HALFEN SANDWICH PANEL ANCHORS

TECHNICAL PRODUCT INFORMATION

HALFEN SANDWICH PANEL ANCHORS

FAÇADE

SP 16-E

HALFEN

YOUR BEST CONNECTIONS

General

HALFEN SP Sandwich panel anchors

HALFEN offers three different types of anchors to connect facing and load-bearing layers of sandwich elements.

- SP-SPA Sandwich panel anchors
- SP-FA Flat anchors
- SP-MVA Sleeve anchors

HALFEN SP benefits

- quick and easy assembly
- easy planning with the free HALFEN Software
- safety through building authority approvals
- EnEV-compatible with minimal thermal bridges
- sustainability through high corrosion resistant stainless steel
- combination of different systems for high versatility, for example in thin building components and above openings

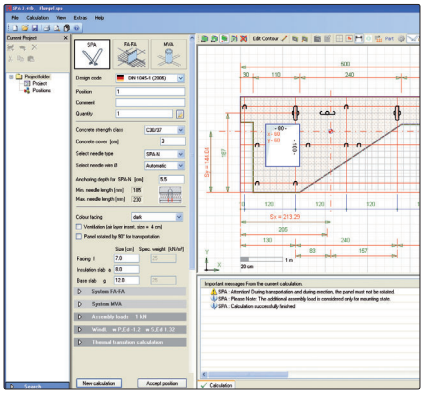
Dedicated software to ease calculation and selection of correct anchor types

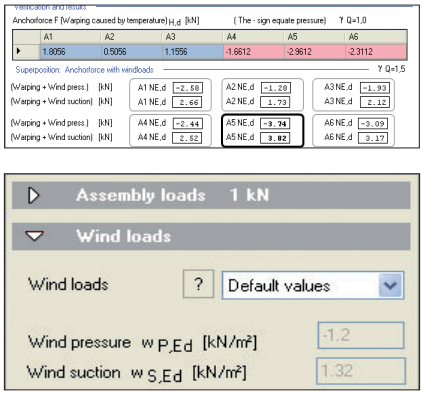
Main benefits

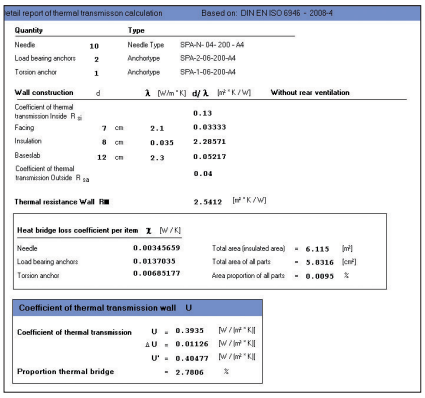
- interactive, easy to use graphical user interface (GUI)
- time efficient, quick and easy input of virtually any slab geometry
- design calculation of each restraint tie and all supporting, horizontal anchors
- free selection of load-anchor positions by the user
- only statically required anchors and pins are displayed
- cost effective economical design
- verifiable printout with detailed results
- all anchor and pin positions remain freely adjustable
- variable wind load input
- software takes the actual wind loads (project /country specific) into account instead of using a standard basic method
- lower wind loads increases anchor residual load bearing capacities resulting in cost-effective designs
- heat transmission value calculation evaluates thermal bridging effects of anchors
- unfavourable standard DIN 4108 calculation methods are avoided by accurate calculation of thermal bridges

NEW!

Optimized anchor design with FE possible!







Note:
All software calculations, especially static values, refer exclusively to HALFEN SP-systems. The basis for calculation is approval Z-21.8-1926 from 4th April 2016 and approval Z-21.8-1979 from 28th of January 2014.
Apparently identical non-HALFEN products may differ substantially in their performance. These differences may be critical.
This HALFEN Software must not be used to calculate non-HALFEN products. HALFEN GmbH is not liable for calculations with HALFEN Software when using non-HALFEN products.

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HALFEN SANDWICH PANEL ANCHORS

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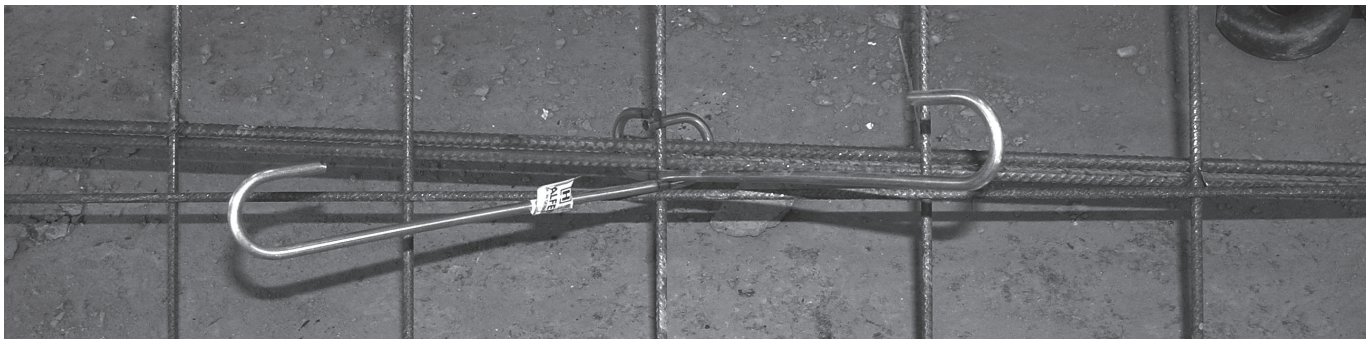

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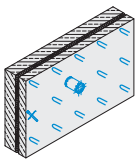

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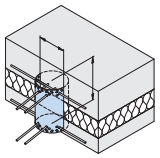

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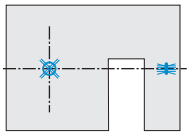

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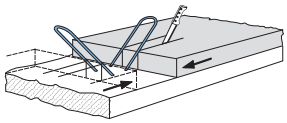

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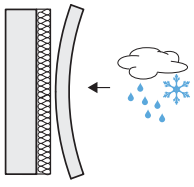

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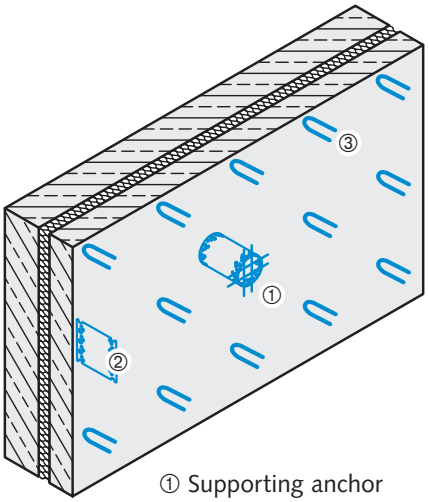
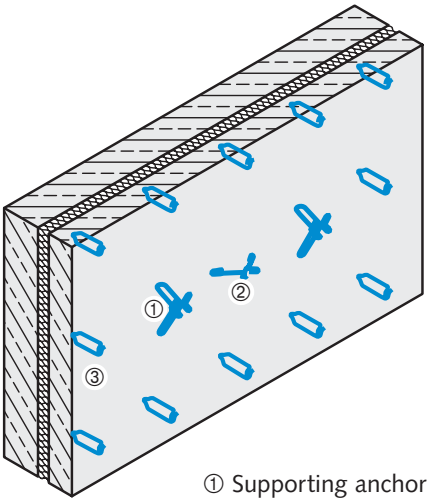
Function of the anchors

Sandwich panels with the MVA supporting system have one sleeve anchor as a supporting anchor at the centre of gravity of the facing layer and one torsion anchor. For panels with a MVA-FA supporting system there are 2 supporting anchors (MVA and FA), the sleeve anchor serving simultaneously as a horizontal anchor. Panels with SPA-SPA and FA-FA supporting systems basically have 2 supporting anchors, i.e. anchor groups, and 1 horizontal anchor (in the case of panels rotated for transporting, 2 horizontal anchors or anchor groups are usually placed).



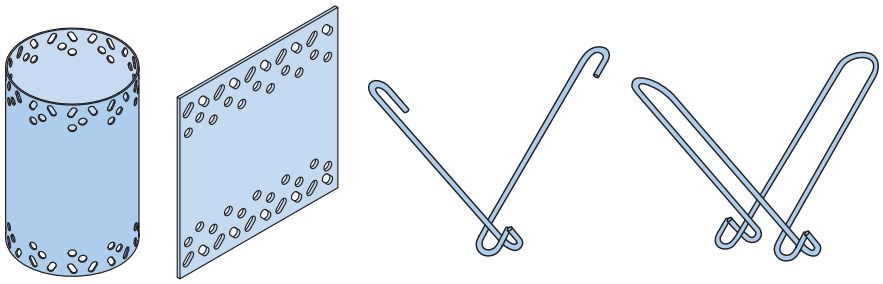
① Supporting anchor
② Torsion anchor
③ Restraint tie



① Supporting anchor
② Horizontal anchor
③ Restraint tie

Supporting anchors see page 8

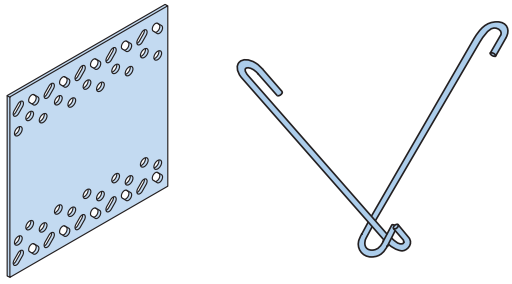
Supporting anchors are primarily responsible for carrying the resulting vertical loads from the dead load of the facing layer. Eccentric loads (planned or unplanned) should also be taken into account, as well as horizontal loads from wind, warping etc.



Torsion anchors / Horizontal anchors see page 10

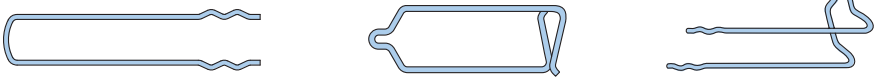
The torsion anchor in the MVA system has to carry any eccentric forces (planned or unplanned).
In the SP-FA and SP-SPA systems the function of the horizontal anchors is to carry horizontally acting forces (for example: from panels hanging askew on the crane, impact forces during lifting or wind forces on soffits).

The horizontal anchors must be sufficiently dimensioned to allow for loads when panels are rotated for transport.



Restraint ties see page 11

Restraint ties carry the forces acting vertically to the panel surface resulting from temperature-deformation, wind or adhesion to formwork.



Connector pin | Clip-on stirrup | Clip-on pin

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Basics

The calculation values for the load capacities $V_{R,d}$, $N_{R,d}$, $M_{R,d}$ are resistance values taking the partial safety factors for the materials into account.
The resistance for $V_{R,d}$, $N_{R,d}$, $M_{R,d}$ needs to be compared with the partial safety coefficient increased effect $V_{E,d}$ (vertical loads, for example dead load of the facing layer and if required any additional loads present), $N_{E,d}$ (horizontal loads, for example from wind loads and deformation) and $M_{E,d}$ (only for the MVA/FA and FA/FA systems) and the specifications in the appropriate approval.

The horizontal loads are mainly affected by the geometry of the slab, the raster spacing as well as the position of the anchors.

Design loads for HALFEN Software

1. Vertical Loads
The dead weight of the facing layer plus any existing additional loads are to be taken into account as influencing vertical loads.

2. Warp loads
- the warp loads are normally verified according to Utescher; whereby the following factors are considered:
- anchor arrangement in a grid with a side-ratio of $0.75 \leq l_X/l_Y \leq 1.33$
- facing layer thickness f = 70 – 120 mm (further verification is necessary for thicker facing layers)
- temperature stresses according to DIBt Guidelines 5/1995: temperature gradient for three-layer panel without ventilation gap (dark surface) $\Delta T = \pm 5°K$

i Alternative verification of the warp loads using FE is possible!

3. Wind loads according to DIN EN 1991-1-4/ NA Germany for SP-FA, SP-MVA and SP-SPA
A sandwich panel with an anchor grid of max. $l_x \times l_y$ = 1.20 m × 1.20 m is assumed.
The wind design loads in the table [kN/m²] take the following assumptions into account:
- simplified velocity pressure for building heights up to 25 m
- applicable for inland regions and wind zones 1 and 2
- wind action area ≤ 1 m² (unfavourable assumption)
- h/d ≥ 5 (unfavourable assumption)
- „Standard region" includes zone D (for pressure) and B (for suction)
- „Periphery region" includes zone D (for pressure) and A (for suction)

Considered combinations

Building height	Wind zone 1		Wind zone 2	
	Normal region	Periphery region	Normal region	Periphery region
≤ 10 m	$w_{D,k}$ = 0.50	$w_{D,k}$ = 0.50	$w_{D,k}$ = 0.65	$w_{D,k}$ = 0.65
	$w_{S,k}$ = - 0.55	$w_{S,k}$ = - 0.85	$w_{S,k}$ = - 0.72	$w_{S,k}$ = - 1.11
≤ 18 m	$w_{D,k}$ = 0.65	$w_{D,k}$ = 0.65	**$w_{D,k}$ = 0.80**	$w_{D,k}$ = 0.80
	$w_{S,k}$ = - 0.72	$w_{S,k}$ = - 1.11	**$w_{S,k}$ = - 0.88**	$w_{S,k}$ = - 1.36
≤ 25 m	$w_{D,k}$ = 0.75	$w_{D,k}$ = 0.75	$w_{D,k}$ = 0.90	$w_{D,k}$ = 0.90
	$w_{S,k}$ = - 0.83	$w_{S,k}$ = - 1.28	$w_{S,k}$ = - 0.99	$w_{S,k}$ = - 1.53

The default wind loads in the HALFEN Calculation software are for a building with a height ≤ 18 m in a standard region for wind zone 2 ($w_{D,k}$ = 0,80 and $w_{S,k}$ = - 0,88).
Other wind loads variables can be entered by the user.

4. Distance from anchors to the fulcrum e
The following influencing factors are taken into account when calculating the admissible distances e:

- Heat insulation thickness b
- Temperature stress according to DIBt guidelines 5/1995:

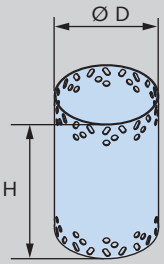
Load-bearing layer temperature (internal, total year)	ϑ_i = +20°C
Facing layer temperature in summer	ϑ_a = +65°C
Facing layer temperature in winter	ϑ_a = -20°C
Temperature difference Compared to condition at installation	$\triangle T = \pm 45°K$

Overview of Available Anchors

Available heights, diameters and lengths of anchors can be found in the following tables.

Sleeve anchors MVA

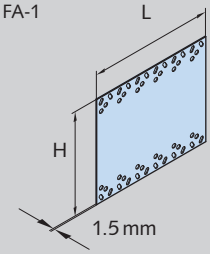
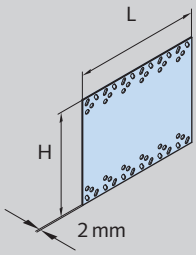
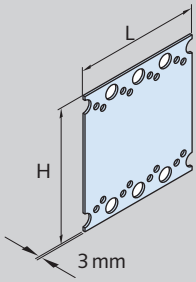
Available anchor diameters D [mm]

Anchor type	Order no. 0770.010-	H = 150 mm	Order no. 0770.010-	H = 175 mm	Order no. 0770.010-	H = 200 mm	Order no. 0770.010-	H = 225 mm	Order no. 0770.010-	H = 260 mm
MVA 	00101	51	00107	51	00117	51	00127	51	00137	51
	00102	76	00108	76	00118	76	00128	76	00138	76
	00103	102	00109	102	00119	102	00129	102	00139	102
	00104	127	00110	127	00120	127	00130	127	00140	127
	00105	153	00111	153	00121	153	00131	153	00141	153
	00106	178	00112	178	00122	178	00032	178	00042	178
			00113	204	00123	204	00033	204	00043	204
			00114	229	00124	229	00034	229	00044	229
			00115	255	00125	255	00035	255	00045	255
			00116	280	00126	280	00036	280	00046	280

Subject to design changes

Flat anchors FA

Available anchor lengths L [mm]

Anchor type	Order no. 0771.010-	H = 150 mm	Order no. 0771.010-	H = 175 mm	Order no. 0771.010-	H = 200 mm	Order no. 0771.010-	H = 225 mm
FA-1 	00001	40	00011	40	00021	40	00031	40
	00002	80	00012	80	00022	80	00032	80
	00003	120	00013	120	00023	120	00033	120
	00004	160	00014	160	00024	160	00034	160
	00005	200	00015	200	00025	200	00035	200
	00006	240	00016	240	00026	240	00036	240
	00007	280	00017	280	00027	280	00037	280
	00008	320	00018	320	00028	320	00038	320
	00009	360	00019	360	00029	360	00039	360
	00010	400	00020	400	00030	400	00040	400
FA-2 	Order no. 0771.020-	H = 175 mm	Order no. 0771.020-	H = 200 mm	Order no. 0771.020-	H = 225 mm	Order no. 0771.020-	H = 260 mm
	00001	40	00011	40	00021	40	00031	40
	00002	80	00012	80	00022	80	00032	80
	00003	120	00013	120	00023	120	00033	120
	00004	160	00014	160	00024	160	00034	160
	00005	200	00015	200	00025	200	00035	200
	00006	240	00016	240	00026	240	00036	240
	00007	280	00017	280	00027	280	00037	280
	00008	320	00018	320	00028	320	00038	320
	00009	360	00019	360	00029	360	00039	360
	00010	400	00020	400	00030	400	00040	400
FA-3 	Order no. 0771.030-	H = 260 mm	Order no. 0771.030-	H = 280 mm	Order no. 0771.030-	H = 300 mm	Order no. 0771.030-	H = 350 mm
	00001	80	00010	80	00018	80	00026	80
	00002	120	00011	120	00019	120	00033	120
	00003	160	00012	160	00020	160	on request	160
	00004	200	00013	200	00021	200	00027	200
	00005	240	00014	240	00022	240	00028	240
	00006	280	00016	280	00023	280	00029	280
	00007	320	00017	320	00024	320	00030	320
	00008	360	00039	360	00025	360	00031	360
	00009	400	00040	400	on request	400	00032	400

Subject to design changes

Note: Larger anchor heights on request

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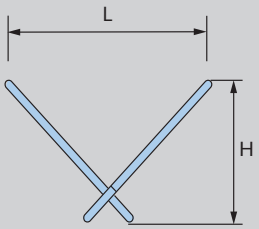
Overview of Available Anchors

Sandwich panel anchors SPA

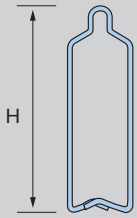
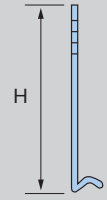
Available anchor heights H and anchor lengths L [mm]

Anchor type	Steel bars-Ø [mm] **05**			Steel bars-Ø [mm] **07**			Steel bars-Ø [mm] **09**			Steel bars-Ø [mm] **10**		
	Order no. SPA-1 0270. SPA-2 0271.	H	L	Order no. SPA-1 0270. SPA-2 0271.	H	L	Order no. SPA-1 0270. SPA-2 0271.	H	L	Order no. SPA-1 0270. SPA-2 0271.	H	L
SPA-1/SPA-2 	010-00001	160	265	010-00003	160	260						
	010-00002	180	305	010-00004	180	300						
	010-00110	200	345	010-00005	200	340						
				010-00006	220	380	010-00138 ①	220	375			
				010-00007	240	420	010-00139 ①	240	415			
				010-00008	260	460	010-00111	260	455			
							010-00112	280	495			
							010-00113	300	535			
							010-00114	320	575			
							010-00115	340	615	010-00015	340	610
							010-00116	360	655	010-00016	360	650
										010-00103	380	690
										010-00105	400	730
										010-00107	420	770
										010-00109	440	810

① valid only for SPA-1. For SPA-2 order numbers please see the HALFEN price list.

Connector pins SPA-N, stirrup ties SPA-B, clip-on pins SPA-A

Available anchor heights H [mm]

Anchor type	Steel bars-Ø [mm] **03**		Steel bars-Ø [mm] **04**		Steel bars-Ø [mm] **05**		Steel bars-Ø [mm] **06**	
	Order no. 0274.010-	H	Order no. 0274.020-	H	Order no. 0274.030-	H	Order no. 0274.040-	H
SPA-N	00001	120						
	00002	140						
	00003	160	00001	160				
	00004	180	00002	180				
	00005	200	00003	200				
			00004	220				
			00005	240	00001	240		
					00002	260		
					00003	280		
					00004	300		
					00005	320		
							00001	340
							00002	360
							00003	380
							00004	400
							00005	420
SPA-B 	Order no. 0273.010-	H	Order no. 0273.020-	H	Order no. 0273.030-	H		
	00001	160	00001	160				
	00002	180	00002	180				
			00003	200				
			00004	220				
			00005	240	00001	240		
					00002	260		
					00003	280		
					00004	300		
					00005	320		
SPA-A 	Order no. 0272.010-	H	Order no. 0272.030-	H	Order no. 0272.050-	H		
	00001	120						
	00002	140						
	00003	160	00001	160				
	00004	180						
			00002	200	00001	200		
			00003	250	00002	250		
					00003	280		
					00004	320		

Subject to design changes

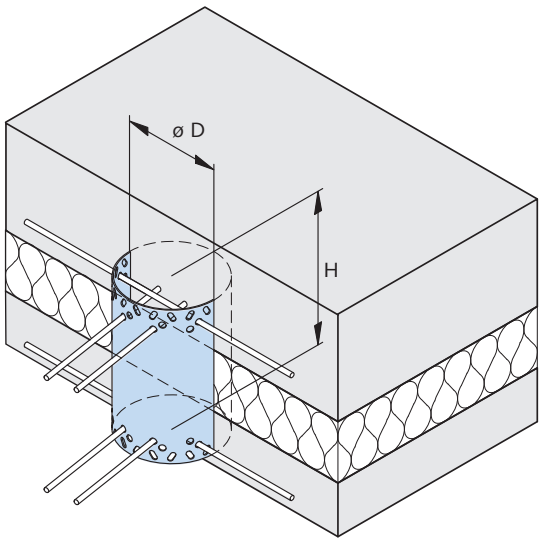
Supporting anchors

Sleeve anchors MVA

Article name: SP-MVA - height [mm] - Ø D [mm]

The cylindrical sleeve anchor has a material thickness of 1.5 mm. The ends have round and oval holes. The round holes are for reinforcement bars and the oval holes are for embedding in the concrete. Sleeve anchors are used in MVA and MVA-FA systems as supporting anchors. The anchors are stamped for identification with their height and diameter.

Material: stainless steel A4



Ordering example:

Article group
Anchor type
Anchor height H [mm]
Sleeve diameter D [mm]

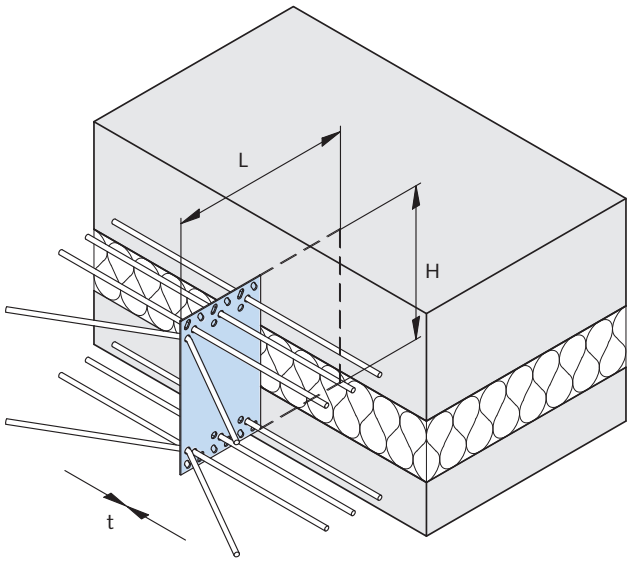
SP - MVA - 225 - 076

Flat anchors FA

Article name: SP-FA-1 - height [mm] - length [mm]
SP-FA-2 - height [mm] - length [mm]
SP-FA-3 - height [mm] - length [mm]

Flat anchors are supplied in the following material thicknesses: 1.5 mm, 2.0 mm or 3.0 mm. Two opposite sides have round and oval holes. The round holes are for the reinforcement bars and the oval holes are for embedding in the concrete. Flat anchors are used in MVA-FA and FA-FA systems as supporting anchors. The anchors are identified by a stamp showing anchor height, length and material thickness.

Material: stainless steel A4



Ordering example:

Article group
Anchor type
Material thickness t
Anchor height H [mm]
Anchor length L [mm]

SP - FA - 2 - 225 - 240

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Anchor Types

Sandwich panel anchors SPA

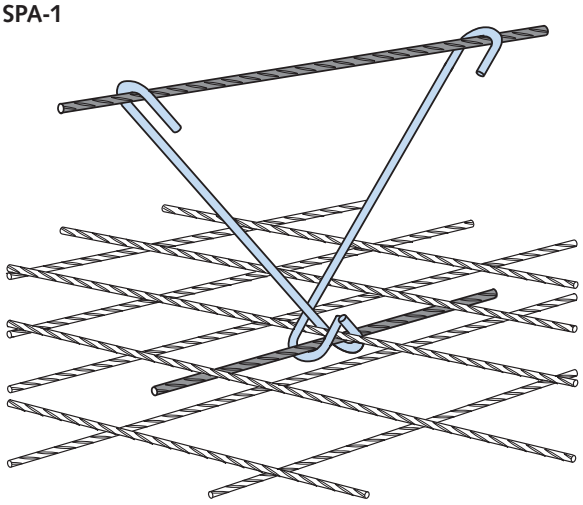
Article name: SP-SPA-1 - Ø [mm] - height [mm]
SP-SPA-2 - Ø [mm] - height [mm]

Sandwich panel anchors SP-SPA-1 and SP-SPA-2 are V-shaped anchors of round steel bar diameters of 5.0 mm, 6.5 mm, 8.5 mm and 10.0 mm. The bent ends serve both as anchorage in the concrete and to secure the reinforcement bars. Sandwich panel anchors are used in SPA-SPA systems as supporting anchors. They are identified by coloured adhesive labels showing type, diameter and height.

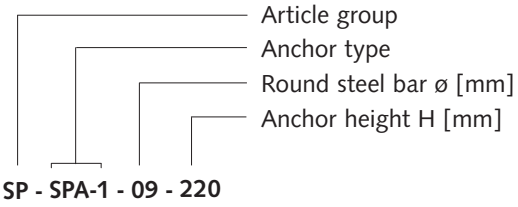
Material: stainless steel A4

Colour marking				
Colour	Anchor type		rebar-Ø	Material
red	SPA-1	SPA-2	05	A4
blue	SPA-1	SPA-2	07	A4
orange	SPA-1	SPA-2	09	A4
yellow	SPA-1	SPA-2	10	A4

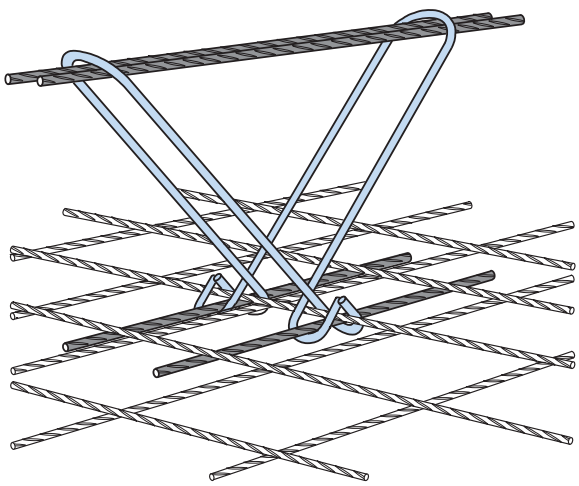
SPA-1



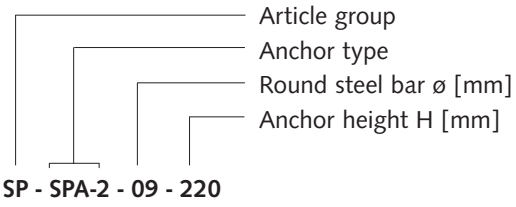
Ordering example:



SPA-2



Ordering example:



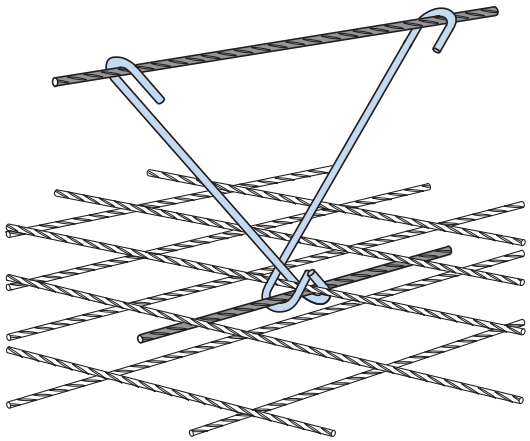
Torsion anchors / Horizontal anchors

The following anchor types can be used in sandwich panels as torsion or as horizontal anchors.

Sandwich panel anchors SPA

The sandwich panel anchor SP-SPA-1 is used in SPA-SPA systems as a horizontal anchor (where necessary the SP-SPA-2 can also be installed as a horizontal anchor).

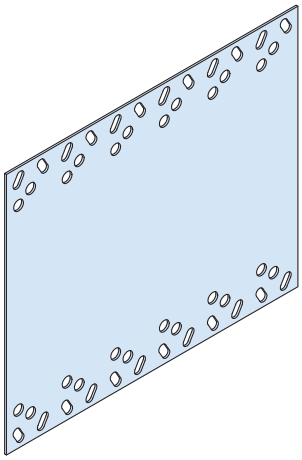
Material: stainless steel A4

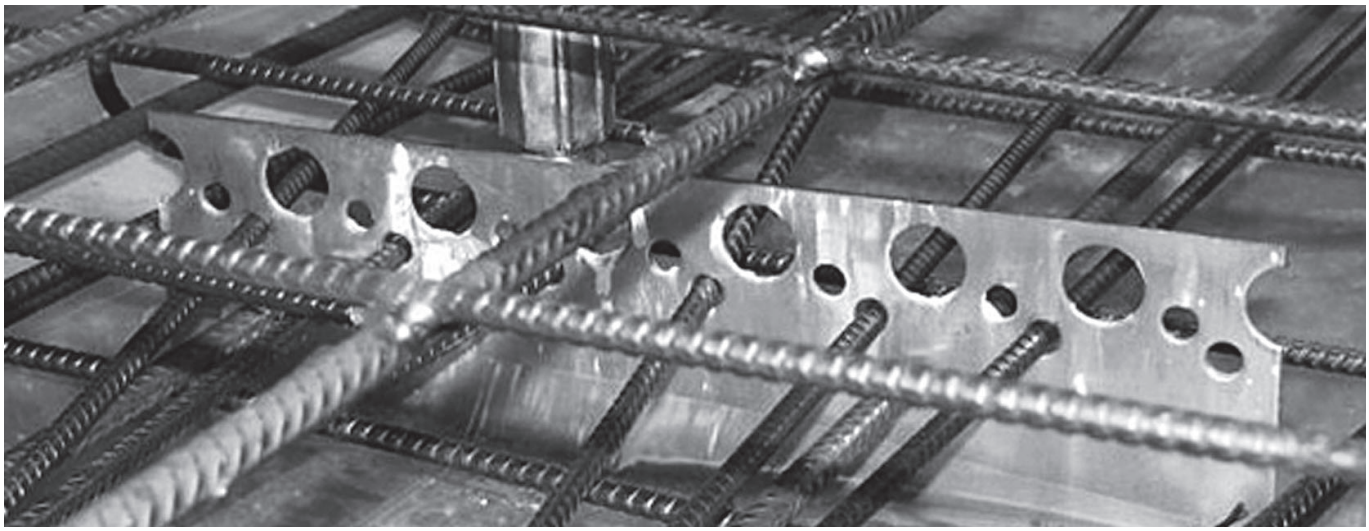


Flat anchor FA

The flat anchor is used in the MVA system as a torsion anchor and in a FA-FA system as a horizontal anchor.

Material: stainless steel A4





Installation of SPA-FA-3 at the precast plant

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Restraint ties

Connector pins SPA-N
Article name: SP-SPA-N - Ø [mm] - height [mm]

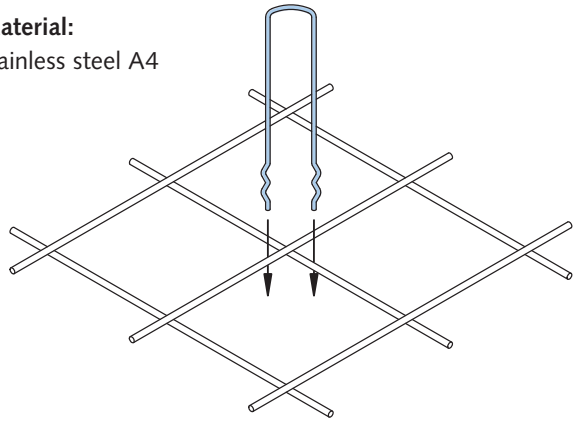
Connector pins are U-shaped bent wires with diameters of 3.0 mm, 4.0 mm, 5.0 mm and 6.5 mm.
Both the corrugated ends and the round end of the anchor are embedded into the concrete.

Ordering example:

Article group
Anchor type
Round steel bar - Ø [mm]
Pin height H [mm]

SP - SPA-N - 04 - 220

Material:
stainless steel A4



Stirrup tie (SPA-B)
Article name: SP-SPA-B - Ø [mm] - height [mm]

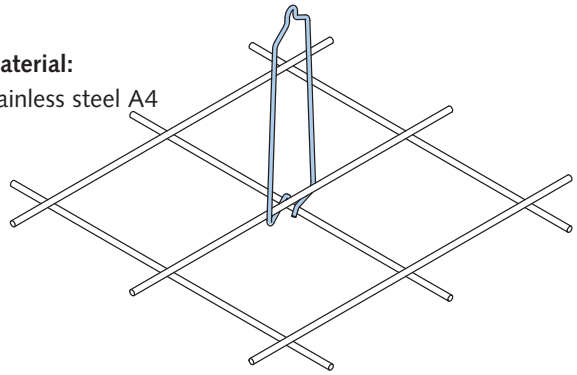
Stirrup ties are bent wires with diameters of 3.0 mm, 4.0 mm and 5.0 mm. They are positioned by hooking them around the bars in the reinforcement mat.
Both ends of the anchor are embedded into the concrete.

Ordering example:

Article group
Anchor type
Round steel bar - Ø [mm]
Stirrup height H [mm]

SP - SPA-B - 04 - 220

Material:
stainless steel A4



Note:
The special shaped tip guarantees the transfer of tensile and compression forces, even in thin load bearing layers.

Clip-on pins SPA-A
Article name: SP-SPA-A - Ø [mm] - height [mm]

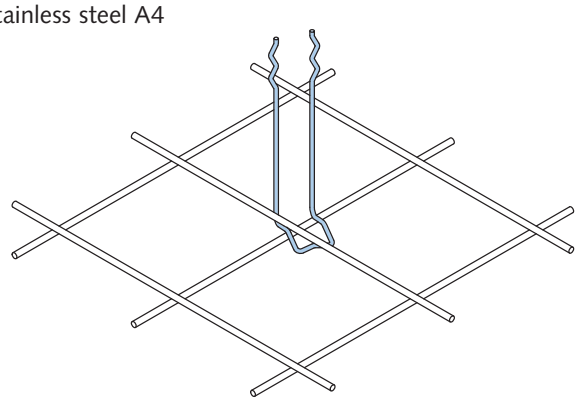
Clip-on pins are connector pins in which the U-shaped end is bent at 90°.
Wire diameters: 3.0 mm, 4.0 mm and 5.0 mm.
They are embedded into the concrete at the corrugated end, the other end is hooked to the bars in the reinforcement mat.

Ordering example:

Article group
Anchor type
Round steel bar - Ø [mm]
Stirrup height H [mm]

SP - SPA-A - 04 - 220

Material:
stainless steel A4



Sleeve anchors MVA

To calculate the load actions, the dead weight of the facing layer, the wind pressure deformation, the temperature (only ΔT) and if required the ground pressure has to be considered.

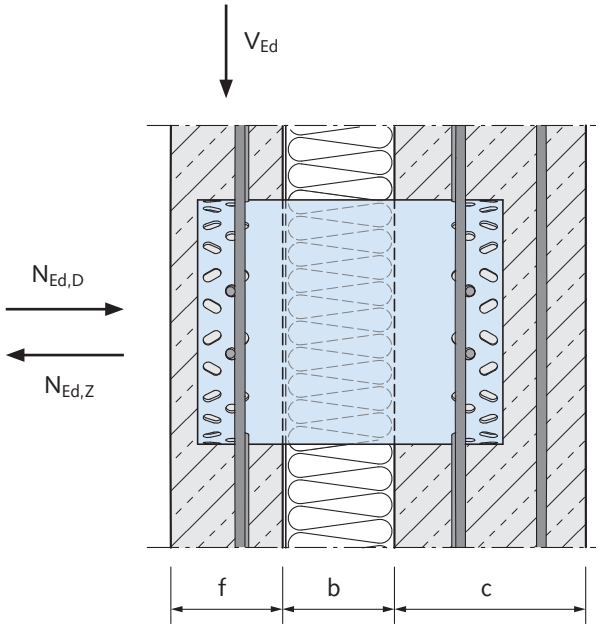
Required input values to calculate the load capacities are the anchor type, thickness of the insulation b and the thickness of the facing layer f.

The following types of failure for the MVA has to be verified:

- pry-out failure
- concrete failure under the anchor
- steel failure

Calculation formulae and load capacities can be found in the MVA/FA general building approval – Annex 6 and 8 to 10.

We recommend calculating the anchor using the HALFEN Sandwich panel anchor calculation software. Available at www.halfen.de



Material for sandwich panel anchors:
Stainless steel A4

Concrete grade:
Facing slab ≥ C 30/37
Load bearing slab ≥ C 30/37

Reinforcement:
Reinforcing steel mesh B500A, B500B
Ribbed reinforcing bar B500A, B500B

Minimum reinforcement for the concrete (facing) layer:
Mesh ≥ 1,88 cm²/m in each layer,
two layers if f or c ≥ 10 cm

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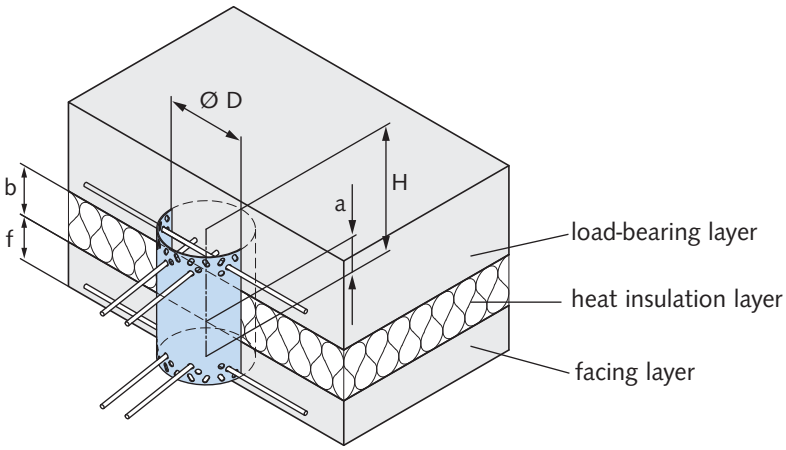
Sleeve anchors MVA



Minimum embedding depth of sleeve anchors MVA
The minimum embedding depth (a) of the sleeve anchor depends on the thickness of the facing layer (f) and the thickness of the insulation layer (b).

Minimum embedding depth a, minimum concrete cover c_{nom} [mm]

f [mm]	b = 30–90 mm		b = 100–140 mm	
	a [mm]	c_{nom} [mm]	a [mm]	c_{nom} [mm]
60 ①	50	10	50	10
70	55	15	60	10
80	60	20	65	15
90 – 120	60	30	70	20

① According to EN 1992-1-1/NA:2013-04 f_{min} ≥ 70 mm applies for the slab thickness.

Selection of anchor height for MVA
The height (H) of the sleeve anchor depends on the thickness of the insulation layer (b) and the depth of embedment (a).

$H \geq 2 \times a + b$

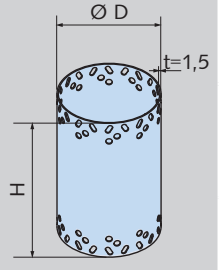
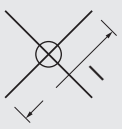
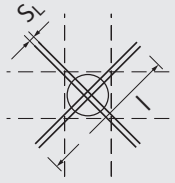
Anchor height H [mm]

f [mm]	b [mm]											
	30	40	50	60	70	80	90	100	110	120	130	140
60 ①	150	150	175	175	175	200	200	225	225	225	260	260
70	150	150	175	175	200	200	200	225	260	260	260	260
80	150	175	175	200	200	200	225	260	260	260	260	-
90 – 120	150	175	175	200	200	200	225	260	260	260	-	-

① According to EN 1992-1-1/NA:2013-04 f_{min} ≥ 70 mm applies for the slab thickness.

Reinforcement for MVA
Support anchors must be located in the facing and load-bearing layers. The number and length of the support anchor depends on the diameter Ø D of the sleeve anchor.

Additional reinforcement

Sleeve anchor	Ø D [mm]		Symbol	Anchoring bars B500A, B500B
	51 76 102			2 × 2 Ø 6 mm l = 500 mm
	127 153 178	S_L = 40 mm		2 × 4 Ø 6 mm l = 700 mm Required extra reinforcement: 2 × 4 Ø 8 mm l = 700 mm crosswise in the cut-out section of the reinforcement mat
	204 229 255 280	S_L = 80 mm		

Please refer to the overview of available anchors on page 6.

Flat anchor FA

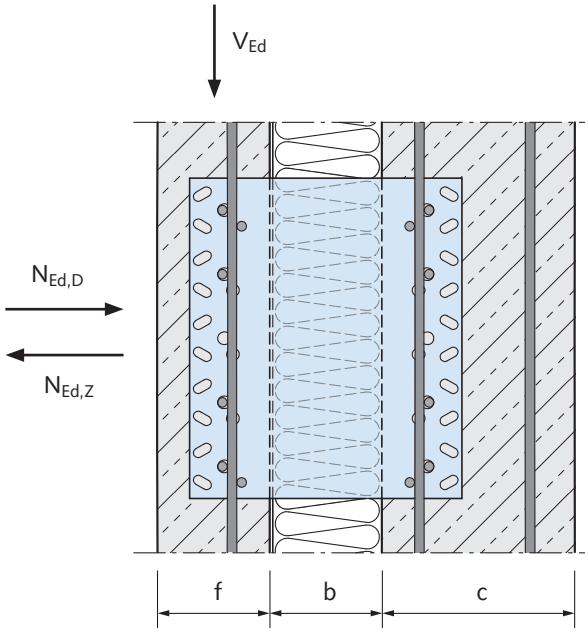
To calculate the load actions, the dead weight of the facing layer, the wind pressure deformation, the temperature (only ΔT) and if required the ground pressure has to be considered.

Required input values to calculate the load capacities are the anchor type, thickness of the insulation b and the thickness of the facing layer f.

The following types of failure for the MVA has to be verified:
- pull-out failure
- pry-out failure
- concrete failure under the anchor
- steel failure

Calculation formulae and load capacities can be found in the MVA/FA general building approval – Annex 7 and 11 to 14.

We recommend calculating the anchor using the HALFEN Sandwich panel anchor calculation software. Available at www.halfen.de



Material of sandwich panel anchors:
Stainless steel A4, L4

Concrete grade:
Facing slab ≥ C 30/37
Load bearing slab ≥ C 30/37

Reinforcement:
Reinforcing steel mesh B500A, B500B
Ribbed reinforcing bar B500A, B500B

Minimum reinforcement for the concrete (facing) layer:
Mesh ≥ 1,88 cm²/m in each layer,
two layers if f or c ≥ 10 cm

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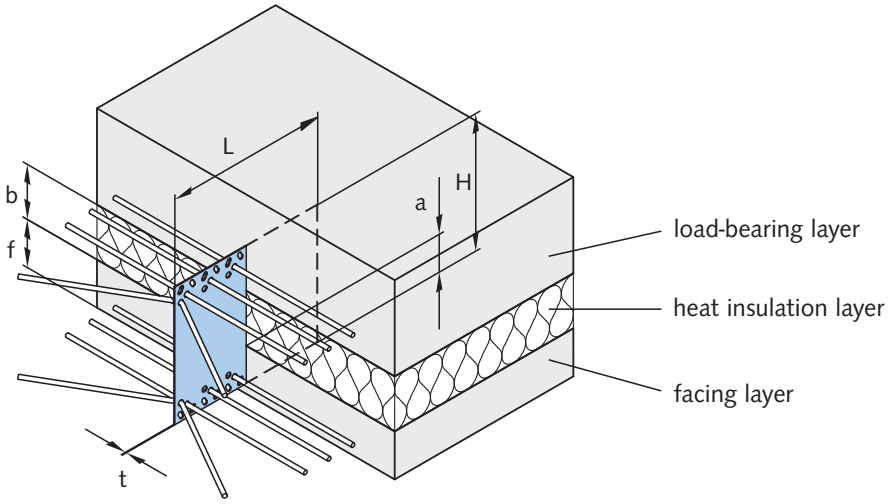
Flat anchor FA



Minimum embedding depth for flat anchor FA

The minimum embedding depth (a) of the flat anchor in the load-bearing and facing layer is 55 mm.

Minimum embedding depth a, minimum concrete cover c_{nom} [mm]

f [mm]	b = 30–250 mm	
	a [mm]	c_{nom} [mm]
60 ①	50	10
70 - 120	55	15

① According to EN 1992-1-1/NA:2013-04 f_{min} ≥ 70 mm applies for the slab thickness.

Selecting the anchor height for FA

The height of the flat anchor (H) depends on the thickness of the insulation layer (b) and the embedding depth (a).

$$H \geq 2 \times a + b$$

Anchor height H [mm]

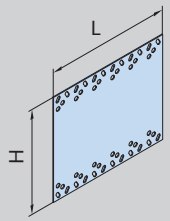
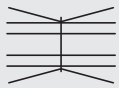
f [mm]	b [mm]														
	30	40	50	60	70	80	90	100	120	140	160	180	200	230	250
60 ①	150	150	175	175	175	200	200	225	225	260	280	300*	325*	350*	375*
70 - 120	150	150	175	175	200	200	200	225	260	260	280	300*	325*	350*	375*

① According to EN 1992-1-1/NA:2013-04 f_{min} ≥ 70 mm applies for the slab thickness.
* on request

Additional reinforcement for FA

The anchoring bars have to be placed in the facing and load-bearing layers. The number of reinforcement bars depends on the size of the flat anchor.

Anchoring in concrete

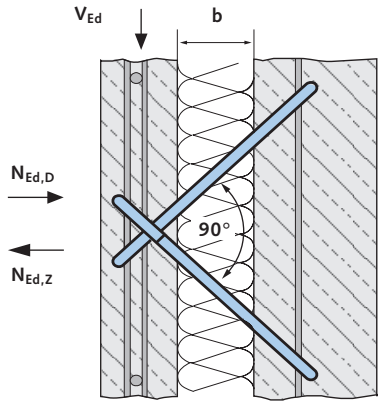
Flat anchor	Length L [mm]	Symbol	Anchoring bars B500A, B500B
	80		2 × 4 Ø 6 mm l = 400 mm
	120		2 × 5 Ø 6 mm l = 400 mm
	160, 200, 240, 280		2 × 6 Ø 6 mm l = 400 mm
	320, 360, 400		2 × 7 Ø 6 mm l = 400 mm

Please refer to the overview of available anchors on page 6.

Sandwich panel anchor SPA

Required input values for determining the allowable load-bearing capacity are anchor type, insulation layer thickness b and present horizontal loads.
The allowable distances e_{max} depend on the insulation layer thickness b.

As an example, the following demonstrates the steel load-bearing capacity and the limit of concrete load-bearing capacity for sandwich panel anchors SPA-1-09 and SPA-2-09.
It explains the procedure for calculating the vertical load-bearing capacity for an insulation layer thickness b = 12 cm and an acting horizontal force of N_{Ed} = 3.0 kN.



Example: Load-bearing capacity for SP-SPA with Ø 8.5 mm

Load-bearing strengths $F_{VR,d}$ [kN]			
b [cm]	e_{max} [cm]	SP-SPA-1-09 $V_{Rd,s} = N_{Rd,s,D}$	SP-SPA-2-09 $V_{Rd,s} = N_{Rd,s,D}$
6	102	26.59	53.18
7	132	25.29	50.57
8	166	24.02	48.03
9	204	22.78	45.56
10	246	21.58	43.16
11	292	20.42	40.84
(a) 12	342	19.30	38.61
13	395	18.23	36.46
14	453	17.21	34.41
15	515	16.23	32.47
16	580	15.31	30.62

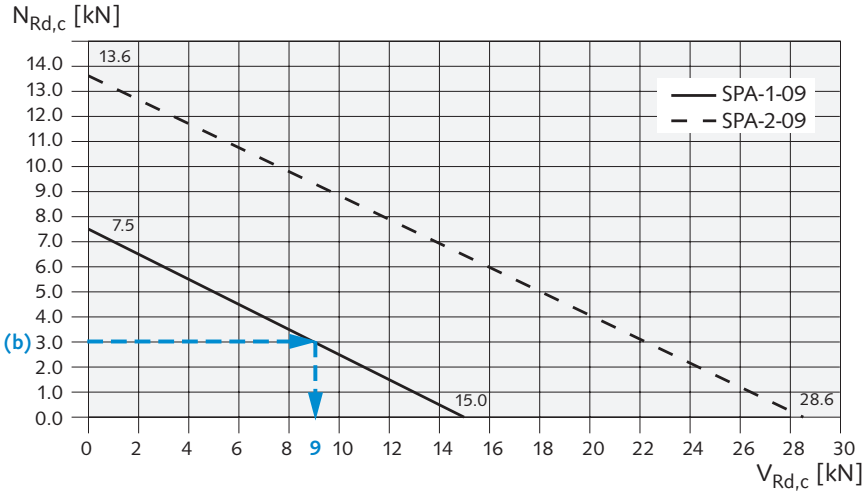
Example calculation:
Insulation layer thickness = 12 cm
Determinant horizontal force
N_{Ed} = 3.0 kN
Supporting anchor SPA-1-09

1. Steel load-bearing capacity (vertical)
   → $V_{Rd,s}$ = 19.30 − 3.0 = 16.30 kN **(a)**

2. Concrete load-bearing capacity (vertical)
   → $V_{Rd,c}$ = 9.0 kN **(b)**

→ **Concrete load-bearing capacity is decisive! V_{Rd} = 9.0 kN**

Concrete load-bearing capacity limit SPA-09



We recommend using HALFEN SPA Software for planning.

Note:
The HALFEN Software verifications correspond with the equations in the Building Authority Approval, these deviate only in method from the example shown on this page.
The results are identical.

Further tables and diagrams are available in the SPA German Building Approval – Appendix 6 to 10

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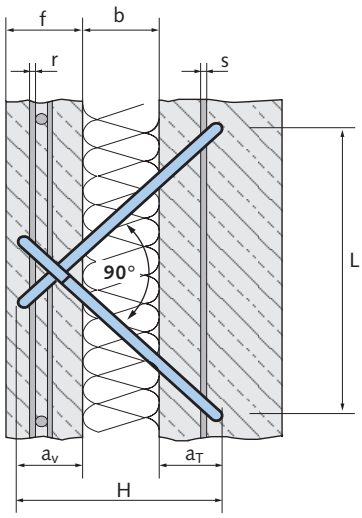
Sandwich panel anchor SPA

Material for sandwich panel anchors:
Stainless steel A4

Concrete quality:
Facing layer ≥ C 30/37
Load-bearing layer ≥ C 30/37

Reinforcement:
Reinforcing mats B500A, B500B
Ribbed reinforcing bars B500A, B500B

Minimum reinforcement for the facing layer:
Square reinforcement mesh 1.3 cm^2 / m



L — values L → see page 7

Minimum embedment depth of the SPA Sandwich panel anchors
The minimum embedment depths a_V, and a_T in the facing and in the load-bearing layer depend on the diameter of the supporting anchor.

Minimum embedding depth a and selection of the anchor height H:

Type	Article name			
	SP-SPA-1-05 SP-SPA-2-05	SP-SPA-1-07 SP-SPA-2-07	SP-SPA-1-09 SP-SPA-2-09	SP-SPA-1-10 SP-SPA-2-10
Ø	5.0	6.5	8.5	10.0
b	30–70	40–150	60–250	200–300
a_v	≥ 49	≥ 50	≥ 53	≥ 54
a_T	≥ 55	≥ 55	≥ 55	≥ 55
H	$a_v + b + a_T$	$a_v + b + a_T$	$a_v + b + a_T$	$a_v + b + a_T$
f ①	≥ 60	≥ 60	≥ 60	≥ 60

All dimensions in [mm]
① According to EN 1992-1-1/NA:2013-04 f_{min} ≥ 70 mm applies for the slab thickness.

Additional reinforcement for SPA
Place anchoring bars in the facing and load-bearing layers. The length and diameter of the reinforcing bars depends on the anchor size.

Additional reinforcement

Type	SPA-1-05	SPA-1-07	SPA-1-09	SPA-1-10
r	1 Ø 8 l = 450	1 Ø 8 l = 450	1 Ø 8 l = 700	1 Ø 8 l = 700
s	1 Ø 8 l = 700	1 Ø 8 l = 700	1 Ø 10 l = 700 ②	1 Ø 10 l = 700 ②
Type	SPA-2-05	SPA-2-07	SPA-2-09	SPA-2-10
r	2 Ø 8 l = 450	2 Ø 8 l = 450	2 Ø 8 l = 700	2 Ø 8 l = 700
s	2 Ø 8 l = 700	2 Ø 8 l = 700	2 Ø 10 l = 700 ②	2 Ø 10 l = 700 ②

All dimensions in [mm]
② for L > 500 mm l = 900 mm, for L > 800 mm l = 1100 mm (values L → see page 7)

Please refer to the overview of available anchors on page 7.

Restraint ties (connector and clip-on pins and stirrup ties)

Required input value for determining the admissible horizontal load-bearing strengths N_{Rd} and the maximum admissible distances e_{max} (→ table on page 19) is the insulation layer thickness b.

Material: Stainless steel A4

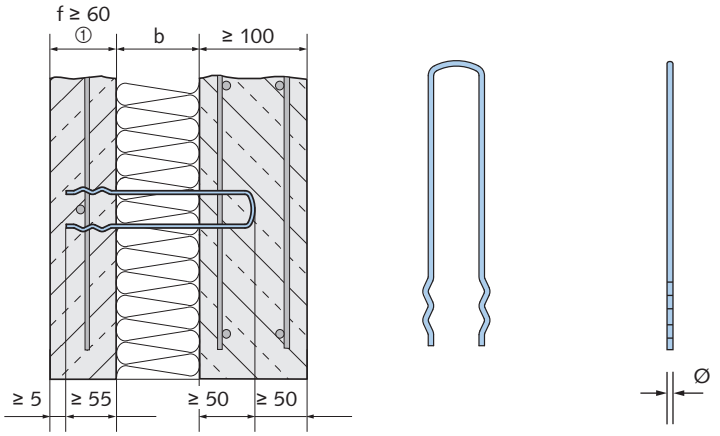
Concrete quality: Facing and load-bearing layer ≥ C 30/37

Reinforcement:
Concrete steel mats B500A, B500B
Reinforcement bars B500A, B500B

Minimum reinforcement for the facing layer:
Square reinforcement mesh 1.3 cm² / m

Connector pins SPA-N

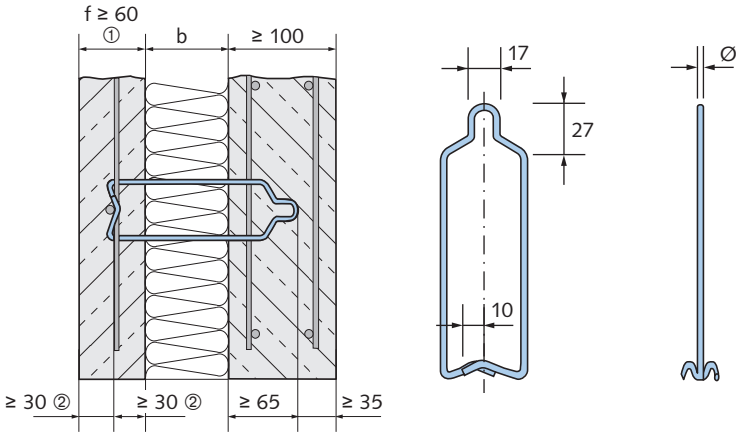
Ø 3.0 Article name SP-SPA-N-03
Ø 4.0 Article name SP-SPA-N-04
Ø 5.0 Article name SP-SPA-N-05
Ø 6.5 Article name SP-SPA-N-06



All dimensions in [mm].
① According to EN 1992-1-1/NA:2013-04
f_{min} ≥ 70 mm applies for the slab thickness.

Stirrup ties SPA-B

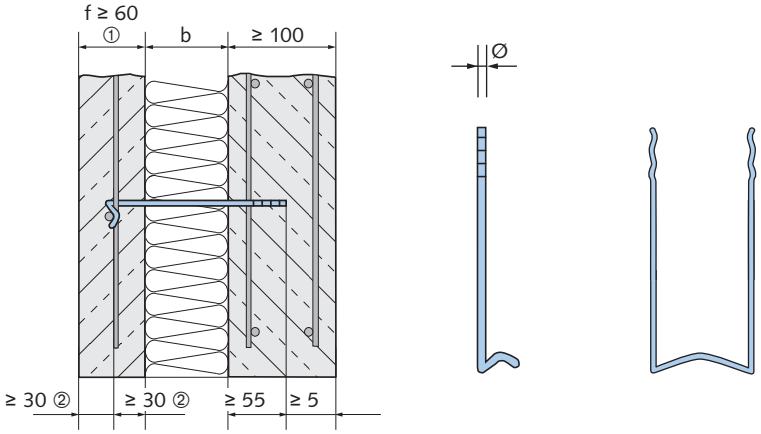
Ø 3.0 Article name SP-SPA-B-03
Ø 4.0 Article name SP-SPA-B-04
Ø 5.0 Article name SP-SPA-B-05



All dimensions in [mm].
① According to EN 1992-1-1/NA:2013-04
f_{min} ≥ 70 mm applies for the slab thicknes
② ≥ 35 for f ≥ 70 mm

Clip-on pins SPA-A

Ø 3.0 Article name SP-SPA-A-03
Ø 4.0 Article name SP-SPA-A-04
Ø 5.0 Article name SP-SPA-A-05



All dimensions in [mm].
① According to EN 1992-1-1/NA:2013-04
f_{min} ≥ 70 mm applies for the slab thicknes
② ≥ 35 for f ≥ 70 mm

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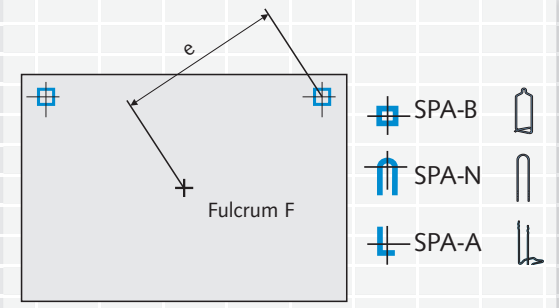
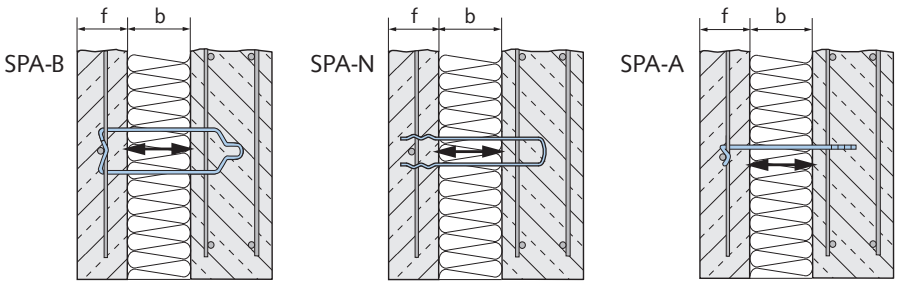
Anchor Calculation for f ≥ 70 mm

e_{max} [cm] SPA-N, SPA-B, SPA-A

	SPA-N-03 SPA-A-03 SPA-B-03		Ø 3 mm		SPA-N-04 SPA-A-04 SPA-B-04			Ø 4 mm		SPA-N-05 SPA-A-05 SPA-B-05			Ø 5 mm			SPA-N-06	Ø 6.5 mm			
N_{Rd} [kN]	1.5	2.4	3.0	3.8	3.0	3.6	4.3	5.1	6.6	3.9	4.5	5.1	5.8	6.7	7.2	4.3	5.1	5.8	6.6	7.2
b [cm]																				
3	162	155	146	135	144	141	138	135	129	139	138	137	136	135	132					
4	265	253	238	220	230	226	221	216	206	218	216	215	213	210	206					
5	392	375	353	327	336	329	322	315	301	313	311	309	306	303	297					
6	545	520	490	454	462	453	443	434	414	426	423	421	417	412	404					
7	722	690	650	602	608	596	583	570	545	557	553	549	544	539	528					
8	925	883	832	770	774	758	742	726	694	705	699	695	689	682	668					
9	1000	1000	998	960	960	940	920	900	860	870	863	858	850	842	825					
10	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	998					
11	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000					
12	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000					
13	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000					
14	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000					
15	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
16					1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
17					1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
18					1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
19										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
20										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
21										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
22										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
23										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
24										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
25										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
26										1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
27																1000	1000	1000	1000	1000
28																1000	1000	1000	1000	1000
29																1000	1000	1000	1000	1000
30																1000	1000	1000	1000	1000
31																1000	1000	1000	1000	1000
32																1000	1000	1000	1000	1000
33																1000	1000	1000	1000	1000
34																1000	1000	1000	1000	1000
35																1000	1000	1000	1000	1000
36																1000	1000	1000	1000	1000
37																1000	1000	1000	1000	1000
38																1000	1000	1000	1000	1000
39																1000	1000	1000	1000	1000
40																1000	1000	1000	1000	1000



Values in white text in dark cells are only allowed with tensile stress!
Load capacity N_{Rd}, e_{max} for 6 cm ≤ f ≤ 7 cm: See general building authority approval.



Please refer to the overview of available anchors on page 7.

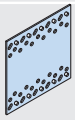
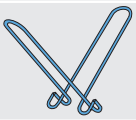
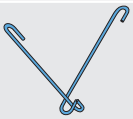
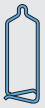
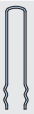
Rules for placement of sandwich panel anchors

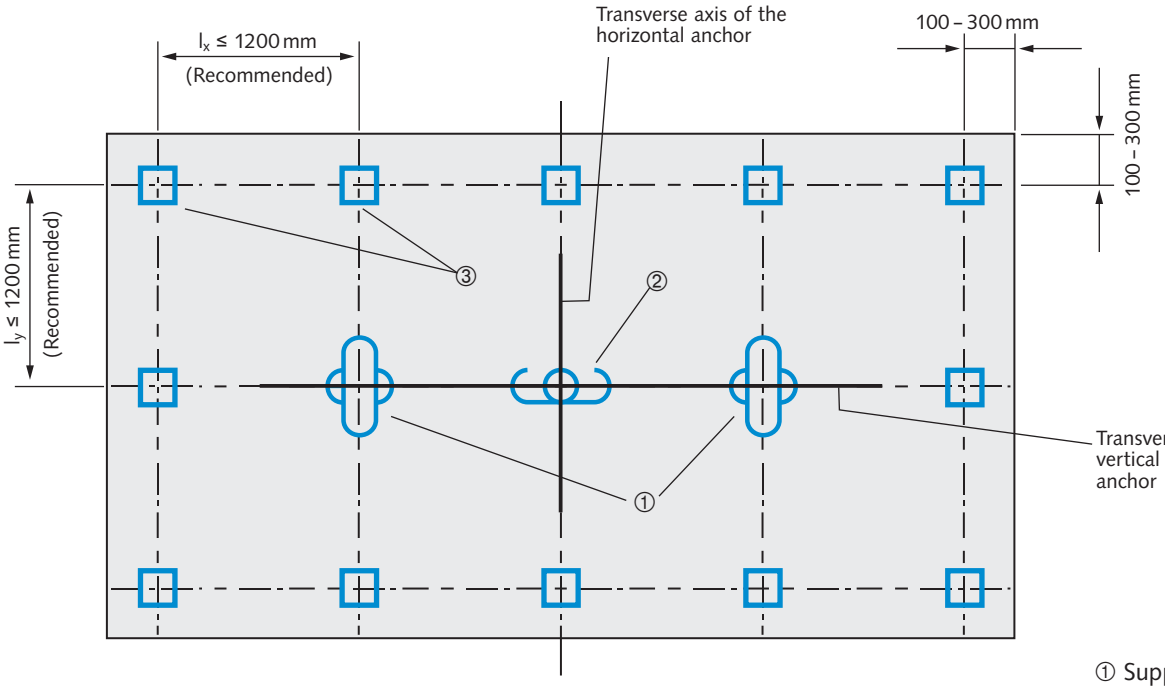
1. Supporting and torsion- i.e. horizontal anchors
When placing supporting, torsion and horizontal anchors the following boundary conditions should be observed:

- the anchors must be situated on the transverse axis of the vertical supporting anchor
- the minimum number of anchors and the relative placement of the anchors to the centre of gravity depend on the selected Supporting system (see page 21 ff.)
- if possible place supporting anchors at grid nodes
- keep within the allowable distance of the anchor from the fulcrum
- keep within the allowable edge and axis distances

2. Restraint ties
When placing restraint ties the following boundary conditions has to be observed:

- if possible place restraint ties at grid nodes
- keep e of the restraint tie within the allowable distance from the fulcrum
- observe the allowable edge and axis distances
- place two restraint ties at a distance of approximately 20 cm at heavily loaded grid nodes (for example with overhangs)

Icons for sandwich panel anchor types		
	MVA	
	FA	
	SPA-2	
	SPA-1	
	SPA-B	
	SPA-N	
	SPA-A	



① Supporting anchor
② Horizontal anchor
③ Restraint tie

Where possible the side ratio l_x/l_y should be between 0.75 and 1.33!

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Fulcrum of the sandwich panels

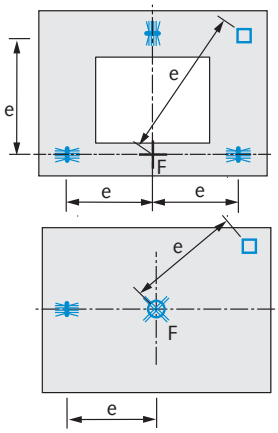
HALFEN supply three different types of anchor for connecting load-bearing and facing layers:

- Sleeve anchor SP-MVA
- Flat anchor SP-FA
- Sandwich panel anchor SP-SPA

Four different types of supporting systems can be created from these (MVA, MVA-FA, FA-FA, SPA-SPA).

To anchor the facing layer to the load-bearing layer as constraint free as possible, certain rules have to be applied.

In principle, the anchoring system must be chosen so that only one single point, a so-called fulcrum, is set in the facing layer from which the slab can expand freely in all directions. This reduces any restraint forces that may arise therefore minimizing cracks in the facing layer. The allowable distances from the fulcrum e must be considered when placing sandwich panel anchors.



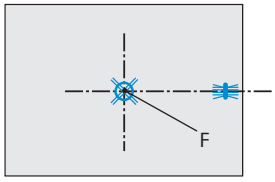
F = fulcrum
See page 20 for explanation of symbols

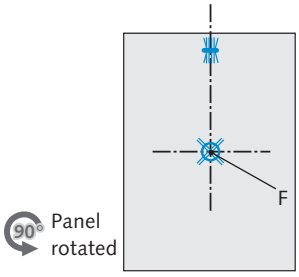
Fulcrum in systems with SP-MVA

The fulcrum for systems with sleeve anchors (MVA, MVA-FA) is always the position of the MVA.

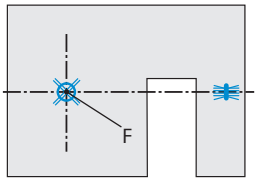
This means that sandwich panels with sleeve anchors always have just one MVA; the same applies for panels where installation orientation = transport orientation and for panels that are rotated for transporting.

MVA





MVA-FA



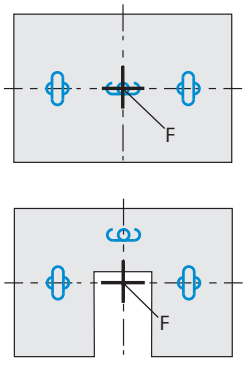
F = fulcrum
See page 20 for explanation of symbols

Fulcrum in systems with SP-FA and SP-SPA

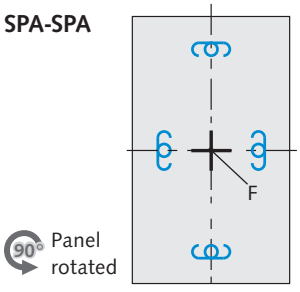
Panels with systems FA-FA and SPA-SPA always contain at least 2 supporting anchors and 1 horizontal anchor which are arranged on 2 axes arranged at 90° to one another.

The fulcrum is always at the intersection of the two anchor transverse axes.

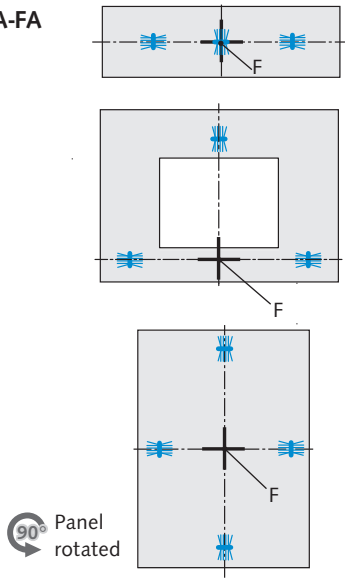
SPA-SPA



SPA-SPA



FA-FA



F = fulcrum
See page 20 for explanation of symbols

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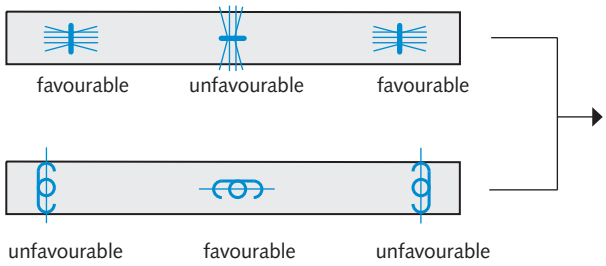
Mixed systems and special solutions

Panels with minimal widths

In panels with minimal widths, it is preferable to install SP-FA as a supporting anchor and SP-SPA as a horizontal anchor.

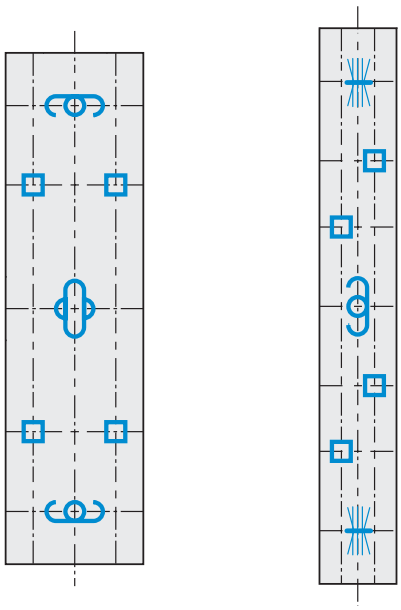
This is because of the height of the anchors and the direction of the reinforcement.

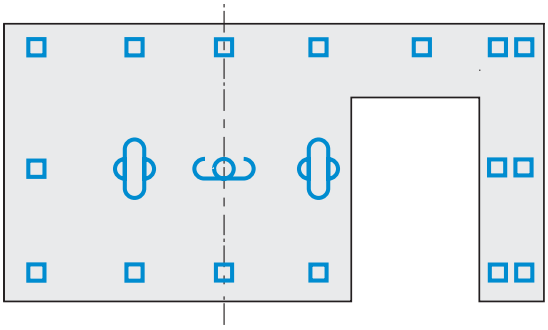


Solution:

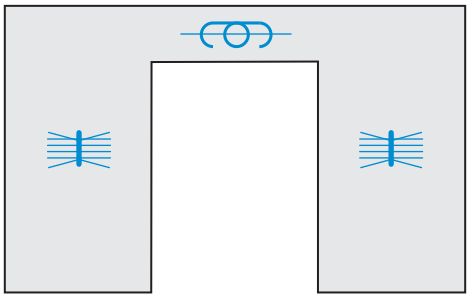
In panels with minimal widths the restraint ties should also be arranged in pairs or staggered even if the minimum axis or edge distances are compromised.

The same procedure applies for all minimal widths (for example minimal widths adjacent to door openings).

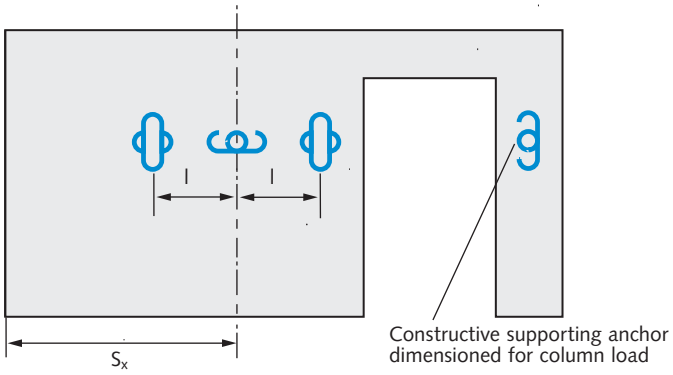




Panels with minimal lintel areas



Panels with posts adjacent to openings with minimal lintel



See page 20 for explanation of symbols

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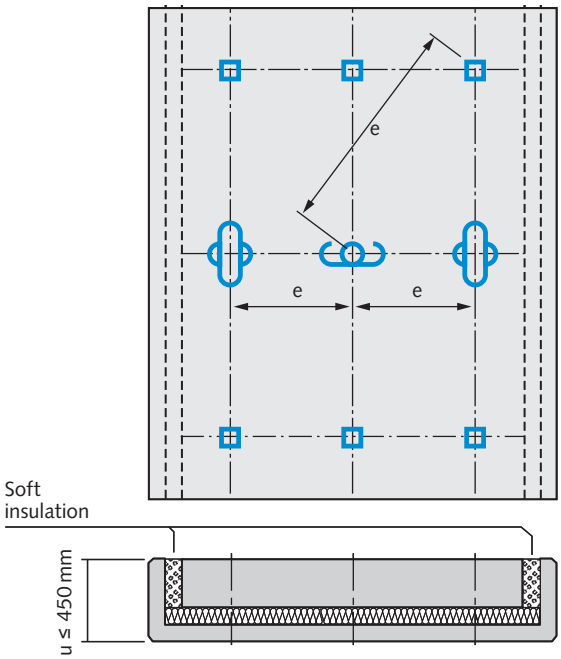
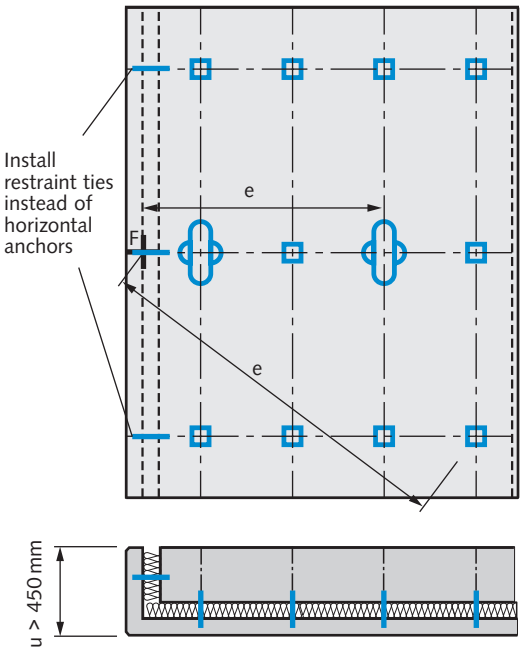
Mixed systems and special solutions (continued)

Restraint tie at panel corners

With corner elements, where u ≤ 450 mm, care must be taken that no connecting elements are placed in the short leg (this applies to both supporting anchors and restraint ties).



If u > 450 mm restraint ties must be placed in the legs. In this case horizontal anchors are not used and the distance e is measured from the leg (see figure below).

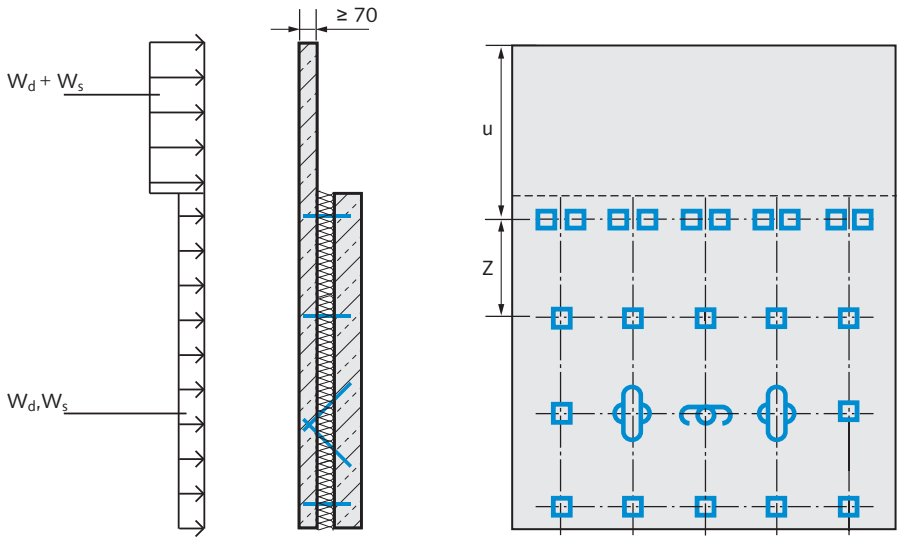


Note: Also possible with supporting system FA-FA.
Placing restraint ties in the shorter legs is not possible with SP-MVA systems (possible distortions).

See page 20 for explanation of symbols

Facing layers with large overlap

Facing layers with large overhang u (approximately 300 to 900 mm) causes high stresses in the outermost row of restraint ties as a result of wind loads. Two restraint ties per grid point should be spaced at about 20 cm centres to carry these forces.
Wind loads cause facing layers with large overhangs to twist at the end supports (last row of restraint ties) and therefore to comparatively large movements at the edge of the facing layer. As a countermeasure, we recommend selecting a lower "Z" value than the maximum admissible value for the first field next to the overlap.



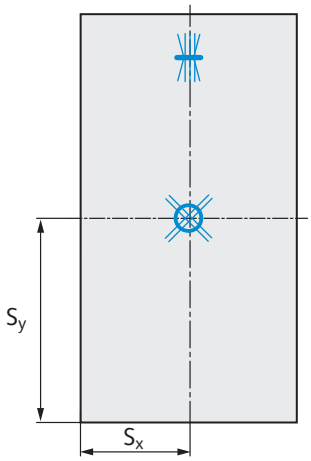
Supporting system diagrams

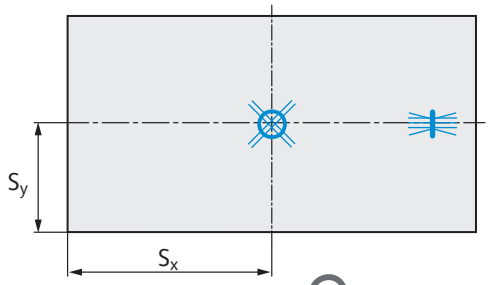
The following details show the various supporting systems and their special features, including examples.

Supporting system MVA

1 SP-MVA as a supporting anchor (positioned in the facing layer at the centre of gravity)
1 SP-FA as torsion anchor
→ as an alternative you can also use a SP-SPA as a torsion anchor.
Note: No additional measures are required for rotated panels.

Rectangular panel





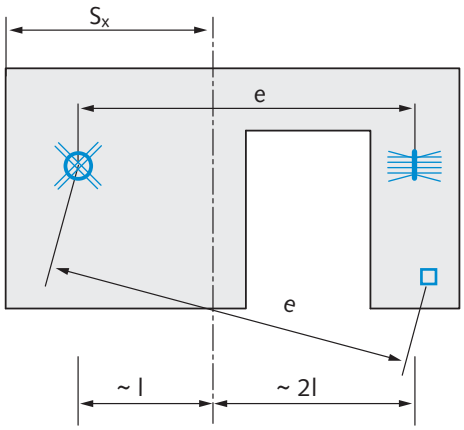
S_x/S_y = centre of gravity

See page 20 for explanation of symbols

Supporting system MVA-FA

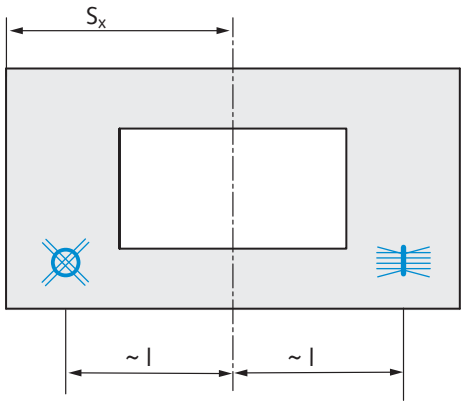
1 SP-MVA and 1 SP-FA as support anchors (arranged asymmetrically to the horizontal axis of centre of gravity at a ratio of 1:2).
No additional horizontal anchor is required.
Note: The Supporting system changes in rotated panels (support anchors are placed on the horizontal axis of centre of gravity S_y).

Rectangular panel with door opening



Attention:
Large distance for e as the panel fulcrum is off-centre.

Rectangular panel with large window opening



Special case:
Support anchors are placed symmetrically.

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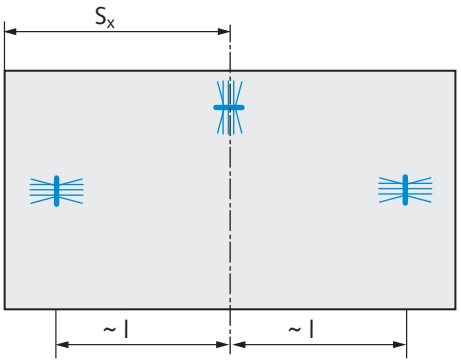
Supporting system FA-FA

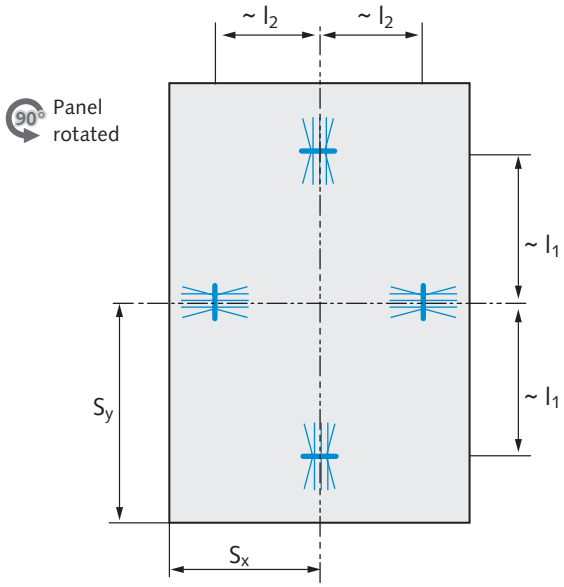
2 SP-FA as support anchors (standard arrangement is symmetrically to the centre of gravity)
1 SP-FA as horizontal anchor
→ as an alternative you can also use an SP-SPA as a horizontal anchor.
Note: For rotated panels the horizontal anchors have to be dimensioned as for the support anchors.

Rectangular panel

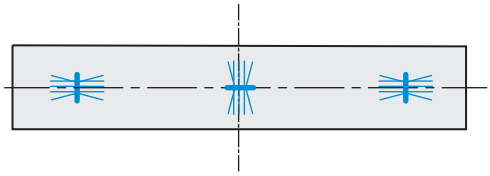


S_x/S_y = centre of gravity

See page 20 for explanation of symbols

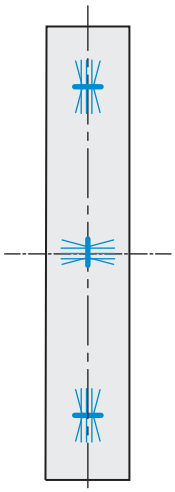


Base panel

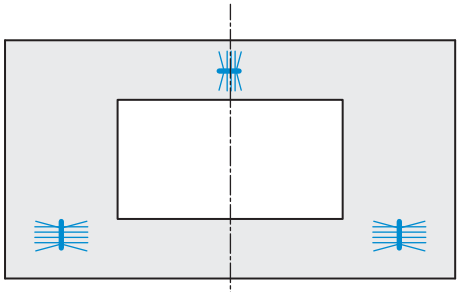


Minimal width, low panel

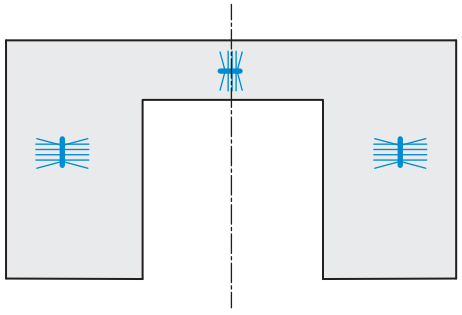
Special case:
1. Support anchor in the axis of centre of gravity
2. Horizontal / Torsion anchors



Panel with window opening



Panel with wide door opening



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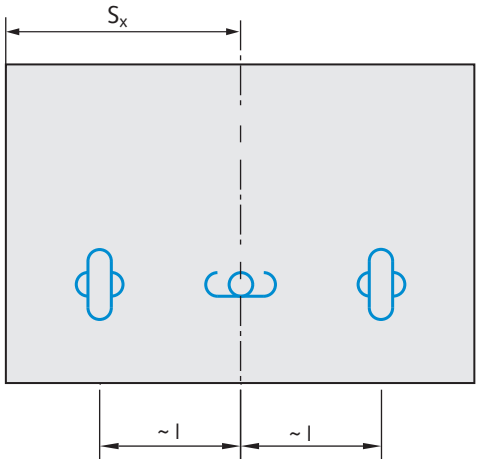
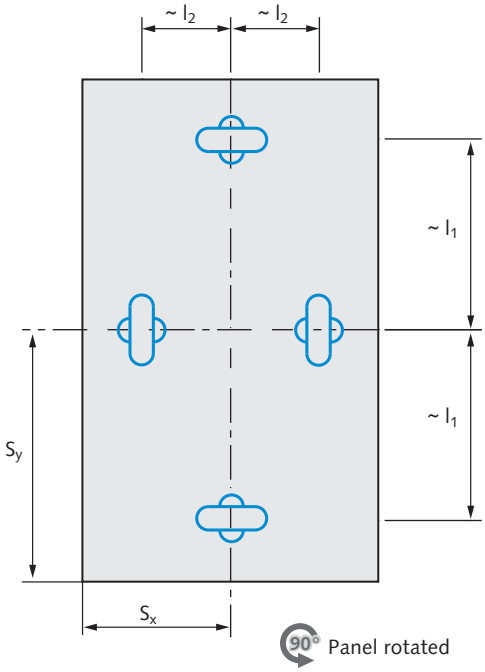
Supporting system SPA-SPA

2 SP-SPA as support anchors, 2 supporting anchor groups (standard arrangement is symmetrically to the axis of centre of gravity)
1 SP-SPA as horizontal anchor.
→ An alternative is to use 1 SP-FA as a horizontal anchor.
Note: For rotated panels the horizontal anchors have to be dimensioned as supporting anchors.

Rectangular panel

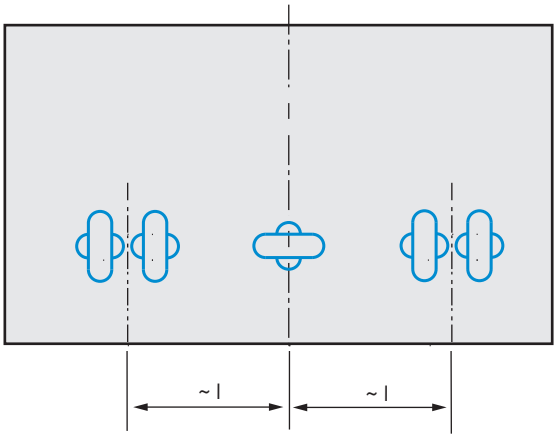


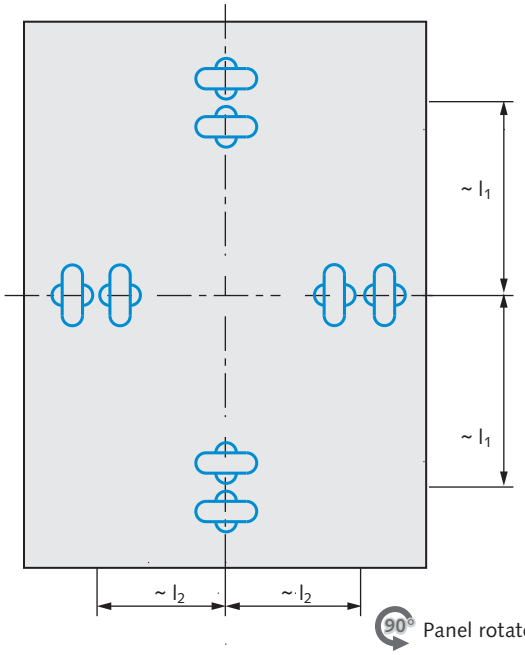


S_x/S_y = centre of gravity

See page 20 for explanation of symbols

Large format panel 2 support anchor groups





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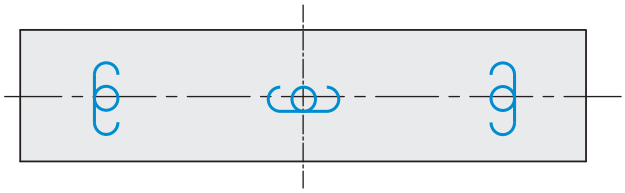
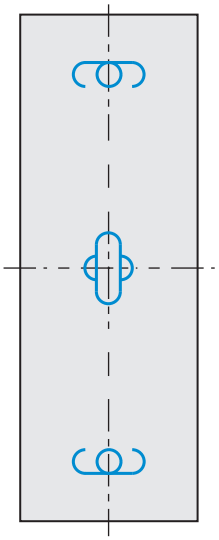
Supporting system SPA-SPA (continued)

Base panel



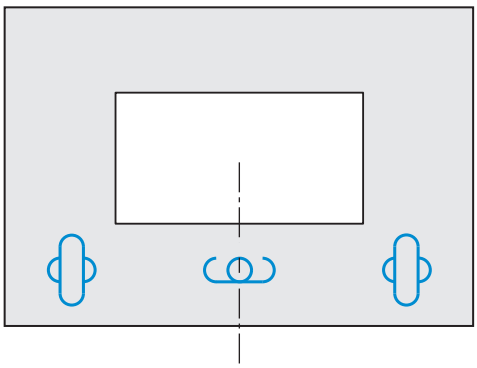
Minimal width, high panel



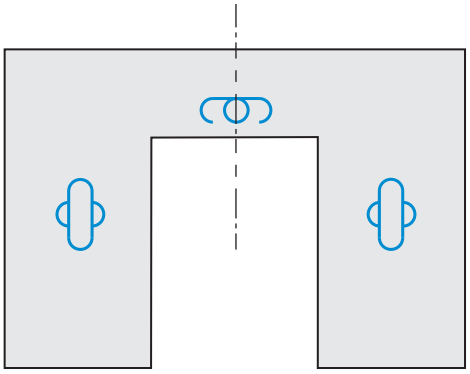
Special case:

1. Support anchor in the axis of centre of gravity
2. Horizontal / Torsion anchors

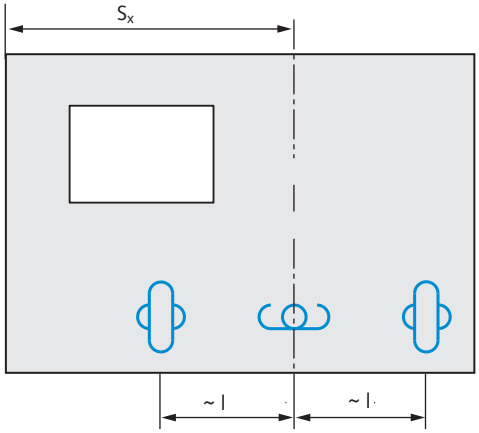
Panel with window opening



Panel with wide door opening



Asymmetric panel



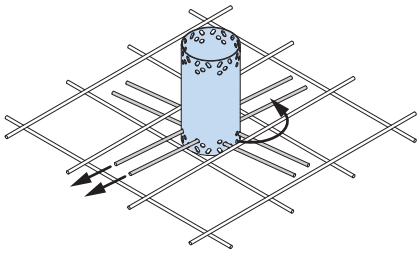
See page 20 for explanation of symbols

Placing anchors using the negative process ① = facing layer down (standard case)

The anchors are installed when laying the facing layer reinforcement. ① For more information please see page 33.

Sleeve anchors MVA

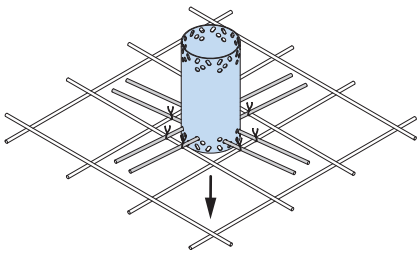
- Insert anchoring bars in the bottom row of round holes of the MVA and turn assembly so that the bars are parallel to the bottom reinforcement bars of the reinforcing mat.
- Insert anchoring bars in the top row of round holes 90° to the bottom layer and parallel to the upper reinforcement bars of the reinforcing mat.
- Rotate the MVA 45° so that the bottom anchoring bars slide under the bottom row of bars and the top ones slide over the top row of bars.
- It is not necessary to secure the MVA to the reinforcing mat.
- Place the prepared facing layer reinforcement into the mould.



Alternative MVA installation

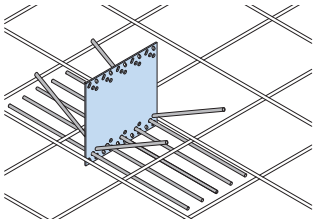
(generally recommended for thin facing layers)

- Place SP-MVA from above into the previously positioned reinforcement.
- No moving of the anchoring bars under the reinforcing mat.
- Secure in place by tying to the reinforcement mat.

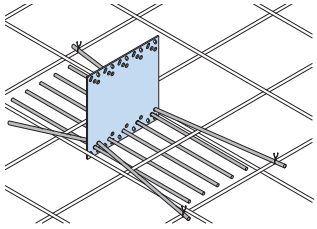


Flat anchors FA

- Insert two anchoring bars bent 30° at the middle (L = 400 mm) in the outside holes of the topmost row of the round holes in the flat anchor.
- Position the flat anchor on the reinforcing mat at the predefined location.
- Insert the anchoring bars from under the reinforcing mat, through the bottom row of round holes of the flat anchor.



- Twist the bent anchoring bars to the horizontal and wire to the reinforcing mat.



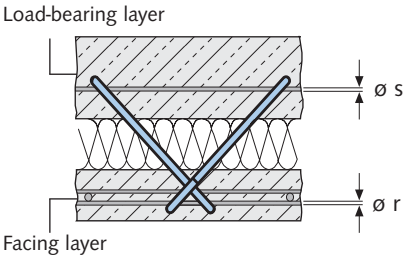
Alternative FA installing

(tying to the reinforcement mat):

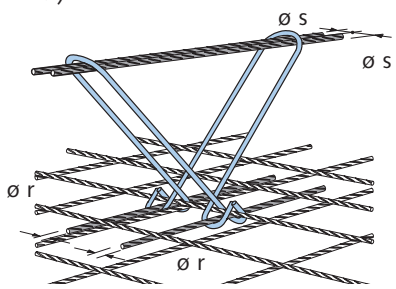
- Place the flat anchors on to the previously placed reinforcing mat from above and secure by tying.

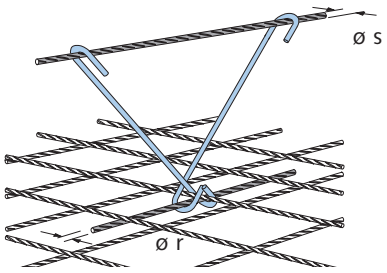
Note: Check the allowable distances e of the FA from the fulcrum (see table in the approval).

Support anchors SPA-1 and SPA-2



- Place the support anchors on the reinforcing mat and secure under the mat with one or two reinforcing bars (ø r depends on anchor type, page 17).





- Pour the bottom facing layer concrete, install the insulation and lay the bottom reinforcement layer for the load-bearing layer.
- Tie 1 or 2 reinforcing bars depending on anchor type to the inside of the top loops of the support anchor (see table on page 17).
- Fix towards the centre of a grid square.

When lifting sandwich panel components from the formwork, the adhesion should be kept as low as possible. In particular, **do not lift parallel** to the tilting table!

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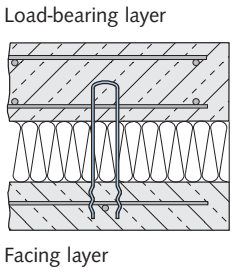
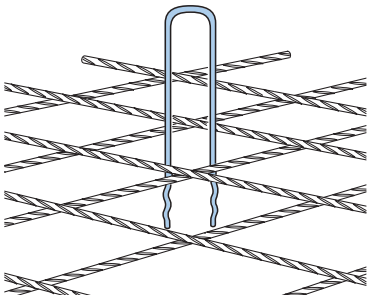
Placing pins and ties

Connector pins SPA-N

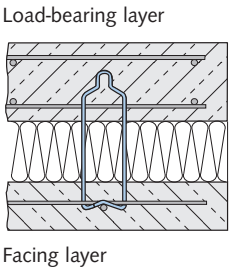


- Press the connector pin through the insulation into the still soft concrete of the facing layer to a depth of at least 55 mm (observe the minimal embedment depth required for the round end of the connector pin).

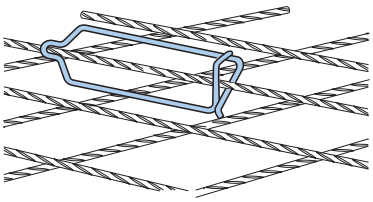


Installation at the precast plant: SPA-A

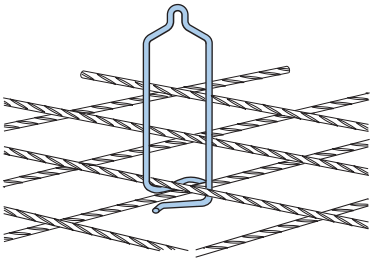
Stirrup tie SPA-B



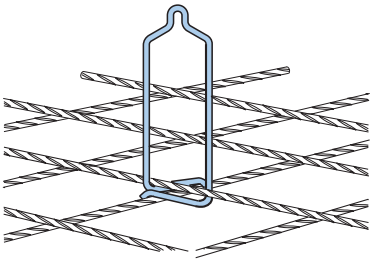
- Hook under the top reinforcing bar as shown below.



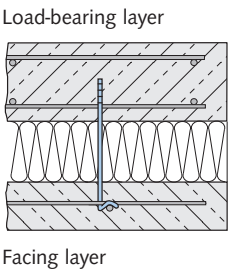
- Turn to an upright position.



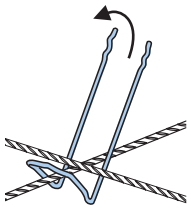
- Turn clockwise whilst pressing the legs together and clip onto the bottom reinforcing bar.



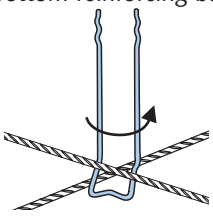
Clip-on pin SPA-A



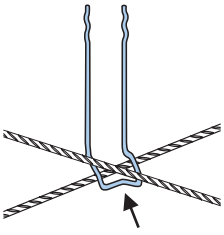
- Pass the clip-on pin under the top reinforcing bar and swing to an upright position.



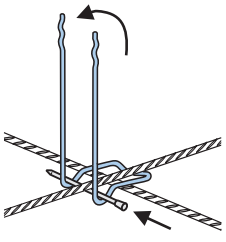
- Twist the clip-on pin to the left over the bottom reinforcing bar.



- Clip the clip-on pin firmly to the mat node.



Alternative:
Pass the clip-on pin in the crossing mat under the top and over the bottom reinforcing bar. Press the legs slightly to the left and insert a nail, as shown, under the top reinforcing bar.



Placing the heat insulation layer

Sleeve anchor MVA

The insulation can be easily pressed over the sleeve anchor (punched out).

Important: The round punched out parts of the heat insulation must be re-placed on the inside of the sleeve anchors.

Otherwise the resulting thermal bridges will be visible as damp round marks on the facing layer.

Flat anchors FA

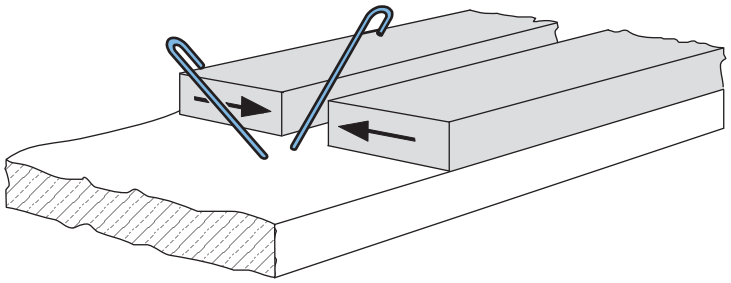
Flat anchors can be simply pressed into the insulation.

Alternatively the insulation joint can be aligned exactly with the position of the flat anchor.

Sandwich panel anchors SPA

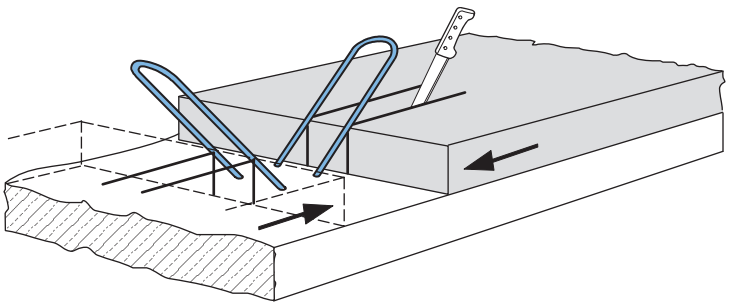
Supporting anchor SPA-1

Placing insulation when using the SPA-1 supporting anchor is simple; cut the insulation material along the longitudinal axis of the anchor and push the segments back together.



Supporting anchor SPA-2

The insulation is cut so that the cut ends are midway between the sandwich supporting anchor. Two cuts are then made in the insulation to accommodate the anchor bars (space between two bars). Both halves are then pushed over the bars of the anchor from each side to close the gap (see illustration on the right).



Connector pins SPA-N

Connector pins are pushed through the previously placed insulation layer.

Stirrup ties SPA-B

Styropor© panels can be easily pressed over the stirrups. When using extruded hard foam, the insulation layer should be cut out at the anchor positions to avoid bending the stirrups.

Clip-on pins SPA-A

The insulation is easily pressed over the corrugated ends.

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Placing anchors using the positive process ① = facing layer up

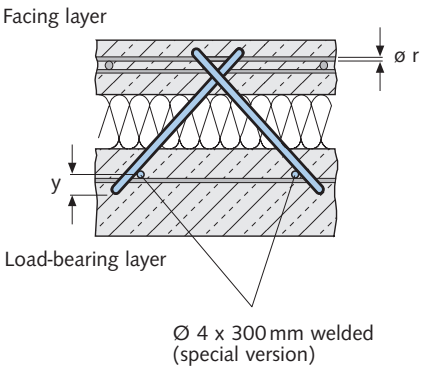
Placing of sleeve anchors MVA and flat anchors FA is the same as with the negative process. ① For details please see page 33.

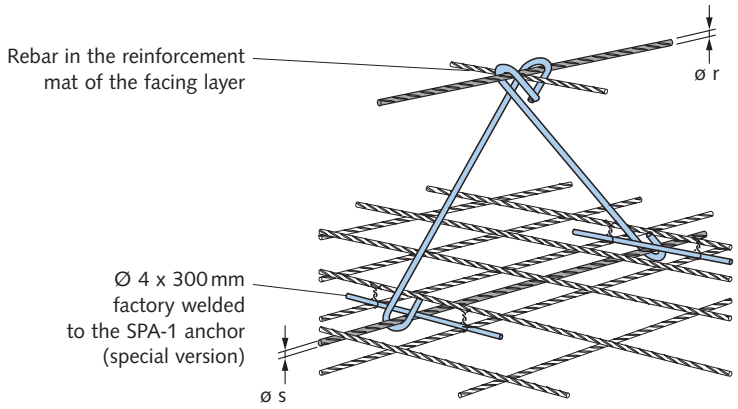
Supporting anchors SPA-1 and SPA-2

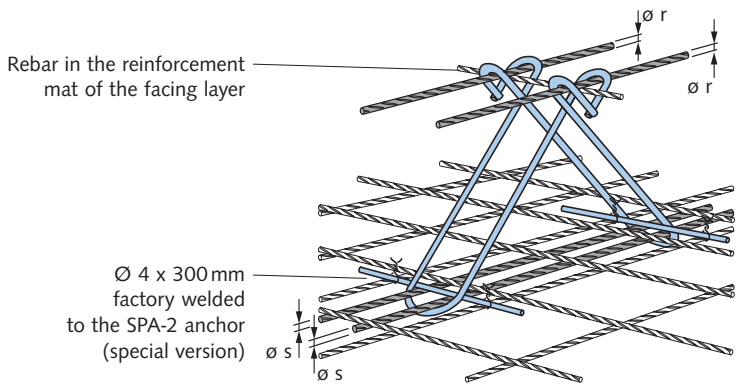
Supporting anchors are fitted with factory welded rebars Ø 4 x 300 mm for producing sandwich panels in the facing layer up method (customized production on request).
The supporting anchors are installed in the top reinforcing mat of the load-bearing layer.
The welded bars are wired to the mat and secured with the secondary rebars (Ø see table on page 17).

After the concrete has been poured and cured and the insulation fitted, the facing layer mat is placed under the exposed hook in the anchor and secured with the secondary rebars. Connector pins type SPA-N are used for horizontal anchoring.

Important:
When ordering, state dimension y (position of the welded-on bars Ø 4 x 300 mm).







When lifting sandwich panel components from the mould, the adhesion should be kept as low as possible. In particular, **do not lift parallel** to the tilting table!

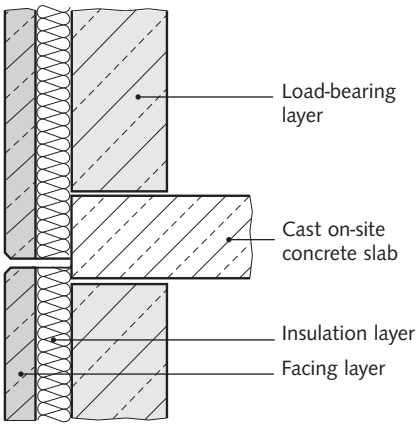
Structure of a sandwich panel

Sandwich panels are large multilayer, reinforced concrete façade elements. They consist of a facing layer, an insulation layer and a load-bearing layer (3-layer assembly).

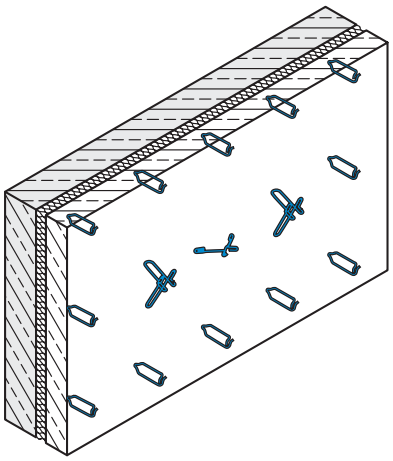
A ventilation gap can also be included between the insulation layer and the facing layer (4-layer assembly).

Sandwich panel anchors (support anchors, torsion anchors or horizontal anchors and restraint ties) connect the facing layer to the load-bearing layer.

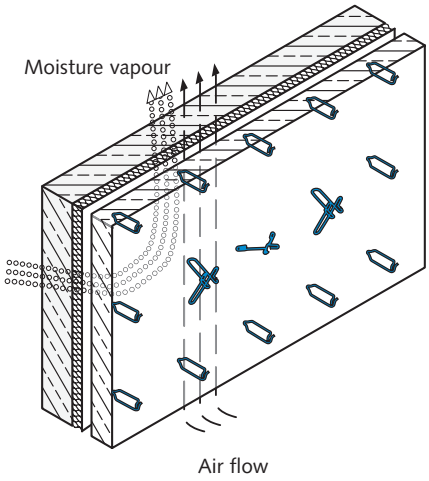
Typical structure of a 3-layer panel



Sandwich panel with no ventilation gap 3-layer panel



Sandwich panel with ventilation gap 4-layer panel



Requirements on the anchorage system

The function of the HALFEN Sandwich panel anchor system is to connect the load-bearing and facing layers of sandwich panels.

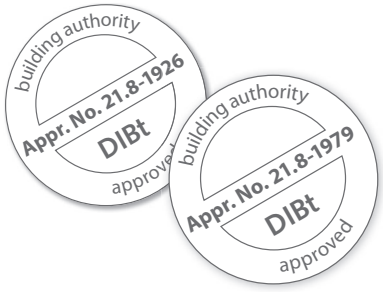
Primarily, the stresses acting on the facing layer must be transferred to the load-bearing layer while avoiding restricting the expansion and contraction of the facing layer.

The anchors are exposed to corrosive environments and must therefore be made of stainless steel (A4, L4).

The following influences must be taken into account when calculating anchors:

- dead load of the facing layer
- wind load
- temperature fluctuations within the facing layer (warping)
- changes to the average temperature of the facing layer (expansion)
- adhesion to the mould
- transport and assembly conditions
- admissible distances e of the load-bearing and the restraint ties to the fulcrum F

HALFEN Sandwich panel anchor systems SPA, MVA and FA are building authority approved.



The approvals can be downloaded free of charge from **www.halfen.de**.

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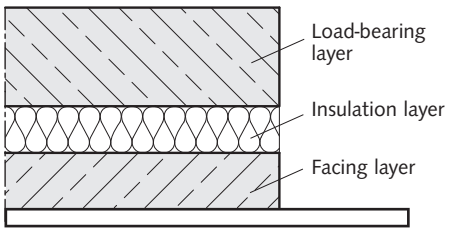
There are two distinct production methods for making Sandwich elements:

- face-down production (see page 28)
- face-up production (see page 31)

Face-down production



Production of the facing layer

- the reinforcement is placed in the prepared mould and supporting anchors and stirrup ties SP-SPA-B or clip-on pins SP-SPA-A are installed to specification
- concrete is poured evenly in the formwork
- compact the concrete (with external-vibrators)

Placing the heat insulation layer

Press the insulation material tightly against the anchors. Cutouts have to be carefully made to accomodate the anchors when high quality pressure resistant insulation material is used. Cavities in the insulation must be prevented as these will fill with concrete and cause thermal bridges or constraint points.

Recommendation:

Stagger the installation of heat insulation in 2 layers. Single layer insulation should have rabbet joints or the joints should be sealed with suitable adhesive tape. This will prevent concrete seeping into the joints.

When using high quality insulation materials (low thermal conductivity capacity and low water absorption) the thickness of the heat insulation layer can be reduced. The resulting increase in anchor load-bearing force permits the use of supporting anchors with a lower load rating. Insulation materials with low water absorption capacity favourably effect concrete shrinkage.

Placing separating foil between layers

Separating foil prevents concrete slurry from entering the heat insulation butt joints. Any adhesion between the heat insulation layer and the load-bearing layer concrete is also avoided. This is important when using rough, expanded polystyrene insulation material.
A foil layer can be placed between the facing layer and the insulation layer to ensure optimal flexibility of the facing layer. No foil is necessary when using high quality insulation material with a smooth surface.

Production of the load-bearing layer

- install the load-bearing layer reinforcement
- a traversable insulation material will assist installation
- the concrete is poured into the mould evenly and compacted

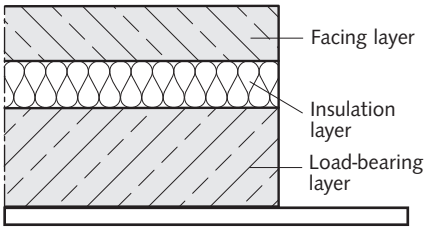
Notes when using connector pins SP-SPA-N

Connecting pins SP-SPA-N are installed at reinforcement nodes in the load-bearing layer reinforcement. The pins are pushed through the heat insulation to the required depth into the still soft concrete of the facing layer at the bottom of the mould. After the pins have been correctly placed it is recommended that subsequently the concrete of the facing layer be compacted again.

Important:

When using a spud-vibrator, avoid contact between the vibrator and the anchors. Contact will cause separation of the facing concrete, resulting in colour variations, making the anchor contours visible.

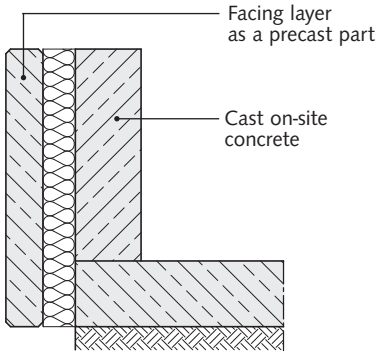
Face-up production



The production of a sandwich panel using the face-up production method is in reverse order to the face-down production method. First the load-bearing layer is poured and then the clip-on pins and any stirrup ties are installed. When using anchors SP-SPA, the instructions for sandwich panels in face-up production should be noted (see page 31).

Sandwich panel as semi-precast part

In this case, a factory made "facing layer" is produced with anchors and insulation installed and used as lost formwork. The "load-bearing layer" is then cast on-site.

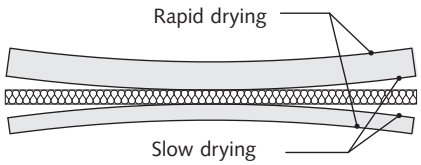


Warping caused by shrinkage

Sandwich panel elements often display signs of warping. Particularly large panels with a length of more than 6 m can be affected by deformation.

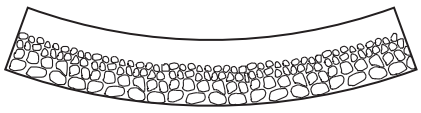
Shrinkage is mainly dependant on the drying of the concrete. This drying proceeds from the exterior inwards. This causes the inner and outer layers of the sandwich element to warp in different directions. The quicker the surface dries and the slower the slab-core dries the more exaggerated the warping. Deformations can be expected in sandwich panels exposed to direct sunlight or wind in the first few days after production. Use appropiate measures to prevent the concrete from drying too rapidly. Insulation with a low water absorption capacity should be used.

Insulation materials with a high water absorption capacity transfer moisture to the concrete during the curing process. This increases the differences in drying in the external and internal slabs in sandwich elements.



Concrete technology (additives etc.) can be used to reduce shrinkage and keep the resulting detrimental effects to a minimum. A low water/cement ratio should be used. The maximum aggregate size is chosen according to the reinforcement and dimensions of the sandwich panel. Keep cement paste and fine sand to a minimum.

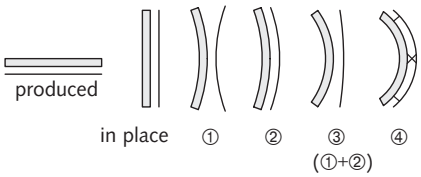
If the ratio of cement paste and fine sand is too high this will result in more shrinkage. The use of concrete additives, especially wetting agents, air-entraining agents, damp-proofing and permeability reducing agents and retarders can have a very detrimental effect on concrete shrinkage. Separation of aggregate is possible when compacting concrete. Large and heavy components in the concrete mix sink to the bottom during vibration. The smaller, lighter and wetter components rise to the top. This results in a higher shrinkage value at the top than at the bottom ('top' and 'bottom' refer to the position of the panel during concreting).



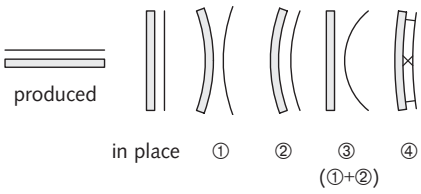
Segregated concrete

The type and intensity of the warping of a sandwich panel also depends on the production method, positive or negative method (see page 33).

Sandwich elements produced in the **face-down method** have a warping tendency in the load-bearing layer caused by time dependent shrinkage (① drying out) this is increased by mix dependent differential shrinkage (② mix separation). In the facing layer the warping tendencies from ① and ② counteract each other ③ and the layer remains virtually flat. The stiffer load-bearing layer imposes its warping on the facing layer via the connecting anchors ④.



In sandwich panels produced in the **face-up method**, the warping tendencies ① - ② are counteractive and the load-bearing layer remains virtually flat ③. The warping tendencies from the facing layer ① - ② accumulate. Warping in the facing layer is prevented by sandwich panel anchors ④.



Preventing warping by using sandwich panel anchors cause forces which can lead to cracks in the facing layer. Care should be taken to prevent this warping. Apart from the described production measures, correct planning and tried and tested construction methods should be used when designing prefabricated elements.

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Deformation of Sandwich Panels

Warping caused by temperature differences

With a rapid increase in temperature the outer surface of the facing layer is subjected to greater expansion than the non-exposed surface nearest to the insulation layer. This can be caused by direct sunlight in winter **(fig. 1**). In summer the facing layer can contract when thunderstorms cause sudden cooling of the surface **(fig. 2)**. The resulting warping of the facing layer is largely restrained by the more rigid load-bearing layer via the anchors. The magnitude of the resulting deformation forces depends on the following factors:

- temperature fluctuation in the facing layer
- thickness of the facing layer
- concrete quality; facing layer (Modulus of Elasticity)
- geometry of the facing layer
- type and arrangement (grid) of the anchors

Favourable influences are:

- light coloured facing layers
- thin facing layer thicknesses (f = 70 – 80 mm)
- evenly distributed grid of anchors (ratio ~ 1:1)

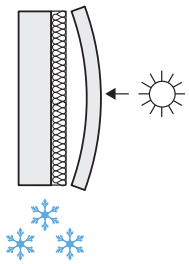


Fig. 1
sudden heat increase in winter

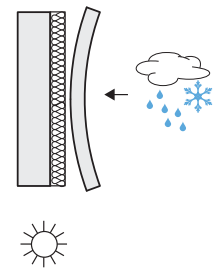
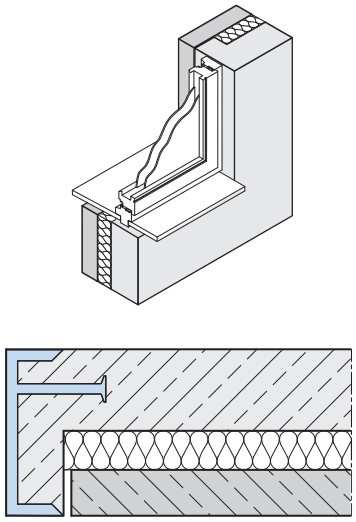


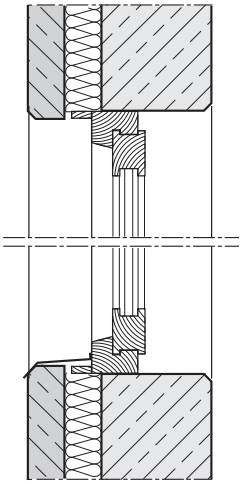
Fig. 2
sudden cooling in summer

Window and door fixings

To avoid cracks the connection of the facing layer to the load-bearing layer must be flexible. Additional fixing points such as windows or doors connected to the facing layer can lead to cracks as movement is restricted.

Window and door elements should only be fixed to one layer (standard is to the load-bearing layer).

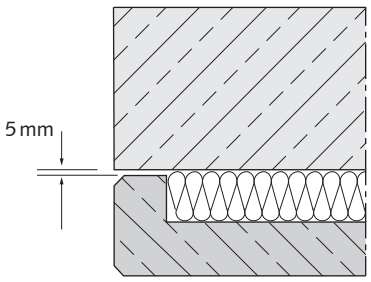




Expansion and contraction

Concrete connections between load-bearing and facing layers have to be avoided.

To allow movement (expansion and contractions), panel edges, reveals at window and door frames must be separated from the load-bearing layer by an expansion joint (min. 5 mm).



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Geometric Boundary Conditions

Forming the facing layer

According to DIN EN 1992-1-1/NA (section 10.9.9) the minimum thickness for a facing layer is 7 cm.
A reinforcement mesh of a_s = 1.3 cm²/m must be specified for SPA and a_s = 1.88 cm²/m for MVA, FA.

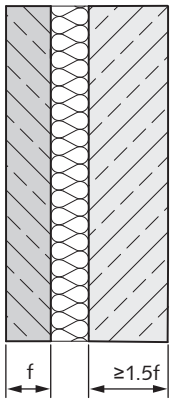
Refer to the appropriate approval for mandatory additional anchors reinforcement in the facing layer (see also → pages 13–17).

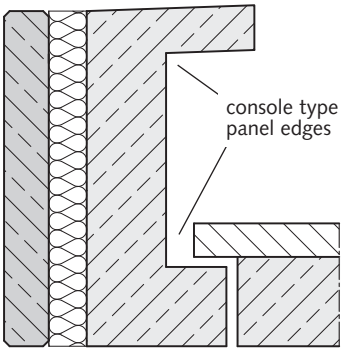
Thick concrete layers where f resp. c ≥ 10 cm should have a 2-layer reinforcement.

Forming the load-bearing layer

To effectively counter the deformations resulting from the facing layer we recommend that the load-bearing layer be at least 50% thicker than the facing layer.

Rigidity can be further increased for special requirements by designing windows sills and panels edges as consoles.

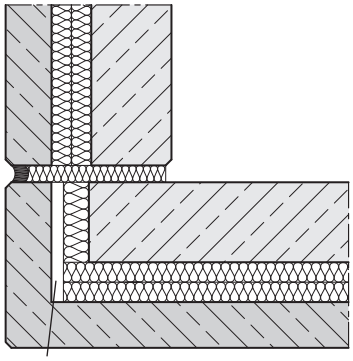


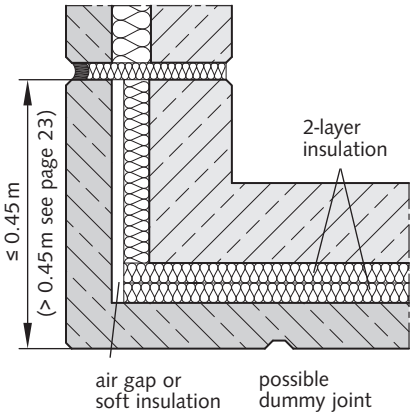


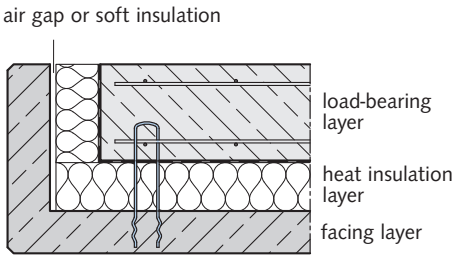
Corner construction

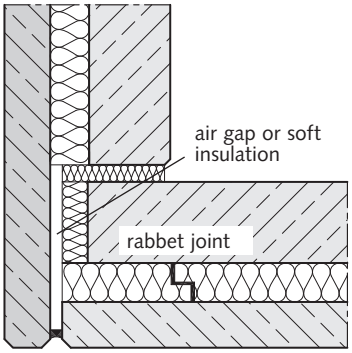
If the facing layer is continued round a corner at building edges or at window or door openings, the following points should be noted:

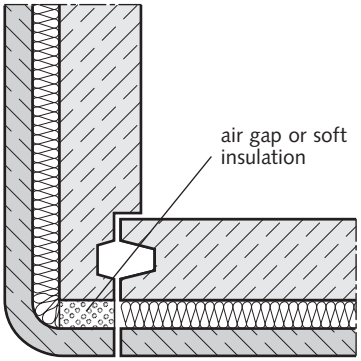
- An air gap must be left between the facing layer and the heat insulation layer in the shorter leg. Alternatively, the insulation can be soft fibre insulation (e. g. mineral wool)
- No restraints are placed in the short leg











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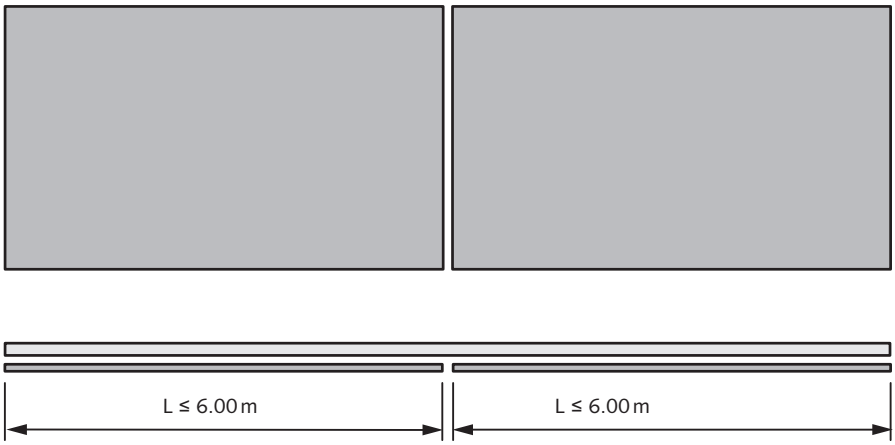
Geometric Boundary Conditions

Panel lengths

To keep crack widths small, technical publications recommend the following maximum dimensions for weather exposed slabs in sandwich elements (for example see BK 88 T2 page 413 ff). For structured weather slabs, L_{max} should be < 8.0 resp. A < 15 m². With smooth slabs the maximum surface area should be 15 m² but the length should be reduced to 5 - 6 m.



If longer elements cannot be avoided it is recommended that the facing layer be devided into smaller elements. However, the supporting layer can be produced in a single piece.

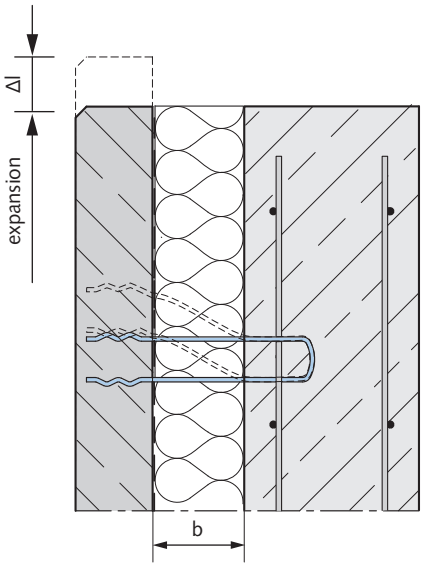
If for architectural reasons longer panels cannot be avoided, this recommendation can be ignored if certain measures are taken ①. These measures should restrict shrinkage and changes in length caused by temperature fluctuation and keep the resulting constraining effect to a minimum.

① **Favourable influences are as follows:**

- lower concrete w/z value
- correct storage and post-treatment of precast parts
- use of light coloured facing layers
- installation of insulation layer in two layers with rabbet joints
- placing a separation layer (foil) between the facing layer and the insulation layer
- adequate thickness of the insulation layer
- strengthening of the load-bearing layer
- design of sufficiently wide expansion joints

With a standard insulation layer thickness (b > 80 mm) the possible facing layer dimensions are not normally limited by the anchor spacing e (see approval).

In this case the decisive factors for the facing layers are normally the recommendations stated above for external concrete slabs dimensions and the required joint design (joint width and the material used).



Large insulation layer thickness b

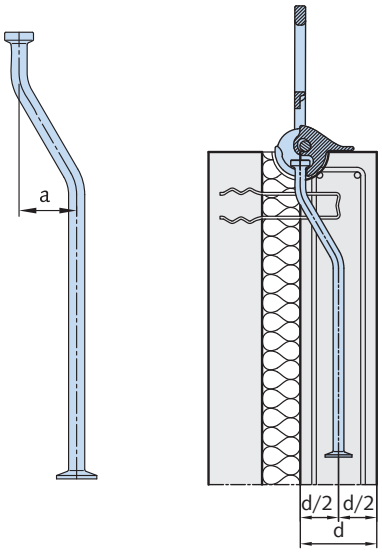
→ Less elongation of the anchor with length variations of the facing layer
→ Larger spacing e possible for the anchor distance from the fulcrum F

Observe DIN 18540 (panels with permanent expansion joints); Joints must be designed to allow a constraint-free expansion of the facing layer.

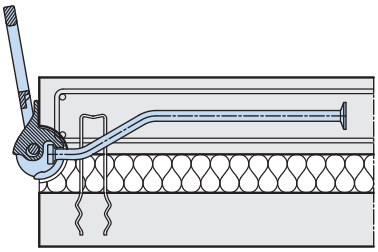
HALFEN supplies two special lifting anchor systems for transporting sandwich panels.

Offset spherical head lifting anchor

The offset spherical head lifting anchor differs from the normal spherical head lifting anchor only by its cranked shape. This special shape permits the use of this anchor for sandwich panels. After installation in the centre of the load-bearing layer, the head is approximately in the centre gravity axis of the sandwich panel; this ensures an effective load transmission.
This allows the sandwich panels to be lifted and mounted almost vertically (the use of a spreader beam is recommended).

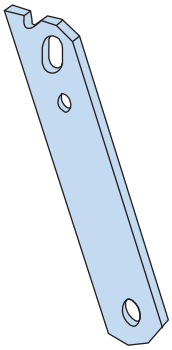


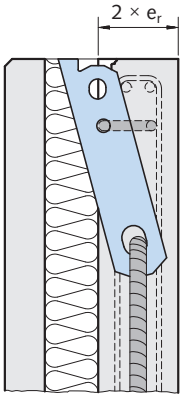
Damage to the concrete is avoided when lifted as shown in the illustration. Placing connector pins in the anchor zone has proven beneficial.
Lift all face-up produced panels using a tilting table (facing layer up method of production → page 33).
The shape of the anchor head has been specially designed for the KKT accessory range.



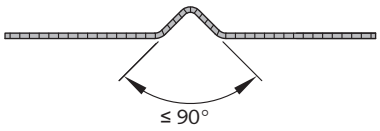
Further information on offset spherical head lifting anchors can be found in the **Technical Product Information KKT**.

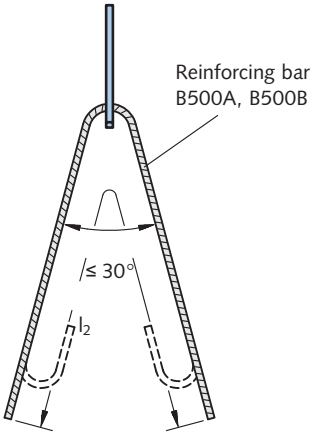
Transport anchor TPA-FX





Additional reinforcement





The lifting anchor type TPA-FX head is designed to be installed at a slant. This ensures that the anchor is approximately at the centre of gravity of the sandwich panel.

This makes sure that the panel hangs almost straight during lifting and installation (the use of a spreader beam is recommended). The TPA-FX can be used to align negative and positive produced sandwich panels (→ page 33).

Further information on sandwich panel lifting anchors type TPA-FX can be found in the **Technical Product Information TPA.**

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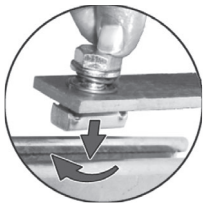
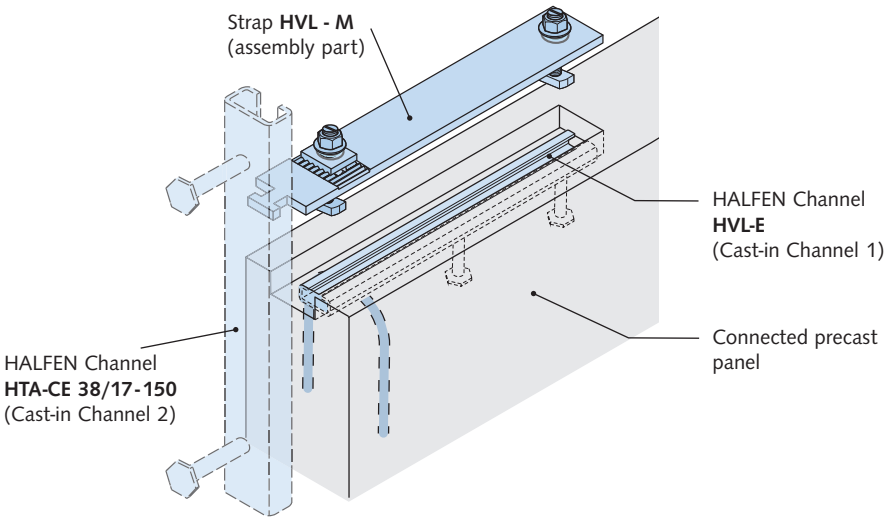
HALFEN supplies further products for fixing sandwich panels.

Precast panel connector HVL

Wall elements (for example the load-bearing layers of sandwich panels) can be connected to in situ columns using the HALFEN HVL precast panel connector.

Assembly:
The connection strap is delivered pre-assembled ready to install.





Betojuster HBJ-W

The HALFEN HBJ Betojuster is a product specially developed by HALFEN. The screw adjustment device allows quick adjustment and alignment of precast concrete elements especially suitable for aligning wall elements.

The HBJ Betojuster provides the building contractor with an easy, and therefore, a safe method for precise vertical adjustment of walls elements, whilst simultaneously avoiding injuries and preventing tool damage to the concrete elements.

Adjustment is quick and easy, requiring only standard tools.

Advantages:

- easy, damage-free height-adjustment
- crane time optimization;
  once the element is placed and secured the crane is available to lift the next element
- adjustment range up to 35 mm
- requires only standard tools
- minimal effort required
- especially designed for restricted access
- it is not necessary to grout the screw slots

CONTACT HALFEN WORLDWIDE

HALFEN is represented by subsidiaries in the following 14 countries, please contact us:

Austria	HALFEN Gesellschaft m.b.H. Leonard-Bernstein-Str. 10 1220 Wien	Phone: +43-1-259 6770 E-Mail: office@halfen.at Internet: www.halfen.at	Fax: +43-1-259-677099
Belgium / Luxembourg	HALFEN N.V. Borkelstraat 131 2900 Schoten	Phone: +32-3-658 07 20 E-Mail: info@halfen.be Internet: www.halfen.be	Fax: +32-3-658 15 33
China	HALFEN Construction Accessories Distribution Co.Ltd. Room 601 Tower D, Vantone Centre No. A6 Chao Yang Men Wai Street Chaoyang District Beijing · P.R. China 100020	Phone: +86-10 5907 3200 E-Mail: info@halfen.cn Internet: www.halfen.cn	Fax: +86-10 5907 3218
Czech Republic	HALFEN s.r.o. Business Center Šafránkova Šafránkova 1238/1 155 00 Praha 5	Phone: +420 -311-690 060 E-Mail: info@halfen-deha.cz Internet: www.halfen-deha.cz	Fax: +420-235-314 308
France	HALFEN S.A.S. 18, rue Goubet 75019 Paris	Phone: +33-1- 44523100 E-Mail: halfen@halfen.fr Internet: www.halfen.fr	Fax: +33-1-44523152
Germany	HALFEN Vertriebsgesellschaft mbH Liebigstr. 14 40764 Langenfeld	Phone: +49-2173-970-0 E-Mail: info@halfen.de Internet: www.halfen.de	Fax: +49-2173-970225
Italy	HALFEN S.r.l. Soc. Unipersonale Via F.lli Bronzetti N° 28 24124 Bergamo	Phone: +39-035-0760711 E-Mail: tecnico@halfen.it Internet: www.halfen.it	Fax: +39-035-0760799
Netherlands	HALFEN b.v. Oostermaat 3 7623 CS Borne	Phone: +31-74-267 14 49 E-Mail: info@halfen.nl Internet: www.halfen.nl	Fax: +31-74-267 26 59
Norway	HALFEN AS Postboks 2080 4095 Stavanger	Phone: +47-51 82 34 00 E-Mail: post@halfen.no Internet: www.halfen.no	Fax: +47-51 82 34 01
Poland	HALFEN Sp. z o.o. Ul. Obornicka 287 60-691 Poznan	Phone: +48-61-622 14 14 E-Mail: info@halfen.pl Internet: www.halfen.pl	Fax: +48-61-622 14 15
Sweden	Halfen AB Vädursgatan 5 412 50 Göteborg	Phone: +46-31-98 58 00 E-Mail: info@halfen.se Internet: www.halfen.se	Fax: +46-31-98 58 01
Switzerland	HALFEN Swiss AG Hertistrasse 25 8304 Wallisellen	Phone: +41-44-849 78 78 E-Mail: info@halfen.ch Internet: www.halfen.ch	Fax: +41-44-849 78 79
United Kingdom / Ireland	HALFEN Ltd. A1/A2 Portland Close Houghton Regis LU5 5AW	Phone: +44 -1582- 47 03 00 E-Mail: info@halfen.co.uk Internet: www.halfen.co.uk	Fax: +44-1582-47 03 04
United States of America	HALFEN USA Inc. PO Box 18687 San Antonio TX 78218	Phone: +1 800.423.91 40 E-Mail: info@halfenusa.com Internet: www.halfenusa.com	Fax: +1 877.683.4910
For countries not listed **HALFEN International**	HALFEN International GmbH Liebigstr. 14 40764 Langenfeld / Germany	Phone: +49 -2173-970-0 E-Mail: info@halfen.com Internet: www.halfen.com	Fax: +49 -2173-970-849

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