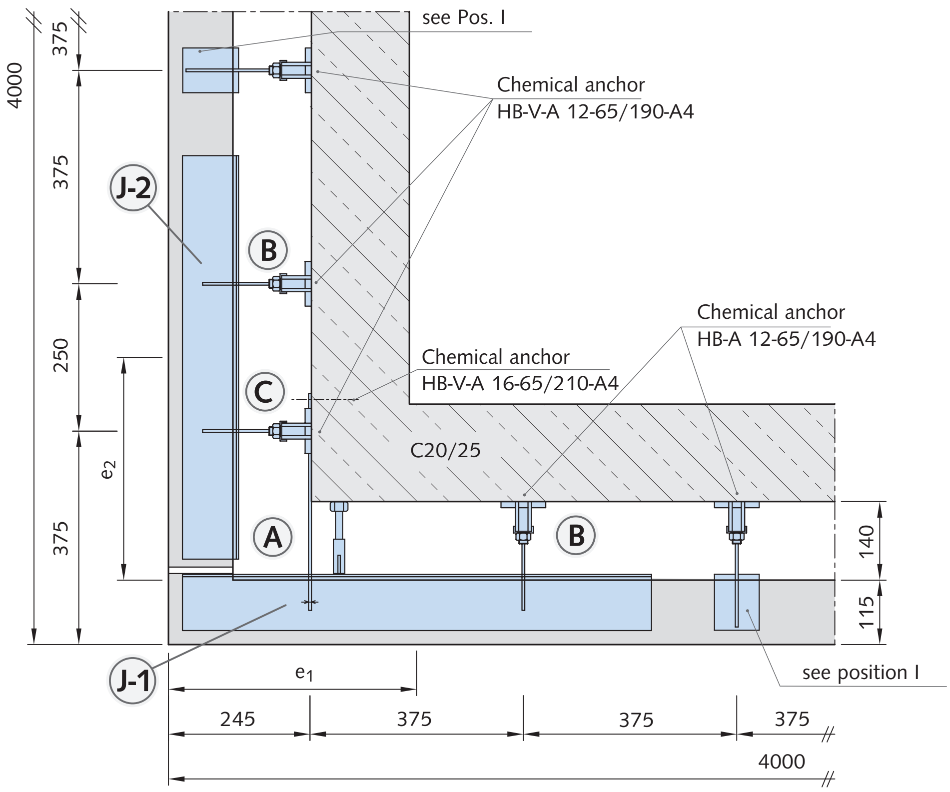
Verification of the tension strap 50 × 4 mm:
$A = 50 \times 4 = 200\,mm^2$
$A_{net} = (50 - 17) \times 4 = 132\,mm^2$
$N_{t,Rd} = 61776\,N$
$S_d = 12623\,N$
$S_d / N_{t,Rd} = 12623 / 61776 = 0.20 < 1$

Connection between the tension strap and welded web in the angle:
Hex-headed bolt HSK M16 × 40, A4-50
Through-hole $d_L = 17\,mm$
$e_1 = e_2 = 25\,mm$
$S_d = 12623\,N$
$F_{v,Rd} = \alpha \times A_{sp} \times f_{ub} / \gamma_{M2} = 0.5 \times 157 \times 500 / 1.25 = 31400\,N$
$S_d / F_{v,RD} = 0.40 < 1$
min t = 4.00 mm
$f_{u,red} = \min(f_u;\ 0.5 \times f_{yk} + 0.6 \times f_u) = 590\,N/mm^2$
$k_1 = \min(2.5;\ 2.8 \times e_2 / \varnothing d_L - 1.7) = 2{,}42$
$\alpha_d = e_1 / (3 \times \varnothing d_L) = 0.49$
$\alpha_b = \min(\alpha_d;\ f_{ub} / f_{u,red};\ 1) = 0.49$
$F_{b,Rd} = k_1 \times \alpha_b \times f_{u,red} \times \min t \times M / \gamma_{M2} = 35800\,N$
$S_d / F_{b,Rd} = 0.35 < 1$

Verification of the restraint bolt:
$l_{total} = 130\,mm$
$N_{cr} = 280500\,N$
$\alpha = 0.49$
$\lambda'0 = 0.4$

Sleeve
$\lambda' = \sqrt{(A \times f_{yk} / N_{cr})} = 0.37$
$\phi = 0.5((1+\alpha x(\lambda' - \lambda'0) + \lambda'^2)) = 0.56$
$\chi = 1/((\phi + (\phi^2 - \lambda'^2)^{0,5})) = 1$
$N_{b,Rd} = \chi \times A \times f_{yk} / \gamma_{M1} = 34173\,N$

Restraint bolt
$\lambda' = \sqrt{(A \times f_{yk} / N_{cr})} = 0.50$
$\phi = 0.5((1+\alpha \times (\lambda' - \lambda'0) + \lambda'^2)) = 0.65$
$\chi = 1/((\phi + (\phi^2 - \lambda'^2)^{0,5})) = 0.94$
$N_{b,Rd} = \chi \times A \times f_{yk} / \gamma_{M1} = 60286\,N$
$D_d / N_{b,Rd,min} = 0.21 < 1$



3.12 Position K, House 2: Parapets — HAV Parapet support brackets

Load calculation:
(determined in accordance with DIN EN 1991-1-4 with simplified wind-gust pressure for buildings up to 25 m in height)
$H = H1 + H2 = 6{,}0 + 7{,}0 = 13.00\,m < 18.0\,m$
$c = 10.99\,m$
$b = 22.99\,m$
$H / c = 1.18$

Gust response factor q_p
Wind zone 2, Non-coastal → $q_p = 0.80\,kN/m^2$

Exterior pressure factor $c_{pe,1}$
$\mathbf{c_{pe,1,A} = -1.40}$
$c_{pe,1,B} = -1.10$
$c_{pe,1,C} = -0.50$
$\mathbf{c_{pe,1,D} = 1.00}$
$c_{pe,1,E} = -0.50$

Element spacing:
$e_N \leq 0.75\,m$ Standard
$e_R \leq 0.375\,m$ Edge
Element height $e_h = 1.10\,m$
$A = 0.83\,m^2$

Load case: Wind pressure
$w_e = c_{pe,1,D} \times q_p = 0.80\,kN/m^2$
$W = w_e \times e_N = 0.60\,kN/m$
$W_d = W \times 1.5 = 0.90\,kN/m$

Load case: Wind suction
$w_e = c_{pe,1,A} \times q_p = -1.12\ kN/m^2$
$W = w_e \times e_N = -0.84\ kN/m$
$W_d = W \times 1.5 = -1.26\ kN/m$

Selecting the parapet support brackets:
Selected:
HAV Parapet support brackets 80/1100
(see FM catalogue)

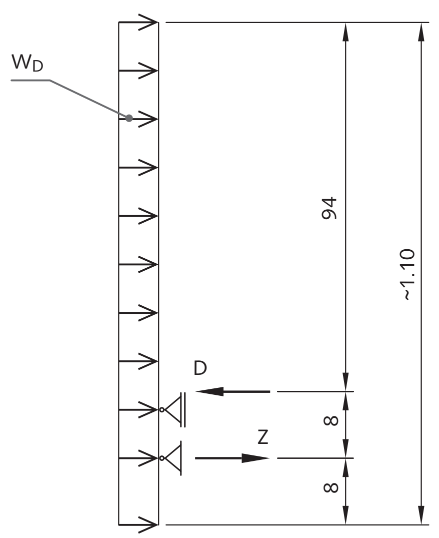
Support loads:
Load case wind suction:
max $Z_d = 9182$ N
max $D_d = 7796$ N

Load case wind pressure:
max $Z_d = 4579$ N
max $D_d = 5569$ N

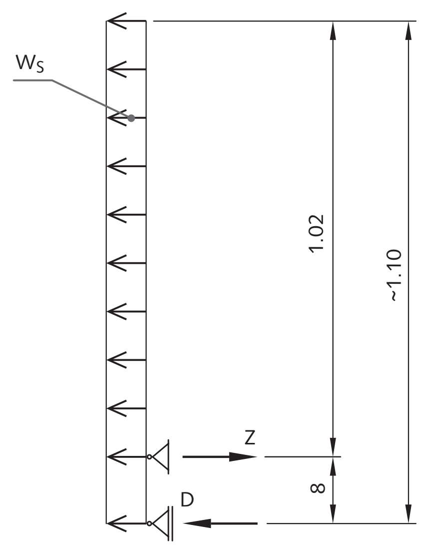
Fixing material:
Selected:
HTA-CE 38/17 with HS 38/17 M 12 × 25

The single-point fixing, which is unstable in its installation state is stabilized by applying the tightening torque to the bolt and by the resulting friction between the steel plate and the concrete.

Load case: Wind pressure



Load case: Wind suction

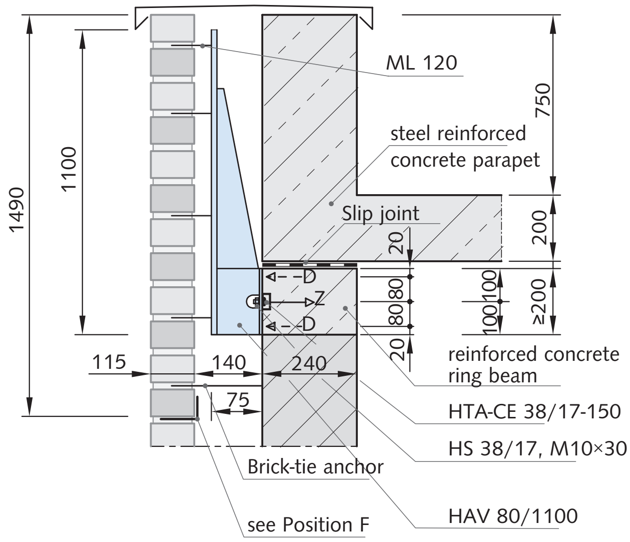


3.12 Position K, House 2: Parapets — HAV Parapet support brackets

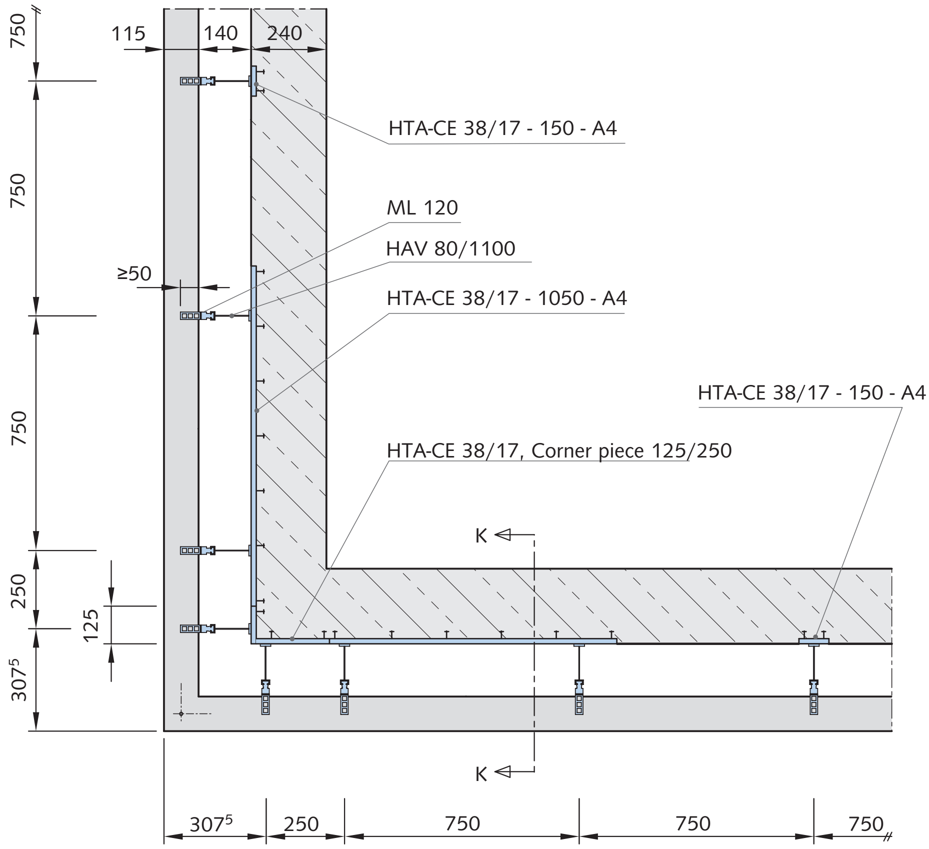
Static calculation for parapet support brackets
(see static calculation for single
HALFEN HAV Parapet support brackets)

Additional verification:
Verification of compression: Concrete C20/25
A surface area of A is assumed for compression
$A \approx 33.33 \times 30 = 1000\,mm^2$
$f_{cd} = \alpha \times f_{ck} / \gamma c = 0.85 \times 20 / 1.5 = 11.3\ N/mm^2$
$\max F_{Rdu} = 3 \times A \times f_{cd} = 33997\ N$
$\max D_d / F_{Rdu} = 7796 / 33997 = 0.23 < 1$

Section K - K



Plan



4.1 Support brackets - HK5 Selection software

The HK5 selection software selects and combines the correct single support brackets and angle support brackets to provide the optimum support system for brick façades, as well as creating suitable drawings and an item list.

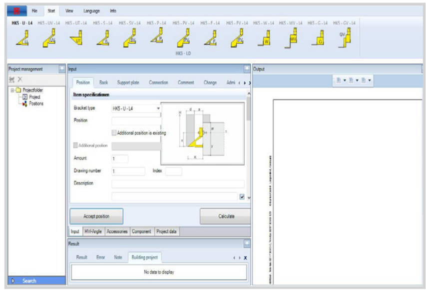
Input

- language selection on program start
- simple and easy-input
- select the required bracket support type (single or angle support type).
- enter the required dimensions for bracket support selection (Thickness of the masonry façade, ventilation cavity, insulation thickness ... etc.)
- if using angle support brackets (HK5- F, FV, etc.) select bracket length and type
- the load can be either user-preselected or determined by the programme based on input values
- selected standard bracket dimensions can be adapted to create custom bracket sizes

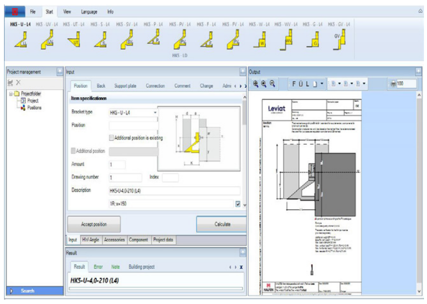
Output

After input is completed, select 'Calculate' and a suitable support bracket is selected.
The selected support bracket and important component dimensions are displayed.
The support bracket dimensions are shown in a drawing.
The overview and the support bracket drawings can be printed.
The selected support bracket can be included in an item list.

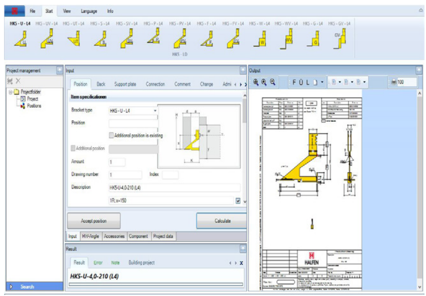
Splashscreen: HK5 Selection software



Input window



Right: Display of the over-view drawing



Right: Display of the selected support bracket

The Windows software for simple and and quick selection of suitable support bracket.
Software requirements: Windows 10 / Windows 8.x

HALFEN Calculation software
Our software can be found under:
www.halfen.com ► Downloads ► Software/CAD
Or simply scan the QR Code.

4.2 HALFEN HB Calculation software

The HALFEN Calculation software for HB Anchor systems provides the user with an easy-to-use and powerful tool to calculate anchor solutions.

Verification

- simple and clear input
- detailed results
- installation close to the component edge for single anchors or multiple anchors
- verification of round or square anchor plates
- stand-off installations
- verifiable print-out
- static verification according to European design methods as defined in EU guidelines
- guidelines for European Technical Assessment, ETAG 001, annex C
- Technical Report TR020 (verification of fire resistance)
- Technical Report TR029 (verification of chemical injection anchors)
- Technical Report TR045 (verification under seismic loads)

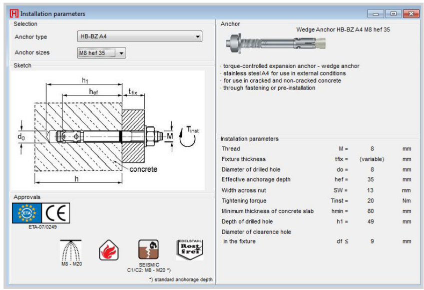
Input

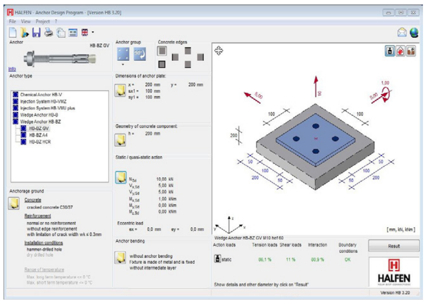
Interactive input of the loads and dimensions. The entries are displayed directly on input in a 3D visualization.

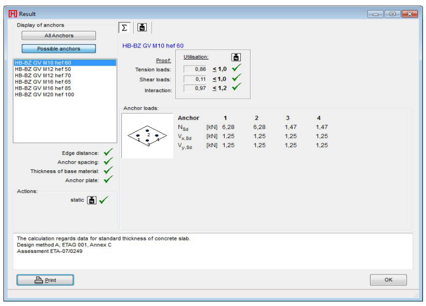
Results

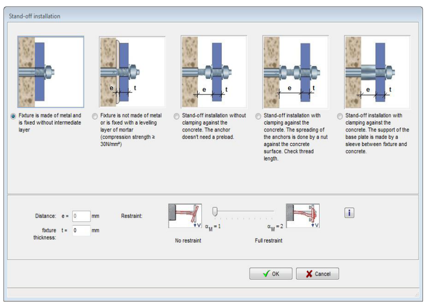
After calculation, the results for the selected anchor bolt types are displayed in a detailed list for printout.

Splash screen: HALFEN HB Software


HB Selection screen


Load input


Dowel selection menu


Bolt bending

HALFEN Calculation software for Windows; simple and efficient static verification of anchor bolt connections.
Software requirements: Windows 10 / Windows 8.x / Windows 7

HALFEN Calculation software
Our software can be found under:
www.halfen.com ⊳ Downloads ⊳ Software/CAD
Or simply scan the QR Code.

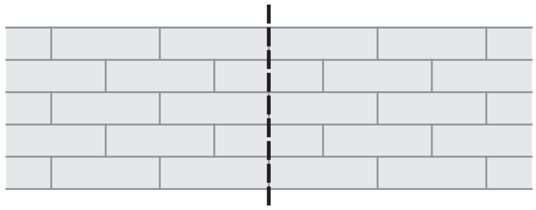
5 Serviceability / Controlling cracks

5.1 Cracks caused by shrinkage and changes in temperature

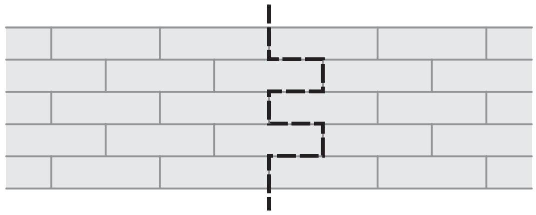
The external brick façade of double-leaf masonry walls is subject to stresses caused by humidity and temperature fluctuations. This leads to tensile stresses if free deformation of the wall is impeded. Because of their deformability, the stainless steel wire ties that are statically required to connect the façade with the main supporting wall, do not restrain necessary movement. Moreover, the façade supports and connections to adjacent components prevent free deformation and are the reason for constraining stresses. The magnitude of tensile stresses that occur in the masonry depends on several factors:

- Extent of deformation (shrinkage and swelling)
- Tensile strength and tension, modulus of elasticity (Secant modulus) of the masonry parallel to the bedding joints
- Level of constraint (supports, wall boundarys/edges)
- Stress reduction by stress relaxation

Crack types



Crack development in the bricks



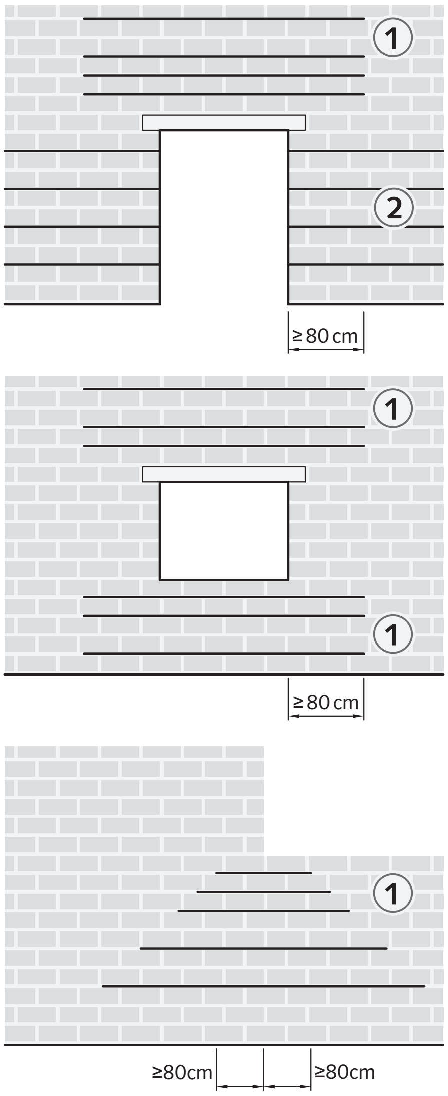
Crack development in the joints

Measures must be taken to prevent crack damage if the planned length of the façade is greater than the length for a crack-free wall. Brick façades are generally not subjected to planned loads (e.g. integrated floor slabs). Therefore, tensile stresses in the brick façade are not suppressed by compressive stresses and impact fully on the crack resistance of the façade. Tension stresses caused by temperature and shrinkage are predominantly horizontal, which means that cracks usually occur in a vertical direction. Depending on the horizontal tensile strength of the brick and the bond/shear strength between the brick and the mortar, the crack will develop either through the bricks or in the joints. Large overlap lengths in the masonry bond are therefore important for the crack resistance of the façade. Half-brick overlap is always preferrable as it provides the largest possible shear force transmitting surface between the brick and the bedding mortar.

The cracks in the masonry considered here generally do not have a negative effect on the stability of the façade. Nevertheless, the usability (protection against moisture, heat, noise) and the aesthetics of the exterior brickwork can be significantly impaired. Currently, experts do not consider crack-widths less than 0.2 mm to be a defect regarding usability and aesthetics. Constructive reinforcement in the bedding mortar cannot prevent cracks. However, steel reinforcement can help to finely distribute any cracks that develop, and to keep cracks under the crack-width criteria of 0.2 mm.

Serviceability / Controlling cracks

Experience has shown that corners located at openings and height offsets are particularly prone to cracking, as deformations and stresses in the wall concentrate at these points. Constructive reinforcement helps prevent cracking here if expansion joints are not used. The reinforcement anchorage length beyond the anticipated crack should be at least 80 cm. We recommend installing the reinforcement bars in at least 3 layers of the bed joints.



Bed joint-reinforcement in crack-prone areas

5.2 Crack free wall lengths l_R

Vertical expansion joints must be used in unreinforced external brickwork façades to prevent cracking. The spacing of the expansion joints depends, for example, on the climatic conditions, the characteristics of the building materials and the colour-design of the external masonry. In addition, the façade must also be able to expand vertically. If angle supports are rigidly fixed to the supporting structure, the parapet masonry should be separated from the rest of the rising façade as much as possible. Table 4 on page 10 provides guide values for maximum horizontal spacing of the vertical expansion joints for brick façades.

It's possible to make larger wall lengths permanently crack-free using structural reinforcement, if the recommended values in the guideline for expansion joint spacing cannot be followed.

5.3 Constructive reinforcement

Structural crack reinforcement is defined as steel reinforcement bars that are not required for transfer of planned loads. Standard mortars are suitable for this application.
Two parallel lengths of reinforcement bars with 5 mm or 6 mm diameters can be used to prevent structural cracks in brick façades.

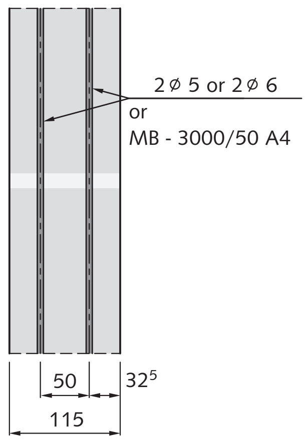
Long-term, permanent corrosion protection and therefore the performance of the reinforcement can only be guaranteed by using stainless steel. Rust formation on the reinforcing steel increases it's volume and will lead to spalling of the mortar. Stainless steel reinforcement is therefore strongly recommended for application in external brickwork façades.

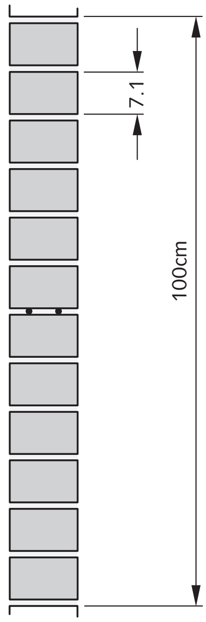
Table 14: Reinforcement bars

ø [mm]	Number/ bed joint	A_S [cm^2]	weight [kg/m]
5	2	2 × 0.196	2 × 0.154
6	2	2 × 0.283	2 × 0.222

Serviceability / Crack control

Reinforcement placement in bedding mortar





The cross-section of reinforcement to limit cracking and increase ductility should not be less than 0.03% of the total cross-section of the wall.

In accordance with Eurocode 6, after calculating the reinforcement for 11.5 cm brick veneer façades, the following minimum stainless steel reinforcement is required for each metre of wall height to limit the crack width if the allowable expansion joint spacing is exceeded:

Table 15

req. A_S [cm^2]	⌀ 5 [number/m height]	⌀ 6 [number/m height]
0.35	1 × 2	1 × 2

5.4 Corrosion protection

There is a risk of corrosion of the structural reinforcement in the masonry if the alkalinity of the mortar around the reinforcement lessens with simultaneous dampness. Adequate corrosion protection of the reinforcement must be ensured as external brickwork is often exposed to the influence of weather which can result in relatively fast carbonation in the mortar.

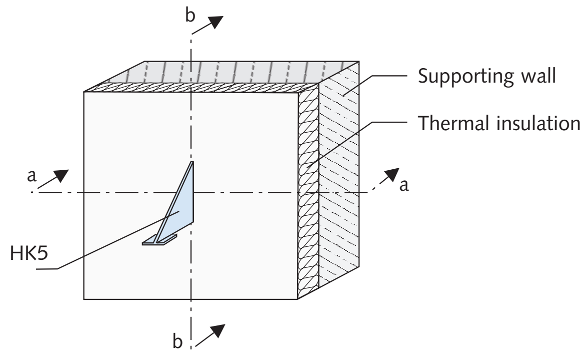
Thermal bridging

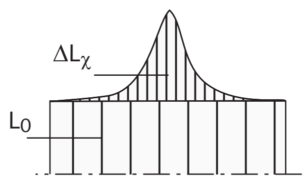
6. Thermal bridging — loss coefficient

6.1 Determining the thermal bridge — loss coefficient with HK5 Support bracket applications

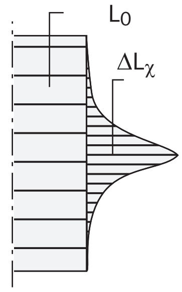
When an insulation layer is penetrated by mechanical fixings — support brackets in double-leaf walls — the influence of the thermal bridge must be quantified and kept as low as possible. The thermal bridge loss coefficient χ can be used to precisely determine the influence of the support brackets on the thermal bridge coefficient U of the wall.

$\Delta Uf = \chi \cdot nf$ [DIN EN ISO 6946, F.3.1]
$U_{ges} = U + \Delta Uf$ [DIN EN ISO 6946, F.1]
with
ΔUf... Correction value for fixings penetrating the insulation layer
χ.... thermal bridge loss coefficient
nf... Number of fixing elements per m²





Section a-a



Section b-b

The additional heat transfer of a support bracket (χi-value) is calculated by totaling the heat transfer in the cross-section of the exterior wall and comparing the result with the heat transfer in the exterior wall without a bracket.
The calculation of the thermal bridge loss coefficient was subject of an expert report.

6.2 Influence of the different boundary conditions on the χ-value

The following boundary conditions are considered for mathematical calculation.

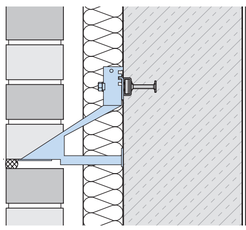
- material and thickness of the anchoring base (thermal resistance of the main supporting structure)
- material, dimensions and cross-section of the anchor bracket penetrating the insulation
- material and thickness of the façade
- thermal conductivity and thickness of the insulation
- method of fixing to the main supporting structure (Anchor bolt or HALFEN Cast-in channel)
- number and spacing of the anchoring elements required for static reasons per m² of wall
- thickness and ventilation of the gap behind the veneer

6.3 Notes on application

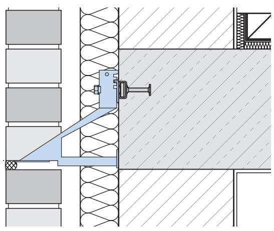
Numerical calculation methods are used to determine the adjustment factor applied to the U-value of the external wall in accordance with DIN EN ISO 6946 when using HALFEN HK5 Support brackets.

The results apply to fixing the support bracket with anchor bolts or to HALFEN Channels at bracket spacing of ≥ 25 cm. Anchorage can be either to a concrete wall (Type 1) or the face of a concrete slab (Type 2) or a reinforced concrete beam (Type 3).

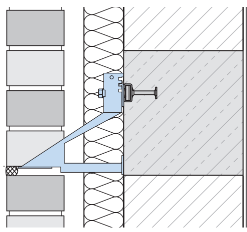
Type 1



Type 2



Type 3

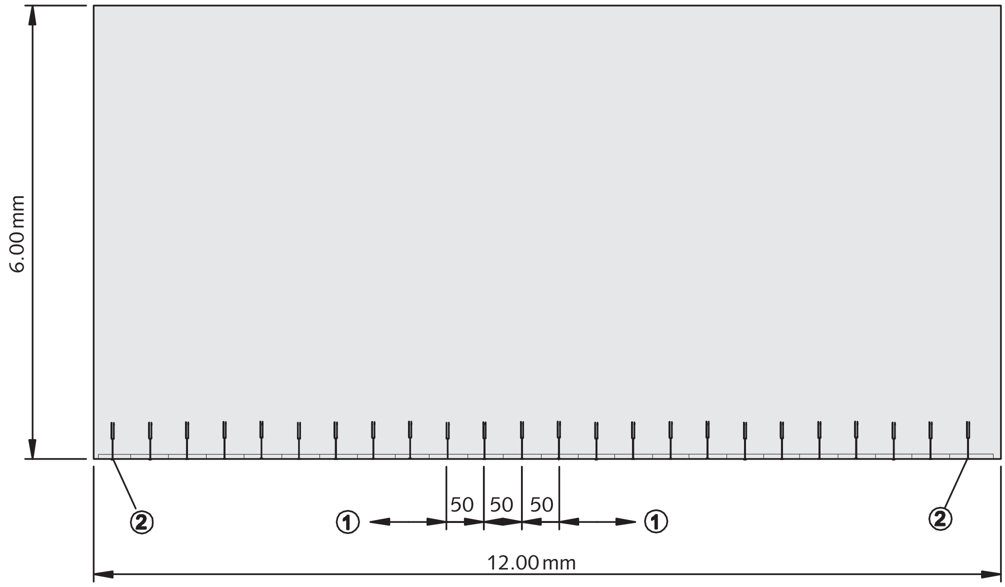


Thermal bridging

Example:
Continuous wall surface — no window openings,
Support length = 12 m
Supported height = 6.0 m
HK5 Support bracket used - U - 8.0 kN

Front view — wall surface

① HK5-U - 8.0 - 230 with
HW 95 × 20 × 2 - 480
② HK5-P - 8.0 - 230

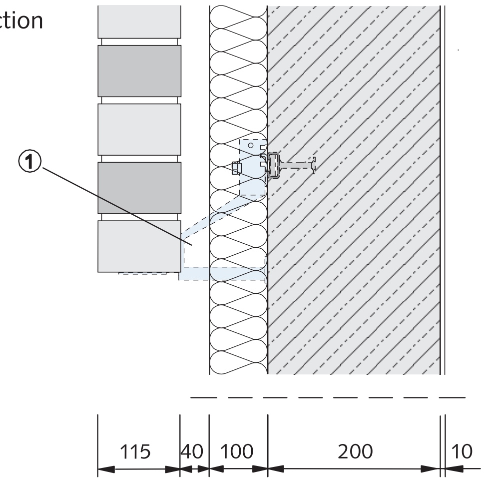


Number of HK5 support brackets, load group 8.0 kN = 24 anchors
Façade area (no windows) = 72 m²

Thermal transmission resistance R [m²×K/W]

Table 17: Thermal transmission resistances			
Wall section	d [m]	λ [W/(m×K)]	R = d / λ [m²×K/W]
Thermal transmission resistance exterior Rse (cavity)			0.08
(Brick) façade	0.115		
Cavity	0.040		
Thermal insulation	0.100	0.035	2.857
Concrete wall	0.200	2.5	0.080
Plaster (interior)	0.010	0.6	0.017
Thermal transmission resistance inner Rsi			0.130
Wall total (no opening, etc.) R_T			3.164

Wall section



Thermal heat transmission coefficient for the wall (no openings) U
U = 1 / RT = 1/ 3.164 = 0.316 W/(m²×K)

Thermal bridge – loss coefficient χi for the support brackets
In acc. with table 20 → page 43
(λ=0.035 W/(m×K); d=10 cm) χ=0.029 W/K

Correction value; thermal heat transmission coefficient ΔU [W/(m²×K)]
24 support brackets, 72 m² façade area
ΔU = nf / A × χ = 24 / 72 m² × 0.029 W/(m×K)
ΔU = 0.010 W/(m²·K)
Uges = U + ΔU = 0.316 + 0.010 = 0.326 W/(m²·K)

Thermal bridging

6.4 Thermal bridging — loss coefficient χi [W/K] for HK5 support brackets

Table 18: Thermal conductivity of the insulation λ = 0.02 (W/mK) fixing to concrete

Thermal insulation d [cm]		4	6	8	10	12	14	16
HK5-	12.0 - 130	0.142						
	8.0 - 130	0.125						
	4.0 - 130	0.093						
HK5-	12.0 - 150	0.150	0.106					
	8.0 - 150	0.132	0.094					
	4.0 - 150	0.092	0.065					
HK5-	12.0 - 170	0.118	0.086	0.066				
	8.0 - 170	0.100	0.072	0.056				
	4.0 - 170	0.076	0.055	0.042				
HK5-	12.0 - 190	0.115	0.084	0.066	0.053			
	8.0 - 190	0.097	0.071	0.055	0.045			
	4.0 - 190	0.074	0.054	0.042	0.034			
HK5-	12.0 - 210		0.073	0.057	0.047	0.039		
	8.0 - 210		0.060	0.047	0.039	0.033		
	4.0 - 210		0.043	0.034	0.028	0.023		
HK5-	12.0 - 230			0.048	0.039	0.033	0.029	
	8.0 - 230			0.040	0.033	0.028	0.024	
	4.0 - 230			0.032	0.026	0.022	0.019	
HK5-	12.0 - 250				0.036	0.031	0.027	0.023
	8.0 - 250				0.032	0.027	0.023	0.020
	4.0 - 250				0.026	0.022	0.020	0.017
HK5-	12.0 - 270					0.031	0.027	0.024
	8.0 - 270					0.026	0.023	0.020
	4.0 - 270					0.022	0.020	0.017
HK5-	12.0 - 290						0.031	0.027
	8.0 - 290						0.023	0.021
	4.0 - 290						0.020	0.018
HK5-	12.0 - 310							0.027
	8.0 - 310							0.021
	4.0 - 310							0.018
HK5-	12.0 - 330							
	8.0 - 330							
	4.0 - 330							
HK5-	12.0 - 350							
	8.0 - 350							
	4.0 - 350							

Core insulation

not covered by the simplified calculation method

Thermal bridging

Table 19: Thermal conductivity of the insulation λ = 0.03 (W/mK)

Thermal insulation d [cm]		4	6	8	10	12	14	16
HK5-	12.0 - 130	0.124						
	8.0 - 130	0.109						
	4.0 - 130	0.081						
HK5-	12.0 - 150	0.133	0.097					
	8.0 - 150	0.117	0.085					
	4.0 - 150	0.082	0.059					
HK5-	12.0 - 170	0.104	0.078	0.061				
	8.0 - 170	0.088	0.066	0.052				
	4.0 - 170	0.067	0.050	0.039				
HK5-	12.0 - 190	0.102	0.077	0.061	0.050			
	8.0 - 190	0.086	0.065	0.052	0.042			
	4.0 - 190	0.066	0.050	0.040	0.032			
HK5-	12.0 - 210		0.067	0.053	0.044	0.037		
	8.0 - 210		0.055	0.044	0.037	0.031		
	4.0 - 210		0.040	0.032	0.026	0.022		
HK5-	12.0 - 230			0.045	0.037	0.032	0.027	
	8.0 - 230			0.037	0.031	0.027	0.023	
	4.0 - 230			0.030	0.025	0.021	0.018	
HK5-	12.0 - 250				0.034	0.029	0.026	0.022
	8.0 - 250				0.030	0.026	0.022	0.020
	4.0 - 250				0.025	0.021	0.019	0.016
HK5-	12.0 - 270					0.029	0.026	0.023
	8.0 - 270					0.025	0.022	0.019
	4.0 - 270					0.021	0.019	0.017
HK5-	12.0 - 290						0.030	0.026
	8.0 - 290						0.022	0.020
	4.0 - 290						0.019	0.017
HK5 -	12.0 - 310							0.026
	8.0 - 310							0.020
	4.0 - 310							0.017
HK5 -	12.0 - 330							
	8.0 - 330							
	4.0 - 330							
HK5 -	12.0 - 350							
	8.0 - 350							
	4.0 - 350							

Core insulation

not covered by the simplified calculation method

Thermal bridging

Table 20: Thermal conductivity of the insulation λ = 0.035 (W/mK)

Thermal insulation d [cm]		4	6	8	10	12	14	16
HK5-	12.0 - 130	0.123						
	8.0 - 130	0.108						
	4.0 - 130	0.080						
HK5-	12.0 - 150	0.125	0.096					
	8.0 - 150	0.110	0.083					
	4.0 - 150	0.077	0.055					
HK5-	12.0 - 170	0.098	0.069	0.045				
	8.0 - 170	0.083	0.058	0.040				
	4.0 - 170	0.063	0.041	0.028				
HK5-	12.0 - 190	0.096	0.065	0.044	0.035			
	8.0 - 190	0.081	0.055	0.038	0.031			
	4.0 - 190	0.062	0.039	0.028	0.022			
HK5-	12.0 - 210	0.095	0.064	0.042	0.034	0.029		
	8.0 - 210	0.081	0.053	0.035	0.030	0.026		
	4.0 - 210	0.062	0.038	0.027	0.022	0.018		
HK5-	12.0 - 230	0.097	0.065	0.043	0.033	0.028	0.025	
	8.0 - 230	0.081	0.053	0.036	0.029	0.025	0.021	
	4.0 - 230	0.064	0.041	0.029	0.024	0.021	0.018	
HK5-	12.0 - 250	0.097	0.065	0.043	0.033	0.028	0.025	0.022
	8.0 - 250	0.081	0.053	0.035	0.028	0.024	0.022	0.019
	4.0 - 250	0.063	0.041	0.029	0.024	0.021	0.018	0.016
HK5-	12.0 - 270	0.096	0.065	0.043	0.033	0.028	0.025	0.022
	8.0 - 270	0.082	0.053	0.035	0.028	0.024	0.021	0.019
	4.0 - 270	0.064	0.041	0.029	0.024	0.021	0.018	0.016
HK5-	12.0 - 290	0.100	0.070	0.047	0.038	0.032	0.028	0.026
	8.0 - 290	0.082	0.053	0.035	0.028	0.024	0.021	0.019
	4.0 - 290	0.064	0.041	0.029	0.024	0.021	0.018	0.016
HK5-	12.0 - 310	0.100	0.070	0.048	0.038	0.033	0.029	0.026
	8.0 - 310	0.081	0.053	0.036	0.029	0.025	0.022	0.019
	4.0 - 310	0.064	0.041	0.030	0.025	0.022	0.019	0.017
HK5-	12.0 - 330	0.100	0.070	0.047	0.038	0.033	0.028	0.025
	8.0 - 330	0.088	0.061	0.043	0.036	0.031	0.027	0.025
	4.0 - 330	0.071	0.049	0.037	0.031	0.027	0.024	0.022
HK5-	12.0 - 350	0.098	0.069	0.046	0.037	0.031	0.026	0.025
	8.0 - 350	0.087	0.060	0.043	0.036	0.029	0.027	0.024
	4.0 - 350	0.070	0.049	0.036	0.031	0.027	0.024	0.022

Core insulation

Thermal bridging

Table 21: Thermal conductivity of the insulation λ = 0.04 (W/mK)								
Thermal insulation d [cm]		4	6	8	10	12	14	16
HK5-	12.0 - 130	0.109						
	8.0 - 130	0.096						
	4.0 - 130	0.071						
HK5-	12.0 - 150	0.118	0.088					
	8.0 - 150	0.104	0.077					
	4.0 - 150	0.073	0.054					
HK5-	12.0 - 170	0.093	0.072	0.057				
	8.0 - 170	0.078	0.061	0.048				
	4.0 - 170	0.060	0.046	0.037				
HK5-	12.0 - 190	0.091	0.071	0.058	0.047			
	8.0 - 190	0.077	0.060	0.049	0.040			
	4.0 - 190	0.059	0.046	0.037	0.030			
HK5 -	12.0 - 210		0.061	0.050	0.042	0.035		
	8.0 - 210		0.051	0.041	0.035	0.029		
	4.0 - 210		0.037	0.030	0.025	0.021		
HK5-	12.0 - 230			0.042	0.035	0.030	0.026	
	8.0 - 230			0.035	0.029	0.025	0.022	
	4.0 - 230			0.028	0.024	0.021	0.018	
HK5-	12.0 - 250				0.032	0.028	0.025	0.022
	8.0 - 250				0.029	0.025	0.022	0.019
	4.0 - 250				0.024	0.021	0.018	0.016
HK5-	12.0 - 270					0.028	0.025	0.022
	8.0 - 270					0.024	0.021	0.019
	4.0 - 270					0.021	0.018	0.016
HK5-	12.0 - 290						0.029	0.026
	8.0 - 290						0.022	0.019
	4.0 - 290						0.018	0.016
HK5-	12.0 - 310							0.026
	8.0 - 310							0.019
	4.0 - 310							0.017
HK5-	12.0 - 330							
	8.0 - 330							
	4.0 - 330							
HK5-	12.0 - 350							
	8.0 - 350							
	4.0 - 350							

Core insulation

not covered by the simplified calculation method

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HALFEN HB Anchor bolt systems catalogue

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