CERTIFICATE

KOMO®

Attestation with product certificate
K26381-8

Issued	*2023-07-14*	**Supersedes**	*K26381/07*
Expires on	*Indefinite*	**Dated**	*2019-10-16*
Page	*1 of 58*		

PRODUCTS RvA C 002

Anchors for concrete sandwich constructions

Terwa B.V.

DECLARATION BY KIWA
This attestation with product certificate is based on BRL 0511 ‘Anchors for concrete sandwich constructions’, dated 09 May 2016, issued in accordance with the Kiwa Regulations for Product Certification.

The quality system and product characteristics applicable to the anchors for concrete sandwich constructions are checked periodically.

Based on the above, Kiwa declares that:

- It has every reason to believe that, upon delivery, the anchors for concrete sandwich constructions supplied by the certificate holder will meet:
  - The technical specifications set out in this attestation with product certificate.
- The requirements laid down in the BRL and in this attestation with product certificate, provided that the anchors for concrete sandwich constructions bear the KOMO® mark in the manner indicated in this attestation with product certificate.
- The concrete sandwich constructions assembled with these anchors will perform as described in this attestation with product certificate and conform to the Building Decree specified in this attestation with product certificate, provided that:
  - The application conditions described in this attestation with product certificate are complied with.
  - The processing is in accordance with the regulations and/or processing methods described in this attestation with product certificate.

Within the framework of this attestation with product certificate, no inspection takes place of the production of the other components of concrete sandwich constructions or of the processing of anchors in concrete sandwich constructions.

Ron Scheepers
Kiwa

474/181121

This attestation with product certificate has been added to the list on the website of Stichting KOMO: www.komo.nl. Users of this attestation with product certificate are advised to check whether it is still valid by referring to the Kiwa website: www.kiwa.nl.

Kiwa Nederland B.V.
Sir Winston Churchilllaan 273
Postbus 70
2280 AB RIJSWIJK
Tel. +31 (0)88 998 44 00
Fax +31 (0)88 998 44 20
info@kiwa.nl
www.kiwa.nl

Certificate holder
Terwa B.V.
Kamerlingh Onneslaan 1-3
3401 MZ IJSSELSTEIN
Tel. +31 (0)30 699 13 29
info@terwa.nl
www.terwa.nl

Production site
Strada Sânzienei
507705 Ghimbav
Romania

BUILDING CODE

The following have been assessed:
- **Quality system**
- **Product**
- **Single performance in use**

Periodic check

CONTENTS

1 TECHNICAL SPECIFICATIONS

1.1 General (subject)

The subject of certification concerns the anchoring products for concrete sandwich constructions. A concrete sandwich construction consists of a concrete outer wall connected to the (load-bearing) concrete inner wall. Between the outer wall and the inner wall there is a cavity, in which an insulation layer and/or an air layer is present. The connection between the concrete outer wall and the (load-bearing) concrete inner wall is achieved by means of anchoring products. The anchoring products are applied under conditions up to and including exposure class C4 of NEN-EN-ISO 12994-2.

Concrete sandwich constructions are applied in building facades. The anchoring products can resist normal forces, shear forces or moments, or combinations thereof, depending on the type.
The anchoring products provide a structural connection between the two concrete parts to be connected in the sandwich construction. The load of the non-load-bearing part is transferred to the load-bearing part by means of the anchoring product.
Within the system, each type of anchor provides a specific performance; therefore, a combination of different types will generally provide the structural connection.

The following functions can be distinguished:

- Supporting anchor: this anchor supports the self-weight of the outer leaf.
  When only one supporting anchor is applied, the use of a torsion anchor is also required.
- Torsion anchor: this anchor prevents rotation of the outer leaf about the load-bearing anchor.
- Tie anchor: this anchor resists normal forces arising from wind loads and adhesion to the formwork during demoulding of the elements.

1.2 Product specification

The following types of anchor can be distinguished:

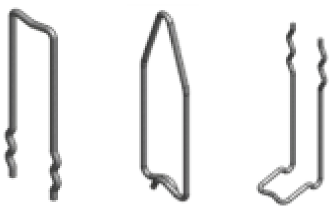
• Sleeve anchors (TMA)

Sleeve anchors are cylindrical anchors provided with round and/or oval holes at the edges. These holes serve for passing reinforcement through and for improving anchorage in the concrete. Sleeve anchors are produced in various diameters. Sleeve anchors are applied as supporting anchors.

• Plate anchors (TFA)

Plate anchors are plates provided with round and/or oval holes at the edges. These holes serve for passing reinforcement through and for improving anchorage in the concrete. Plate anchors are produced in various thicknesses and lengths. Plate anchors can be applied as load-bearing anchors or as torsion anchors.
In the latter case, this applies particularly where the torsional force occurring is substantial.

• Hairpin anchors (TVA, TVB and TVH)



Hairpin anchors / connection stirrups are slender bent steel pins produced in a number of different diameters. Single hairpin anchors serve as tie anchors. A hairpin cross can serve as a torsion anchor where the torsional force occurring is low.
A hairpin cross consists of two hairpin anchors inserted into the concrete surface at an angle of 45°. The angle between them is therefore 90°.

1.3 Components included in this certification system

1.3.1 Products manufactured from stainless steel

Sleeve anchors (TMA)
Grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 275 N/mm^2 and fu ≥ 550 N/mm^2
Grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 275 N/mm^2 and fu ≥ 550 N/mm^2
Grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 275 N/mm^2 and fu ≥ 550 N/mm^2

Plate anchors (TFA)
Grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 275 N/mm^2 and fu ≥ 550 N/mm^2
Grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 275 N/mm^2 and fu ≥ 550 N/mm^2
Grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 275 N/mm^2 and fu ≥ 550 N/mm^2

Hairpin anchors (TVA, TVB and TVH) Panel stirrups (TSPA1 and TSPA2)
Grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 350 N/mm^2 and fu ≥ 700 N/mm^2
Grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 350 N/mm^2 and fu ≥ 700 N/mm^2
Grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 350 N/mm^2 and fu ≥ 700 N/mm^2

1.4 Other components

1.4.1 Reinforcing steel

Reinforcing steel B500 in accordance with NEN 6008. Diameter, length and positioning depending on the anchorage details.

2 Marks and indications on the products / packaging / delivery documents

The packaging is marked with:

- The KOMO® mark followed by the certificate number. The mark is applied as follows:
- Name of the certificate holder
- Production code / type designation and date of manufacture

In addition, each sleeve anchor and plate anchor is marked with:

- Type designation
- Material code (e.g. 1.4571)

The delivery documents contain at least the following:

- The KOMO® mark followed by the certificate number
- Name of the certificate holder
- The production site
- Production code / type designation and date of manufacture

3 PERFORMANCE UNDER THE BUILDING DECREE

3.1 Date on which the Building Decree enters into effect

Building Code section No. and title	Limit value / Determination method	Performance in accordance with the attestation with product certificate	Comments related to application
Chapter 2 – Technical building regulations regarding safety			
2.1 General strength of the structure	The strength shall be determined in accordance with NEN-EN 1993-1-1 and NEN-EN 1993-1-4 for the part of the structure manufactured from stainless steel as referred to in those standards, NEN-EN 1992-1-1 for the part of the structure manufactured from concrete as referred to in that standard, and, for glass fibre reinforced polymer elements, in accordance with BRL 0513; BRL 0513 contains provisions for determining the strength of glass fibre bars for application as reinforcement in concrete. Where applicable, this may be supplemented by testing in accordance with NEN-EN 1990 Annex D.	For each type and dimension, installation guidelines are stated and, for each type and dimension, tables are included specifying the design value of the permissible loads for various configurations of the sandwich construction and various horizontal (normal) forces. In these tables, the forces resulting from anchor positioning, wind load and temperature shall already have been taken into account.	
2.2 Strength in case of fire	Not applicable to anchors for concrete sandwich constructions. For the load-bearing wall, the time to failure may be determined in accordance with NEN-EN 1992-1-1 and NEN-EN 1992-1-2 or NEN 6069.	It is stated that the aspect 'Strength in case of fire' has not been assessed for anchors for concrete sandwich constructions. It is further stated that, where necessary, the strength of anchors for concrete sandwich constructions in the application in case of fire shall be determined at project level. Optionally, it may be stated that the time to failure of the load-bearing wall of the concrete sandwich construction is indicated.	
Chapter 3 – Technical building regulations regarding safety			
3.5 Moisture control	The watertightness of the separating construction is determined in accordance with NEN 2778. The specific air volume flow of a separating construction is determined in accordance with NEN 2690. The internal surface temperature factor is determined in accordance with NEN 2778. Water absorption is determined in accordance with NEN 2778.	Performance values are provided with which anchors for concrete sandwich constructions comply in application, together with the corresponding application conditions, and/or it is stated that the watertightness, air volume flow, internal surface temperature factor and water absorption of anchors for concrete sandwich constructions in application shall be determined at project level.	
Chapter 5 – Technical building regulations regarding energy efficiency and the environment			
5.1 Energy efficiency, new builds	The thermal resistance of the separating construction is determined in accordance with NEN 1068. The air volume flow is determined in accordance with NEN 2686.	Performance values are provided with which anchors for concrete sandwich constructions comply in application, together with the corresponding application conditions, and/or it is stated that the thermal resistance and air volume flow of anchors for concrete sandwich constructions in application shall be determined at project level.	

3.2 Technical building regulations with regard to safety

3.2.1 General strength of the structure

The anchors for concrete sandwich constructions comply, with regard to strength, with Articles 2.2, 2.3 paragraph 1 and Article 2.4, paragraphs 1a and 1b of the Building Decree.

The strength of the anchors for concrete sandwich constructions has been determined in accordance with NEN-EN 1993 and NEN-EN 1992. Where applicable, this may be supplemented by testing in accordance with NEN-EN 1990 Annex D.
For each type and dimension, tables are included stating the design value of the permissible loads for various configurations of the sandwich construction and various horizontal (normal) forces.

Sandwich panels may be classified in a lower consequence class than the total structure of which they form part (NEN-EN 1990/NB Annex B, Table NB.20 B1). The condition that must be fulfilled is that the consequences of failure of sandwich constructions are of a lesser order. In the event of failure, the sandwich constructions must not give rise to progressive collapse. Sandwich constructions comply with this condition.
For consequence class CC2 of the total structure, the sandwich construction may be classified in consequence class CC1, and for CC3 of the total structure, consequence class CC2 applies to the sandwich constructions.

Application conditions:
The number and types of anchors shall be determined on the basis of structural calculations.

3.2.2 Product performances

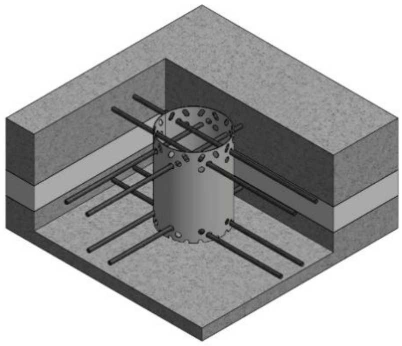
The performances of the anchors can be divided into the performances of:
- Sleeve anchors (TMA)
- Plate anchors (TFA)
- Hairpin anchors / stirrups (TVA, TVB, TVH)

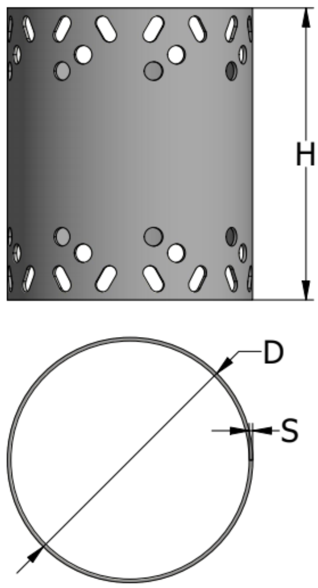
The tables below state the performances of sleeve anchors, plate anchors and hairpin anchors for various configurations.
Each project has a unique detailing, and it is the responsibility of the facade designer/structural engineer to verify that the anchoring components do not exceed the values stated in the tables.

All loads stated in this document are design values.
<u>Overview of symbols used:</u>

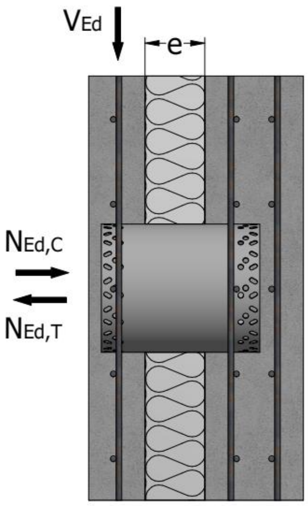
a = embedment depth in concrete
d = thickness of outer leaf
e = cavity width
G = weight of outer leaf
H = height of sleeve or plate anchor
L = length designation
N = normal force load
Q = shear force load
q = torsional force
sh = distance to anchorage centre
t = thickness of plate material

3.2.3 Performances of sleeve anchors





The load-bearing sleeve anchor TMA is a cylindrical sleeve made of stainless steel plate, material grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 240 N/mm^2 and fu ≥ 540–690 N/mm^2, grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 240 N/mm^2 and fu ≥ 530–680 N/mm^2, and grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 240 N/mm^2 and fu ≥ 530–680 N/mm^2. This anchor may be used as a single load-bearing element in combination with tie anchors. Both ends of the anchor are provided with two rows of round holes and one row of oval holes. Reinforcement bars are inserted through the round holes, and the oval holes serve for anchorage in the concrete. The plate thickness (mm × 10), the height and the diameter of the anchor are marked on the surface of the anchor for identification. TMA-XX-YYY-ZZZ, where XX = plate thickness (mm × 10), YYY = height (mm), ZZZ = sleeve diameter (mm).
For example: TMA-10-125-051 for article no. 44139 – Table 1.



The load on the TMA anchors depends on the self-weight of the facade layer, wind load and deformation due to temperature.

Design load effects:
$N_{Ed,C}$ – design value of the compressive load
$N_{Ed,T}$ – design value of the tensile load
V_{Ed} – design value of the shear load

The permissible load-bearing capacity depends on the type of anchor, the thickness of the insulation layer (e) and the actual horizontal load.

Installation of TMA anchor

Concrete quality:	**Reinforcement:**	**Minimum reinforcement for the facade layer**
Facade layer ≥ C30/37	Reinforcement mesh B500B	Square reinforcement mesh > 1.88 cm²/m
Load-bearing layer ≥ C30/37	Reinforcing steel B500B	Two layers where the load-bearing layer is thicker than 100 mm

Table 1

Height H mm	Diameter D mm	Thickness 1 mm		Height H mm	Diameter D mm	Thickness 1.5 mm	
		TMA-XX-YYY-ZZZ	Product no.			TMA-XX-YYY-ZZZ	Product no.
150	51	TMA-10-150-051	**44067**	225	51	TMA-15-225-051	**43435**
	76	TMA-10-150-076	**44068**		76	TMA-15-225-076	**43436**
	102	TMA-10-150-102	**44069**		102	TMA-15-225-102	**43437**
	127	TMA-10-150-127	**44070**		127	TMA-15-225-127	**43438**
	153	TMA-10-150-153	**44071**		153	TMA-15-225-153	**43439**
	178	TMA-10-150-178	**44072**		178	TMA-15-225-178	**43440**
	204	TMA-10-150-204	**66960**		204	TMA-15-225-204	**43441**
	229	TMA-10-150-229	**44990**		229	TMA-15-225-229	**43442**
	255	TMA-10-150-255	**68063**		255	TMA-15-225-255	**43443**
	280	TMA-10-150-280	**68064**		280	TMA-15-225-280	**43444**
175	51	TMA-10-175-051	**44154**	260	51	TMA-15-260-051	**43445**
	76	TMA-10-175-076	**44155**		76	TMA-15-260-076	**43446**
	102	TMA-10-175-102	**44156**		102	TMA-15-260-102	**43447**
	127	TMA-10-175-127	**44157**		127	TMA-15-260-127	**43448**
	153	TMA-10-175-153	**44158**		153	TMA-15-260-153	**43449**
	178	TMA-10-175-178	**44159**		178	TMA-15-260-178	**43450**
	204	TMA-10-175-204	**44160**		204	TMA-15-260-204	**43451**
	229	TMA-10-175-229	**44161**		229	TMA-15-260-229	**43452**
	255	TMA-10-175-255	**44162**		255	TMA-15-260-255	**43453**
	280	TMA-10-175-280	**44163**		280	TMA-15-260-280	**43454**
200	51	TMA-10-200-051	**44079**	300	51	TMA-15-300-051	**49482**
	76	TMA-10-200-076	**44080**		76	TMA-15-300-076	**49483**
	102	TMA-10-200-102	**44081**		102	TMA-15-300-102	**49484**
	127	TMA-10-200-127	**44082**		127	TMA-15-300-127	**49485**
	153	TMA-10-200-153	**44083**		153	TMA-15-300-153	**49486**
	178	TMA-10-200-178	**44084**		178	TMA-15-300-178	**49487**
	204	TMA-10-200-204	**44085**		204	TMA-15-300-204	**49488**
	229	TMA-10-200-229	**44086**		229	TMA-15-300-229	**49089**
	255	TMA-10-200-255	**44087**		255	TMA-15-300-255	**49090**
	280	TMA-10-200-280	**44088**		280	TMA-15-300-280	**49489**

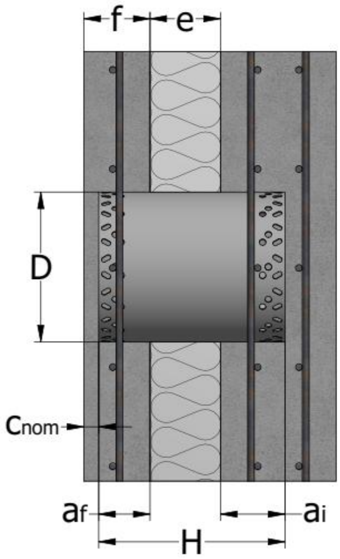
TMA-XX-YYY-ZZZ

XX - plate thickness (mm × 10)

YYY - height (mm)

ZZZ - sleeve diameter (mm)

ANCHOR HEIGHT



The anchor height (**H**) depends on the facade layer thickness (D) and the insulation layer thickness (**e**) – Table 2.

$$\boldsymbol{H \geq 2\ x\ a_f + e}$$

$$\boldsymbol{a_i \geq a_f}$$

Table 2

f [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150
60	H = 150	H = 150	H = 175	H = 175	H = 175	H = 175	H = 200	H = 225	H = 225	H = 225	H = 260	H = 260	H = 260
70	H = 150	H = 150	H = 175	H = 175	H = 200	H = 200	H = 200	H = 225	H = 260	H = 260	H = 260	H = 300	H = 300
80		H = 175	H = 175	H = 200	H = 200	H = 200	H = 225	H = 260	H = 260	H = 260	H = 300	H = 300	H = 300
90		H = 175	H = 175	H = 200	H = 200	H = 200	H = 225	H = 260	H = 260	H = 260	H = 300	H = 300	H = 300
100		H = 175	H = 175	H = 200	H = 200	H = 200	H = 225	H = 260	H = 260	H = 260	H = 300	H = 300	H = 300
120		H = 175	H = 175	H = 200	H = 200	H = 200	H = 225	H = 260	H = 260	H = 260	H = 300	H = 300	H = 300

ANCHORAGE DEPTH OF ANCHOR

The minimum anchorage depth ($\boldsymbol{a_f}$) of the sleeve anchor depends on the facade layer thickness (f) and the insulation layer thickness (**e**) – Table 3.

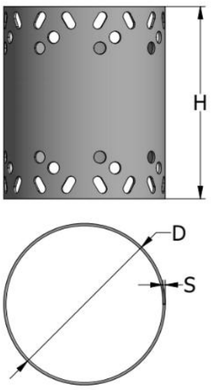
Table 3

Facade layer thickness f [mm]	Insulation thickness e = 30 – 90 mm		Insulation thickness e = 100 – 150 mm	
	a_f min	c_{nom} min	a_f min	c_{nom} min
	[mm]	[mm]	[mm]	[mm]
60	50	10	50	10
70	55	15	60	10
80	60	20	70	10
90-120	60	30	70	20

ANCHORAGE IN CONCRETE

The reinforcement bars for anchoring the sleeve anchor are inserted through the round holes at both ends of the anchor, coupled in each row and positioned perpendicular to each other (for large diameters). The anchorage bars are inserted into the facade layer and the load-bearing layer. The number and length of the anchorage bars depend on the diameter of the sleeve anchor, as indicated in the following table.

Table 4

<table>
<tr><th>Sleeve anchor
TMA</th><th>Diameter
mm</th><th>Symbol</th><th>Anchorage bars
B500B</th></tr>
<tr><td rowspan="12"></td><td></td><td rowspan="5"></td><td rowspan="5">2 × 2 bars with a diameter of 6 mm
L = 500 mm</td></tr>
<tr><td>51</td></tr>
<tr><td>76</td></tr>
<tr><td>102</td></tr>
<tr><td></td></tr>
<tr><td>127</td><td rowspan="7"></td><td rowspan="7">2 × 4 bars with a diameter of 6 mm
L = 700 mm

Additional reinforcement required:
2 × 4 bars with a diameter of
8 mm,
L = 800 mm, placed crosswise in the opening of the reinforcement mesh.</td></tr>
<tr><td>153</td></tr>
<tr><td>178</td></tr>
<tr><td>204</td></tr>
<tr><td>229</td></tr>
<tr><td>255</td></tr>
<tr><td>280</td></tr>
</table>

DIAMETER OF SLEEVE ANCHOR – TMA

After the height of the sleeve anchor has been determined, the diameter of the sleeve anchor is determined depending on the shear loadV_{Ed} of the sleeve anchor, the facade layer thickness and the insulation layer thickness – Tables 5, 6, 7, 8 and 9.

The permissible shear load V_{adm} (kN) on the anchor for a three-layer sandwich panel and facade layer thickness f ≤ 80 mm (N_{Ed} ≤ 5.7 kN).

Table 5

e [mm] / D [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150
51	12.6	12.6	12.6	12.6	12.6	11.6	10.0	5.4	5.0	4.5	3.9	3.4	3.1
76	18.9	18.9	18.9	18.9	18.9	17.3	15.0	10.8	10.7	10.3	9.5	8.5	8.1
102	25.4	25.4	25.4	25.4	25.4	23.0	20.3	14.6	14.4	14.3	14.0	13.9	13.8
127	31.6	31.6	31.6	31.6	31.6	28.4	25.7	17.7	17.6	17.4	17.1	16.9	16.7
153	38.1	38.1	38.1	38.1	37.8	34.4	31.1	20.7	20.5	20.3	20.0	19.7	19.3
178	44.4	44.4	44.4	44.4	43.2	39.8	35.8	30.9	29.2	27.4	25.9	24.6	23.2
204	50.9	50.9	50.9	50.9	49.3	45.2	41.2	35.2	33.1	31.2	29.6	28.1	26.7
229	57.1	57.1	57.1	57.1	55.4	50.6	45.9	39.3	36.7	34.8	32.8	31.2	29.7
255	63.6	63.6	63.6	63.6	59.4	54.0	51.3	43.6	40.8	38.5	36.5	34.4	32.8
280	69.8	69.8	69.8	69.8	62.1	55.4	51.3	47.4	44.6	42.0	39.8	37.5	35.9

The permissible shear load V_{adm} (kN) on the anchor for a three-layer sandwich panel and facade layer thickness f ≤ 90 mm (N_{Ed} ≤ 7.8 kN).

Table 6

D [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150
51	12.6	12.6	12.6	12.2	10.8	9.5	8.1	5.1	4.5	3.9	3.6	3.0	2.7
76	18.8	18.8	18.8	18.8	17.3	15.5	13.5	10.4	9.7	9.3	8.8	8.1	7.7
102	25.4	25.4	25.4	25.4	23.6	22.3	19.2	14.0	13.8	13.0	12.4	11.7	11.2
127	31.6	31.6	31.6	31.6	29.7	27.3	24.2	17.3	17.1	16.9	15.9	15.1	14.3
153	38.1	38.1	38.1	38.1	35.8	33.1	29.8	20.4	20.3	20.0	19.6	18.5	17.6
178	44.3	44.3	44.3	44.3	43.2	38.5	35.1	27.3	25.7	24.3	23.0	21.7	20.9
204	50.8	50.8	50.8	50.8	47.3	43.9	39.8	32.0	29.7	28.2	26.7	25.2	24
229	57.1	57.1	57.1	57.1	54.0	50.0	44.6	36.2	33.8	31.9	30.2	28.6	27.1
255	63.6	63.6	63.6	63.6	58.1	54.0	50.0	40.2	37.8	35.8	33.8	32.0	30.6
280	69.8	69.8	69.8	68.9	60.8	55.4	50.0	44.3	41.6	39.2	37.1	35.0	33.6

The permissible load V_{adm} (kN) on the anchor for a three-layer sandwich panel and facade layer thickness f ≤ 100 mm (N_{Ed} ≤ 9.3 kN).

Table 7

D [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150
51	9.2	8.9	7.3	6.5	5.7	5.4	4.9						
76	18.8	18.8	18.8	15.3	14.6	13.0	10.9	5.5	5.4	5.3	5.1	4.6	4.2
102	25.2	25.2	25.2	23.2	21.5	19.3	17.6	10.8	10.0	9.5	9.0	8.5	8.1
127	31.6	31.6	31.6	30.5	28.1	25.4	22.7	15.1	14.2	13.5	12.7	12.0	11.5
153	38.1	38.1	38.1	37.5	34.4	31.3	28.4	19.3	18.2	17.4	16.5	15.7	14.9
178	44.3	44.3	44.3	43.5	40.5	37.1	33.3	24.0	22.3	21.3	20.1	19.0	18.2
204	50.8	50.8	50.8	50.6	46.3	43.2	37.8	28.6	26.6	25.2	23.8	22.5	21.5
229	57.1	57.1	57.1	57.1	53.1	49.0	43.5	32.9	30.5	29.0	27.4	26.1	24.6
255	63.6	63.6	63.6	63.5	59.0	53.3	49.3	37.4	34.7	32.9	31.2	29.4	28.1
280	69.8	69.8	69.8	68.6	60.8	54.3	49.3	41.0	38.5	36.7	34.4	32.7	31.2

The permissible load V_{adm} (kN) on the anchor for a three-layer sandwich panel and facade layer thickness f ≤ 120 mm (N_{Ed} ≤ 12.7kN).

Table 8

D [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150
51													
76													
102	20.3	19.6	17.6	15.5	14.2	13.2	11.6						
127	31.1	29.0	27.0	25.0	22.3	20.9	18.2						
153	37.9	37.8	35.1	32.4	29.7	27.7	25.0						
178	44.3	44.3	43.2	37.8	36.5	32.4	29.7	4.1	3.6	3.4	3.2	3.2	3.1
204	50.8	50.8	50.0	45.9	43.2	38.5	35.8	13.5	12.4	11.6	10.8	10.7	10.5
229	57.0	57.0	56.7	52.7	50.0	44.6	40.5	18.9	18.4	17.0	16.2	15.5	15.0
255	63.5	63.5	63.5	58.1	56.7	51.3	45.9	24.8	23.5	22.0	20.7	19.7	19.2
280	69.8	69.8	69.8	64.8	58.1	52.7	45.9	29.7	28.4	26.6	25.1	23.6	23.0

The permissible load V_{adm} (kN) on the anchor for a four-layer sandwich panel and facade layer thickness f ≤ 80 mm (N_{Ed} ≤ 8.9 kN).

Table 9

D [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150
51	No air cavity permitted			8.5	7.6	6.6	5.7	No tests performed					
76				16.9	15.1	13.5	11.7						
102				24.3	22.3	19.6	17.6						
127				31.1	28.4	25.7	23.0						
153				37.8	35.1	31.7	28.6						
178				44.3	41.2	37.8	33.8						
204				50.8	47.3	43.2	39.2						
229				57.1	53.3	48.6	44.6						
255				63.5	58.1	52.7	50.0						
280				67.5	60.8	54.0	50.0						

INSTALLATION OF SLEEVE ANCHOR TMA IN SANDWICH PANEL

Table 10 – First variant I

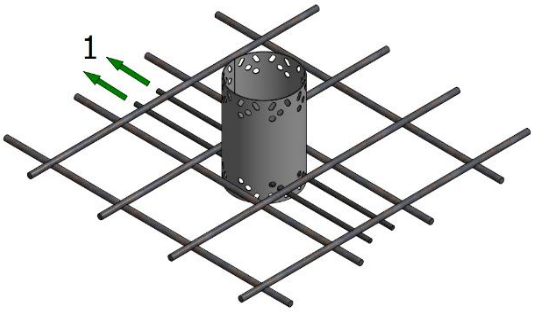
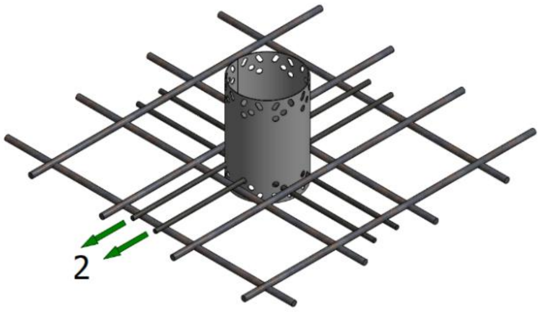
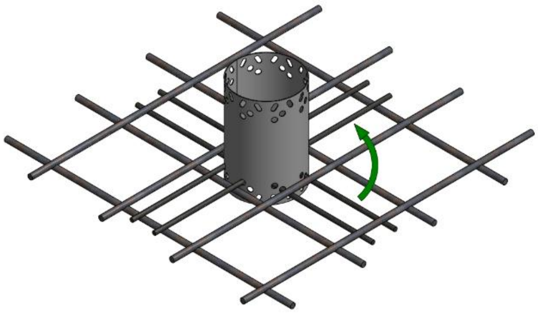
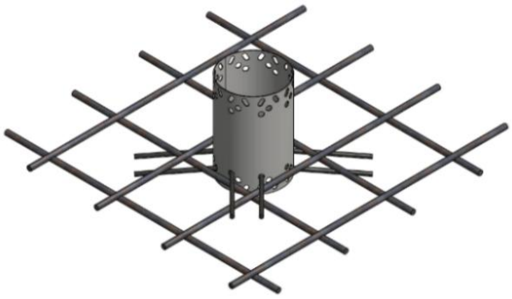
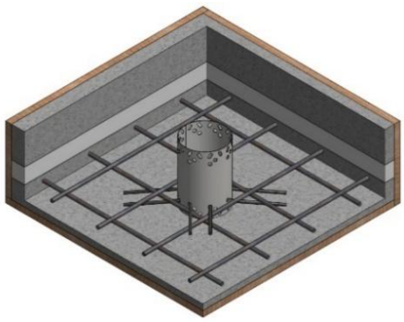
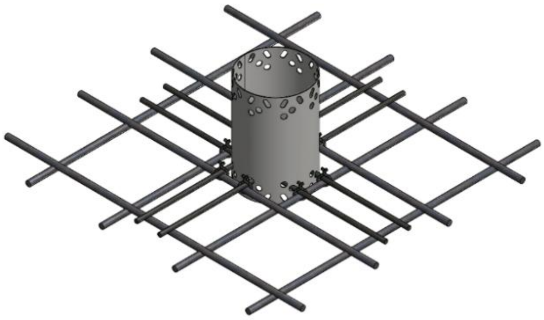
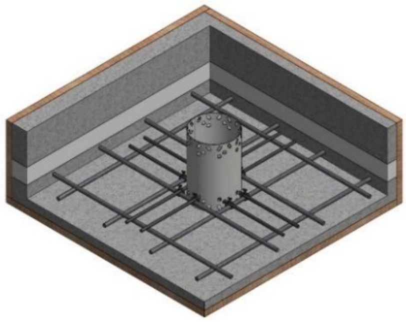
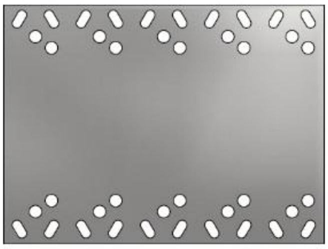
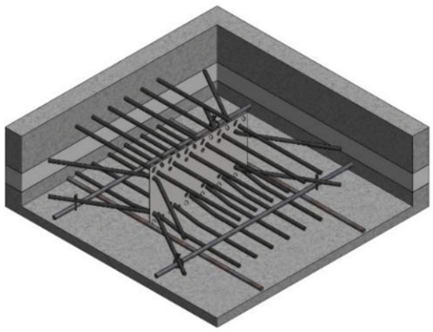
1. *The TMA anchor may be installed once the reinforcement mesh for the facade layer has been tied. First, two anchorage bars are inserted through the lower row of round holes so that they are positioned parallel to the lower layer of the reinforcement mesh.*	
2. *Two anchorage bars are then inserted through the upper row of round holes, perpendicular to the first two anchorage bars. These bars are thus almost parallel to the upper layer of the reinforcement mesh.*	
3. *The sleeve anchor is rotated by 45°.*	
4. *After rotation, the lower anchorage bars are positioned beneath the lower layer of the reinforcement mesh and the upper anchorage bars above the upper layer of the reinforcement mesh. In this way, it is not necessary to tie the anchorage bars to the reinforcement mesh.*	
5. *The complete reinforcement assembly with the TMA anchor is then placed in the formwork. The concrete for the facade layer is subsequently cast, after which the insulation layer, the reinforcement mesh for the load-bearing layer and the anchorage bars for the upper row of round holes are installed.* ***6.*** *Replace each cut bar of the reinforcement mesh with additional reinforcement of the same diameter.* ***7.*** *Cast the concrete for the inner layer.*	

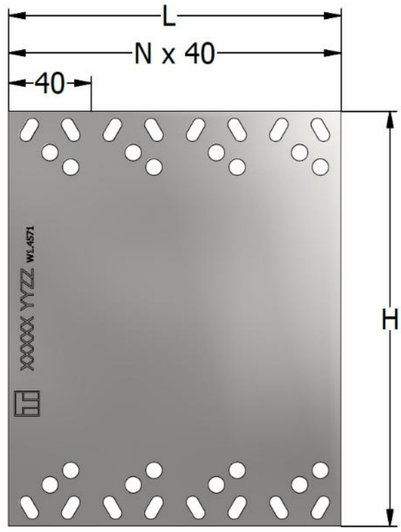
Table 11 – Second variant II

1. *For a thin outer layer, the TMA sleeve anchor is placed above the reinforcement mesh of the facade layer, which is installed first. The TMA anchor is installed without placing anchorage bars beneath the reinforcement mesh. The four anchorage bars are positioned above the reinforcement mesh and then tied to the mesh to prevent movement during concrete casting.*	
2. *The complete reinforcement assembly with the TMA anchor is then placed in the formwork. The concrete for the facade layer is subsequently cast, after which the insulation layer, the reinforcement mesh for the load-bearing layer and the anchorage bars for the upper row of round holes are installed.* ***3.*** *Replace each cut bar of the reinforcement mesh with additional reinforcement of the same diameter.* ***4.*** *Cast the concrete for the inner layer.*	

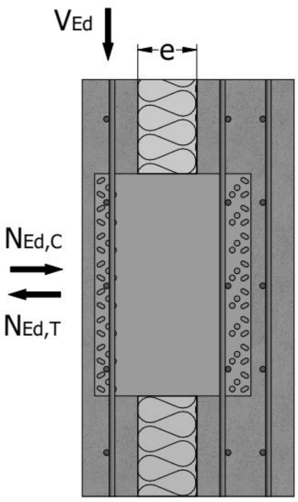
3.2.4 Performances of plate anchors







The supporting anchor TFA is an anchor made of stainless steel plate, material grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 240 N/mm^2 and fu ≥ 540–690 N/mm^2, grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 240 N/mm^2 and fu ≥ 530–680 N/mm^2, and grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-2 with fy ≥ 240 N/mm^2 and fu ≥ 530–680 N/mm^2. This anchor may only be used in combination with a TMA sleeve anchor or with other TFA plate anchors as supporting anchors. Both ends of the anchor are provided with two rows of round holes and one row of oval holes. Reinforcement bars are inserted through the round holes, and the oval holes serve for anchorage in the concrete. The plate thickness (mm × 10), the height and the length of the anchor are marked on the surface of the anchor for identification. TFA-XX-YYY-ZZZ, where XX = plate thickness (mm × 10), YYY = height (mm), ZZZ = plate length (mm).
For example: TFA-10-150-0080 for article no. 44175 – Table 12.



The load on the TFA anchors depends on the self-weight of the facade layer, wind load and deformation due to temperature.

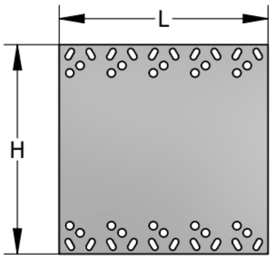
Design load effects:
$N_{Ed,C}$ – design value of the compressive load
$N_{Ed,T}$ – design value of the tensile load
V_{Ed} – design value of the shear load

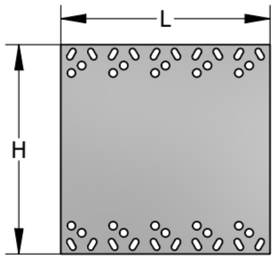
The permissible load-bearing capacity depends on the type of anchor, the thickness of the insulation layer (e) and the actual horizontal load.

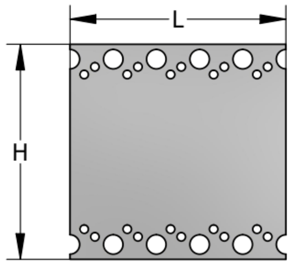
Installation of TFA anchor

Concrete quality:	**Reinforcement:**	**Minimum reinforcement for the facade layer**
Facade layer ≥ C30/37	Reinforcement mesh B500B	Square reinforcement mesh > 1.88 cm²/m
Load-bearing layer ≥ C30/37	Reinforcing steel B500B	Two layers where the load-bearing layer is thicker than 100 mm

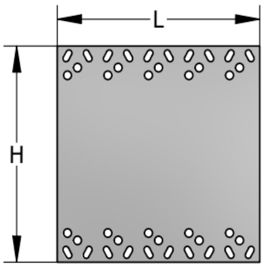
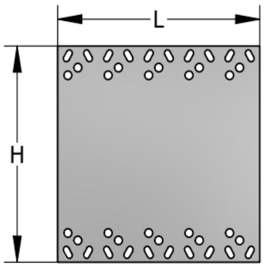
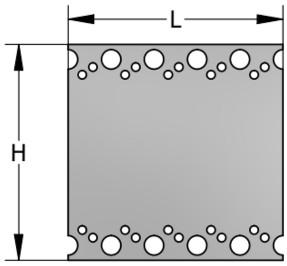
Table 12





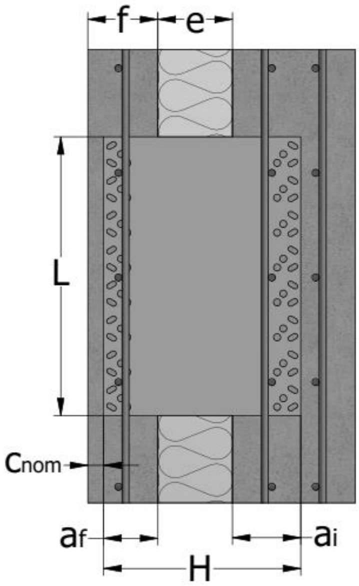


Height H mm	Length L mm	Thickness 1.5 mm		Thickness 2 mm		Thickness 3 mm	
		TFA-XX-YYY-ZZZ	Product no.	TFA-XX-YYY-ZZZ	Product no.	TFA-XX-YYY-ZZZ	Product no.
150	80	TFA-15-150-0080	**43456**	TFA-20-150-0080	**44186**		
	120	TFA-15-150-0120	**43457**	TFA-20-150-0120	**44187**		
	160	TFA-15-150-0160	**43458**	TFA-20-150-0160	**44188**		
	200	TFA-15-150-0200	**43459**	TFA-20-150-0200	**44189**		
	240	TFA-15-150-0240	**43460**	TFA-20-150-0240	**44190**		
	280	TFA-15-150-0280	**43461**	TFA-20-150-0280	**44191**		
	320	TFA-15-150-0320	**43462**	TFA-20-150-0320	**44192**		
	360	TFA-15-150-0360	**43463**	TFA-20-150-0360	**44193**		
	400	TFA-15-150-0400	**43464**	TFA-20-150-0400	**44194**		
175	80	TFA-15-175-0080	**43466**	TFA-20-175-0080	**44208**		
	120	TFA-15-175-0120	**43467**	TFA-20-175-0120	**44209**		
	160	TFA-15-175-0160	**43468**	TFA-20-175-0160	**44210**		
	200	TFA-15-175-0200	**43469**	TFA-20-175-0200	**44211**		
	240	TFA-15-175-0240	**43470**	TFA-20-175-0240	**44212**		
	280	TFA-15-175-0280	**43471**	TFA-20-175-0280	**44213**		
	320	TFA-15-175-0320	**43472**	TFA-20-175-0320	**44214**		
	360	TFA-15-175-0360	**43473**	TFA-20-175-0360	**44215**		
	400	TFA-15-175-0400	**43474**	TFA-20-175-0400	**44216**		
200	80	TFA-15-200-0080	**43476**	TFA-20-200-0080	**44229**	TFA-30-200-0080	**65792**
	120	TFA-15-200-0120	**43477**	TFA-20-200-0120	**44230**	TFA-30-200-0120	**65793**
	160	TFA-15-200-0160	**43478**	TFA-20-200-0160	**44231**	TFA-30-200-0160	**65794**
	200	TFA-15-200-0200	**43479**	TFA-20-200-0200	**44232**	TFA-30-200-0200	**65795**
	240	TFA-15-200-0240	**43480**	TFA-20-200-0240	**44233**	TFA-30-200-0240	**65796**
	280	TFA-15-200-0280	**43481**	TFA-20-200-0280	**44234**	TFA-30-200-0280	**65797**
	320	TFA-15-200-0320	**43482**	TFA-20-200-0320	**44235**	TFA-30-200-0320	**65798**
	360	TFA-15-200-0360	**43483**	TFA-20-200-0360	**44236**	TFA-30-200-0360	**65799**
	400	TFA-15-200-0400	**43484**	TFA-20-200-0400	**44237**	TFA-30-200-0400	**63891**
225	80	TFA-15-225-0080	**43486**	TFA-20-225-0080	**44250**	TFA-30-225-0080	**65800**
	120	TFA-15-225-0120	**43487**	TFA-20-225-0120	**44251**	TFA-30-225-0120	**65801**
	160	TFA-15-225-0160	**43488**	TFA-20-225-0160	**44252**	TFA-30-225-0160	**65802**
	200	TFA-15-225-0200	**43489**	TFA-20-225-0200	**44253**	TFA-30-225-0200	**65803**
	240	TFA-15-225-0240	**43490**	TFA-20-225-0240	**44254**	TFA-30-225-0240	**65804**
	280	TFA-15-225-0280	**43491**	TFA-20-225-0280	**44255**	TFA-30-225-0280	**67055**
	320	TFA-15-225-0320	**43492**	TFA-20-225-0320	**44256**	TFA-30-225-0320	**67056**
	360	TFA-15-225-0360	**43493**	TFA-20-225-0360	**44257**	TFA-30-225-0360	**67057**
	400	TFA-15-225-0400	**43494**	TFA-20-225-0400	**44258**	TFA-30-225-0400	**48986**
260	80			TFA-20-260-0080	**43936**	TFA-30-260-0080	**48670**
	120			TFA-20-260-0120	**43937**	TFA-30-260-0120	**48666**
	160			TFA-20-260-0160	**43938**	TFA-30-260-0160	**48667**
	200			TFA-20-260-0200	**43939**	TFA-30-260-0200	**63857**
	240			TFA-20-260-0240	**43940**	TFA-30-260-0240	**48669**
	280			TFA-20-260-0280	**43941**	TFA-30-260-0280	**65751**
	320			TFA-20-260-0320	**43942**	TFA-30-260-0360	**66480**
	360			TFA-20-260-0360	**43943**	TFA-30-260-0360	**65752**
	400			TFA-20-260-0400	**43944**	TFA-30-260-0400	**48410**

							
Height H mm	Length L mm	Thickness 1.5 mm		Thickness 2 mm		Thickness 3 mm	
		TFA-XX-YYY-ZZZ	Product no.	TFA-XX-YYY-ZZZ	Product no.	TFA-XX-YYY-ZZZ	Product no.
280	80					TFA-30-280-0080	**60718**
	120					TFA-30-280-0120	**60719**
	160					TFA-30-280-0160	**46944**
	200					TFA-30-280-0200	**60720**
	240					TFA-30-280-0240	**49520**
	280					TFA-30-280-0280	**60721**
	320					TFA-30-280-0320	**60722**
	360					TFA-30-280-0360	**46945**
	400					TFA-30-280-0400	**46636**
300	80					TFA-30-300-0080	**43738**
	120					TFA-30-300-0120	**48243**
	160					TFA-30-300-0160	**43740**
	200					TFA-30-300-0200	**48242**
	240					TFA-30-300-0240	**60668**
	280					TFA-30-300-0280	**46292**
	320					TFA-30-300-0320	**48244**
	360					TFA-30-300-0360	**43745**
	400					TFA-30-300-0400	**43746**
350	80					TFA-30-350-0080	**47002**
	120					TFA-30-350-0120	**46528**
	160					TFA-30-350-0160	**47003**
	200					TFA-30-350-0200	**46529**
	240					TFA-30-350-0240	**65808**
	280					TFA-30-350-0280	**47032**
	320					TFA-30-350-0320	**47004**
	360					TFA-30-350-0360	**47005**
	400					TFA-30-350-0400	**46530**

TFA-XX-YYY-ZZZ
XX - plate thickness (mm × 10)
YYY - height (mm)
ZZZ - sleeve diameter (mm)

ANCHOR HEIGHT



The anchor height depends on the minimum anchorage depth of the facade layer a_f and the insulation layer thickness (**e**) – Table 13.

$$H \geq 2\,x\,a_f + e$$
$$a_i \geq a_f$$

Minimum anchorage depth a_f
Minimum concrete cover c_{nom}

Facade layer thickness f [mm]	Insulation thickness e = 30 – 240 mm	
	a_f min	c_{nom} min
	[mm]	[mm]
60	50	10
≥ 70	55	15

Table 13

	Insulation layer thickness e [mm]														
f [mm]	30	40	50	60	70	80	90	100	110	120	140	160	180	200	240
60	H = 150														
60			H = 175												
60						H = 200									
60								H = 225							
60											H = 260	H = 260			
60													H = 280	H = 300	
60															H = 350
≥ 70	H = 150														
≥ 70			H = 175												
≥ 70					H = 200										
≥ 70								H = 225							
≥ 70										H = 240	H = 260				
≥ 70												H = 280			
≥ 70													H = 300	H = 335	
≥ 70															H = 350

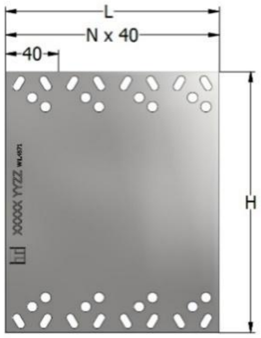
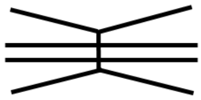
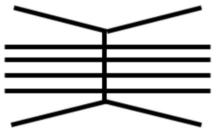
ANCHORAGE DEPTH OF ANCHOR

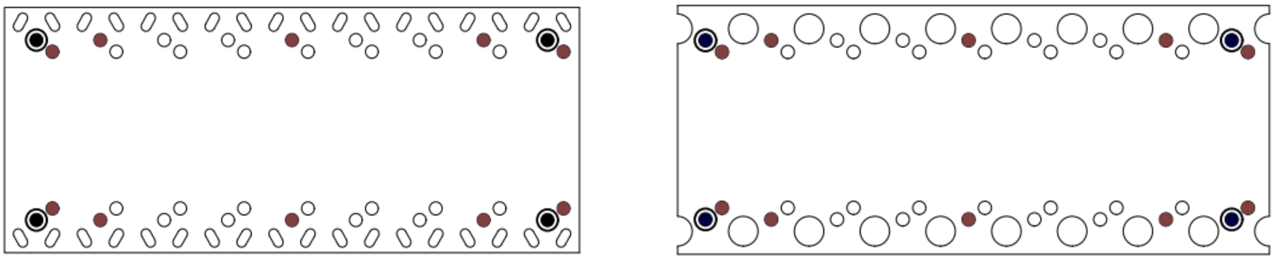
The minimum anchorage depth for the TFA plate anchor is approximately 50 mm. A greater anchorage depth may result in a higher load-bearing capacity or a higher safety factor in order to prevent concrete failure. The use of a plate anchor is not limited by the thickness of the outer layer.

ANCHORAGE IN CONCRETE

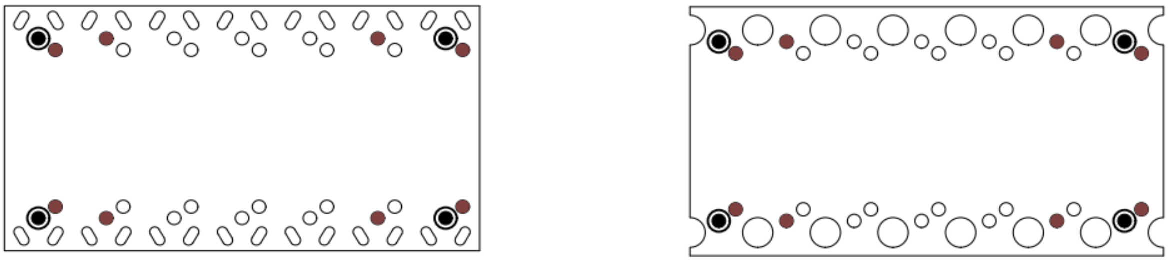
The reinforcement bars for anchoring the plate anchor are inserted through the round holes at both ends of the anchor. The anchorage bars are inserted into the facade layer and the load-bearing inner layer. The number and length of the anchorage bars depend on the length of the plate anchor – Table 14.

Table 14

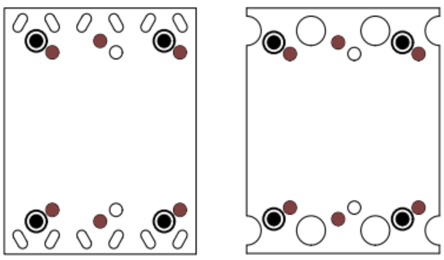
Plate anchor TFA	Anchor length L mm	Symbol	Anchorage bars B500B
	80		2 × 4 bars with a diameter of 6 mm L = 400 mm
	120		2 × 5 bars with a diameter of 6 mm L = 400 mm
	160, 200, 240, 280		2 × 6 bars with a diameter of 6 mm L = 400 mm
	320, 360, 400		2 × 7 bars with a diameter of 6 mm L = 400 mm



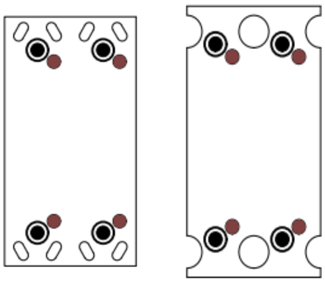
TFA L = 320 – 400 mm 2 × 7 bars with a diameter of 6 mm L = 400 mm



TFA L = 160 – 280 mm 2 × 6 bars with a diameter of 6 mm L = 400 mm



TFA L = 120 mm 2 × 5 bars with a diameter of 6 mm L = 400 mm



TFA L = 80 mm 2 × 4 bars with a diameter of 6 mm L = 400 mm

Bent reinforcement bar

Straight reinforcement bar

LENGTH OF PLATE ANCHOR – TFA

The length of the TFA plate anchor depends on the load and the insulation layer thickness, as indicated in the tables.

The permissible shear load V_{adm} (kN) on the plate anchor with a thickness t = 1.5, 2.0, 3.0 mm for a three-layer sandwich panel and facade layer thickness f = 80 mm (N_{Ed} ≤ 5.7 kN).

Table 15

t [mm]	e [mm] / L [mm]	30	40	50	60	70	80	90	100	110	120	130	140	150	180
1.5	80	7.3	6.9	6.5	6.1	5.3	4.3	3.4	2.6	1.8	0.7				
2.0	80				9.3	8.1	6.9	5.7	4.9	4.1	3.2	2.8	2.6	2.2	
3.0	80										6.3	6.2	5.9	5.7	5.4
1.5	120	11.5	10.9	10.4	10.0	9.3	8.5	7.7	6.9	4.9	3.5				
2.0	120				13.6	12.7	11.9	10.9	9.9	8.6	7.6	6.9	6.2	5.5	
3.0	120										9.0	8.9	8.5	8.1	7.7
1.5	160	15.5	15.0	14.4	13.9	13.2	12.6	11.7	10.7	9.2	6.9				
2.0	160				19.4	18.2	16.9	15.7	14.9	13.9	13.1	12.2	11.2	10.3	
3.0	160										13.1	12.7	12.2	11.5	9.5
1.5	200	19.7	19.2	18.5	18.0	17.3	16.6	15.8	14.6	13.0	10.5				
2.0	200				25.8	24.4	23.0	21.6	20.4	19.3	18.1	16.9	15.7	14.4	
3.0	200										18.1	17.6	16.7	15.8	14.9
1.5	240	23.9	23.4	22.7	22.0	21.3	20.5	19.8	18.6	16.9	14.3				
2.0	240				31.2	30.1	28.9	27.8	26.3	24.8	23.4	21.7	20.3	18.8	
3.0	240										23.9	23.5	22.4	21.2	20.0
1.5	280	28.1	27.4	26.7	26.1	25.4	24.6	23.9	22.5	20.4	18.5				
2.0	280				36.5	35.4	34.4	33.5	32.0	30.4	28.9	26.9	25.0	23.0	
3.0	280										31.3	30.5	29.0	27.5	26.3
1.5	320	32.3	31.6	30.9	30.2	29.4	28.6	27.8	26.6	25.0	22.8				
2.0	320				41.7	41.4	41.0	40.8	38.6	36.3	34.2	32.0	29.7	27.4	
3.0	320										39.7	38.7	36.9	35.0	33.1
1.5	360	36.3	35.8	35.1	34.4	33.6	32.8	31.7	30.5	29.0	27.0				
2.0	360				47.4	47.1	46.8	46.6	44.3	42.0	39.7	37.3	35.0	32.7	
3.0	360										49.4	47.9	45.6	43.2	40.8
1.5	400	40.5	40.0	39.3	38.6	37.7	36.7	35.6	34.4	33.1	31.2				
2.0	400				52.7	52.5	52.2	52.1	49.8	47.4	45.2	42.7	40.2	37.7	
3.0	400										60.2	58.3	55.5	52.7	49.8

The permissible shear load V_{adm} (kN) on the plate anchor with thickness t = 1.5, 2.0, 3.0 mm for a three-layer sandwich panel and facade layer thickness f = 90 mm (N_{Ed} ≤ 7.8 kN).

Table 16

t [mm]	L [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	150	180	210	240
1.5	80	6.8	6.2	5.8	5.1	4.3	3.6	2.6	1.2						
2.0	80				8.0	7.0	5.9	5.0	4.2	3.2	2.3				
3.0	80				8.1	7.6	7.2	6.6	6.3	5.9	5.5	4.7	4.3	3.1	2.2
1.5	120	10.8	10.5	9.6	9.0	8.4	7.4	6.5	5.4	3.2	1.4				
2.0	120				11.6	10.9	10.3	9.6	8.4	7.0	5.8	4.1			
3.0	120				11.9	11.2	10.5	9.9	9.3	8.8	8.2	7.0	6.2	5.7	3.4
1.5	160	15.1	14.6	13.8	13.0	12.3	11.5	10.5	9.2	7.4	4.5				
2.0	160				17.3	16.2	15.1	14.0	13.1	12.3	11.3	7.7			
3.0	160				17.6	16.5	15.3	14.2	13.5	12.7	12.0	10.3	9.0	8.1	7.3
1.5	200	19.3	18.5	17.8	17.0	16.3	15.5	14.6	13.1	11.2	8.2				
2.0	200				24.4	22.8	21.1	19.6	18.4	17.3	16.1	12.0			
3.0	200				24.8	23.2	21.6	20.0	18.9	18.0	16.9	14.3	12.8	11.5	10.1
1.5	240	23.6	22.7	21.9	21.2	20.3	19.6	18.6	17.1	15.3	12.2				
2.0	240				30.5	29.3	27.9	26.7	25.1	23.6	22.0	16.1			
3.0	240				33.8	31.5	29.3	27.0	25.7	24.3	23.0	20.1	17.6	15.5	14.0
1.5	280	27.8	27.0	26.2	25.2	24.3	23.5	22.7	20.4	18.9	16.2				
2.0	280				35.8	34.7	33.5	32.5	30.8	29.2	27.4	20.7			
3.0	280				44.6	41.6	38.7	35.8	34.0	32.1	30.4	25.9	23.0	20.3	18.2
1.5	320	31.7	31.1	30.4	29.4	28.5	27.7	26.6	25.0	23.1	20.5				
2.0	320				41.2	40.6	40.0	39.4	37.3	35.0	32.9	24.7			
3.0	320				56.7	53.1	49.5	45.9	43.5	40.9	38.5	33.2	29.0	25.9	23.4
1.5	360	35.9	35.4	34.4	33.6	32.4	31.7	30.5	29.0	27.1	25.0				
2.0	360				46.8	46.4	46.2	45.8	43.3	40.9	38.5	28.8			
3.0	360				70.6	66.2	61.8	57.4	54.3	51.0	47.9	41.6	36.5	32.4	29.2
1.5	400	40.2	39.4	38.5	37.8	36.9	35.6	34.4	33.1	31.1	29.0				
2.0	400				52.1	51.8	51.4	51.2	48.7	46.3	43.9	35.2			
3.0	400				81.0	77.2	73.3	69.5	65.9	62.4	58.7	50.6	44.3	39.8	35.8

The permissible shear load V_{adm} (kN) on the plate anchor with a thickness t = 1.5, 2.0, 3.0 mm for a three-layer sandwich panel and facade layer thickness f = 100 mm (N_{Ed} ≤ 9.3 kN).

Table 17

t [mm]	e [mm] / L [mm]	30	40	50	60	70	80	90	100	110	120	150	180	210	240
1.5	80	6.3	5.9	4.7	4.6	3.6	2.6	1.6	0.3						
2.0	80				6.6	5.9	5.1	4.5	3.6	2.7	2.0				
3.0	80				6.9	6.3	5.9	5.4	5.1	4.9	4.5	3.6	3.4	2.8	0.8
1.5	120	10.5	10.0	9.3	8.6	7.7	6.8	5.7	4.5	1.9					
2.0	120				10.4	9.7	9.0	8.2	7.3	6.2	3.8	3.6			
3.0	120				10.7	9.9	9.2	8.5	8.0	7.7	7.3	6.2	5.4	4.7	4.6
1.5	160	14.7	14.0	13.2	12.6	11.6	10.7	9.7	8.2	6.5	3.1				
2.0	160				15.8	14.9	13.8	12.7	12.0	11.3	10.7	7.0	2.8		
3.0	160				16.1	15.0	13.9	12.8	12.2	11.5	10.8	9.2	8.1	7.2	6.5
1.5	200	18.9	18.1	17.3	16.6	15.7	14.7	13.8	12.2	10.3	6.8				
2.0	200				22.5	21.2	19.8	18.4	17.3	16.2	15.1	11.2	6.6		
3.0	200				23.0	21.5	20.0	18.5	17.4	16.3	15.3	13.4	11.7	10.4	8.6
1.5	240	23.0	22.3	21.3	20.7	19.7	18.8	17.8	16.2	15.1	11.2	6.6			
2.0	240				30.1	28.5	26.7	25.1	23.6	22.3	20.9	15.5	10.7		
3.0	240				33.1	30.5	28.1	25.5	24.4	23.5	21.2	18.4	16.2	14.4	13.0
1.5	280	27.1	26.5	25.7	24.7	23.8	22.7	21.7	20.1	18.1	14.9				
2.0	280				35.1	34.6	33.8	33.2	30.9	28.8	26.5	20.1	14.7		
3.0	280				43.7	42.1	40.6	33.8	31.9	30.1	28.4	24.4	21.6	19.2	17.3
1.5	320	31.3	30.6	29.8	28.8	27.8	26.7	25.7	24.0	22.1	19.0				
2.0	320				40.9	40.2	39.4	38.7	36.5	34.3	32.1	24.2	18.8		
3.0	320				56.4	52.1	47.8	43.5	41.2	39.0	36.7	31.3	27.5	24.6	22.3
1.5	360	32.9	34.7	33.9	33.1	33.2	30.6	29.7	26.2	23.2					
2.0	360				46.3	45.9	45.9	45.1	42.5	40.0	37.4	29.4	23.0		
3.0	360				70.2	65.1	60.1	54.9	52.0	49.0	46.0	39.7	34.8	31.1	27.9
1.5	400	39.7	38.9	38.1	37.0	36.0	34.8	33.5	31.9	30.2	27.5				
2.0	400				51.7	51.3	50.8	50.4	47.9	45.5	42.9	34.4	27.3		
3.0	400				81.0	76.4	71.8	67.2	63.6	60.1	56.6	48.7	42.8	38.2	34.3

The permissible shear load V_{adm} (kN) on the plate anchor with a thickness t = 1.5, 2.0, 3.0 mm for a three-layer sandwich panel and facade layer thickness f = 120 mm (N_{Ed} ≤ 12.7 kN).

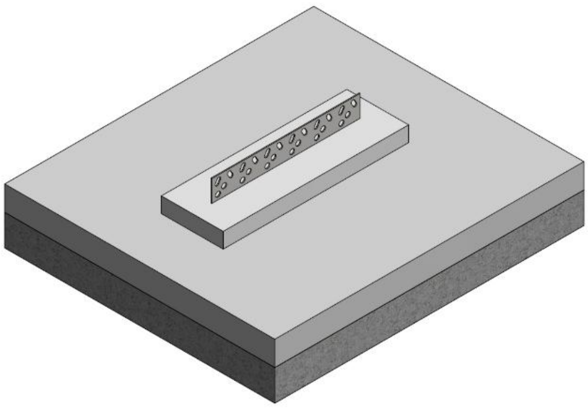
Table 18

t [mm]	e [mm] / L [mm]	30	40	50	60	70	80	90	100	110	120	150	180	210	240
1.5	80														
2.0	80														
3.0	80														
1.5	120	5.4	5.1	4.5	3.4	3.2	3.1	2.7	2.6						
2.0	120				3.4	3.2	3.1	2.7	2.6	2.4	2.3	1.9			
3.0	120				3.5	3.5	3.4	3.1	3.1	3.0	2.7	2.3	2.3	2.0	1.5
1.5	160	13.1	12.0	10.8	9.5	8.9	8.4	7.7	6.5	4.3	0.4				
2.0	160				9.5	8.9	8.4	7.8	7.3	6.9	6.3	4.6			
3.0	160				9.6	9.0	8.5	8.1	7.6	7.2	6.6	5.5	5.1	4.5	4.1
1.5	200	18.2	17.3	16.6	15.5	14.3	12.2	10.5	6.8	4.1					
2.0	200				16.2	15.3	14.2	13.2	12.4	11.7	10.9	8.6			
3.0	200				16.3	15.4	14.3	13.5	12.7	11.9	11.1	9.6	8.6	7.6	6.8
1.5	240	22.3	21.6	20.4	19.3	18.2	17.3	16.2	14.2	11.6	7.8				
2.0	240				24.0	22.4	20.9	19.4	18.5	17.7	16.5	13.1			
3.0	240				24.3	23.0	21.6	20.3	19.0	18.0	16.7	14.2	12.6	11.5	10.1
1.5	280	26.6	25.7	24.8	23.8	22.3	21.2	20.3	18.2	15.7	12.2				
2.0	280				33.9	31.9	29.7	27.4	26.1	24.7	23.1	17.6			
3.0	280				34.3	32.1	30.0	27.7	26.3	25.0	23.5	20.3	17.6	16.2	14.2
1.5	320	30.4	29.8	29.0	27.7	26.6	25.0	24.2	22.3	19.7	16.2				
2.0	320				40.0	38.9	37.8	36.7	34.6	32.4	30.2	21.5			
3.0	320				45.9	42.9	40.1	37.1	35.2	33.2	31.3	27.0	23.6	21.3	18.9
1.5	360	35.0	34.0	33.1	31.9	30.6	29.2	28.1	26.3	23.8	20.5				
2.0	360				45.5	44.8	44.3	43.6	41.0	38.3	35.8	26.7			
3.0	360				59.4	55.6	51.7	47.9	45.5	42.9	40.5	35.1	30.8	27.4	24.3
1.5	400	39.2	38.2	37.3	36.2	34.8	33.3	32.0	30.1	27.8	24.8				
2.0	400				50.8	50.2	49.7	49.1	46.6	43.9	41.2	32.1			
3.0	400				74.3	69.5	64.8	60.1	57.0	53.7	50.6	43.9	38.3	34.4	30.4

Permissible distance ‘S’ (m) between the TFA plate anchor and the anchorage centre (fulcrum) for an anchor with thickness t = 1.5, 2.0, 3.0 mm for a three- or four-layer sandwich panel with a facade layer thickness f ≤ 120 mm.

Table 19

t [mm]	L [mm] \ e [mm]	30	40	50	60	70	80	90	100	110	120	150	180	210	240
1.5	80	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	80				3.6	3.6	3.7	4.2	4.6	5.1	5.6				
3.0	80				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	120	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	120				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	120				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	160	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	160				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	160				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	200	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	200				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	200				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	240	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	240				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	240				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	280	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	280				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	280				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	320	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	320				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	320				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	360	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	360				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	360				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2
1.5	400	2.0	3.3	3.5	3.6	3.6	3.7	4.2	4.6	5.1	5.6				
2.0	400				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0			
3.0	400				3.6	3.6	3.7	4.2	4.6	5.1	5.6	7.0	8.4	9.8	11.2



The maximum permissible values for the distance between the plate anchor and the anchorage centre in the sandwich panel are given in the table above (Table 19). If this value is exceeded, the mobility of the plate anchor shall be ensured by installing an additional insulation strip in the area around the anchor. This increases the insulation layer thickness, resulting in S being greater than the value indicated in the table.

INSTALLATION OF PLATE ANCHOR TFA IN SANDWICH PANEL

Table 20 – First variant

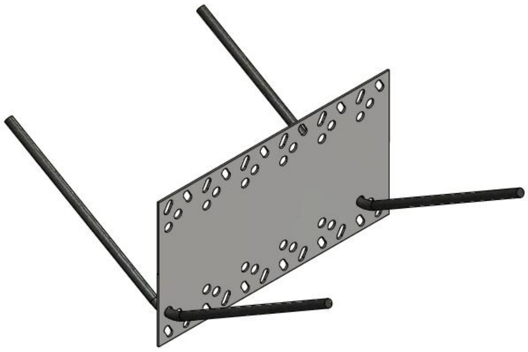
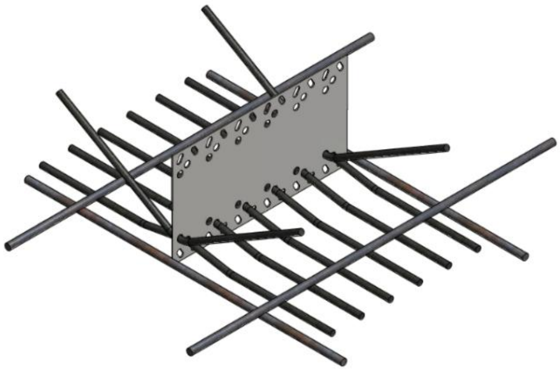
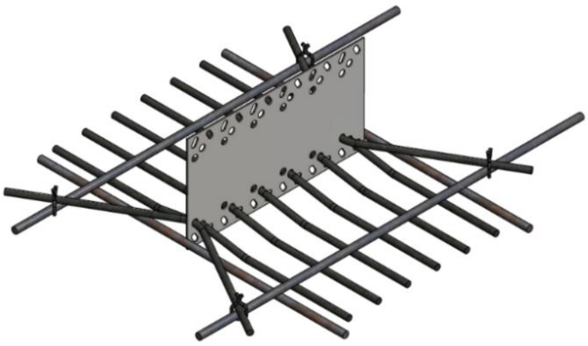
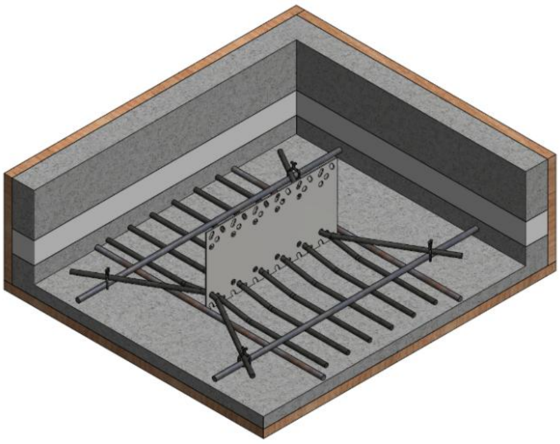
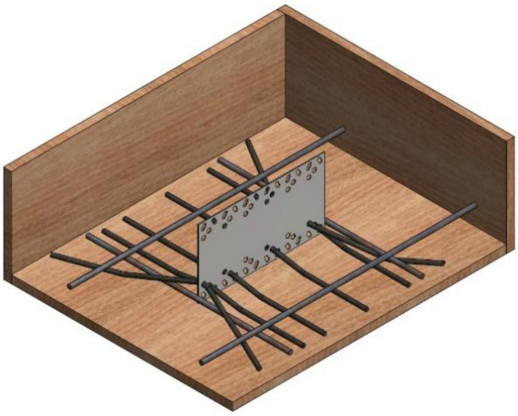
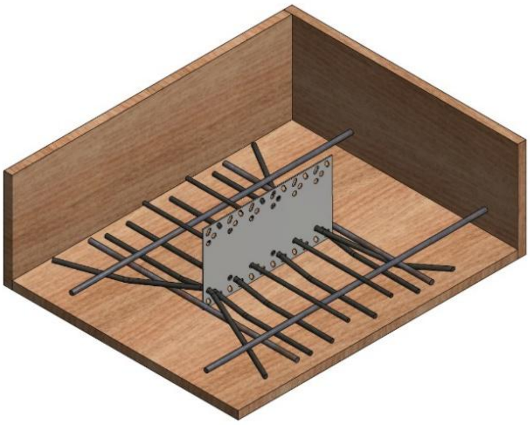
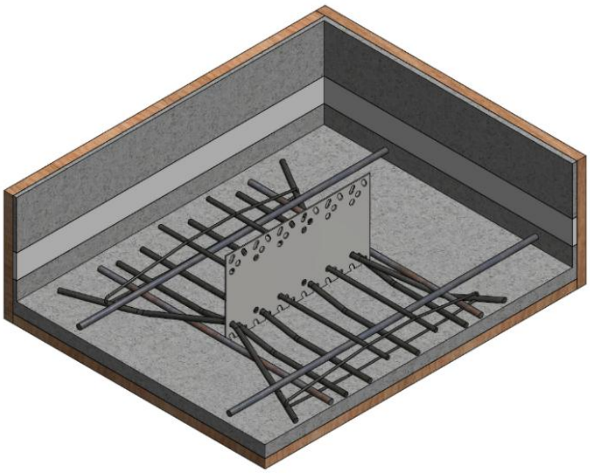
1. *Two anchorage bars, bent 30° in the centre, are inserted through the outer holes of the upper row of round holes.*	
2. *The anchor is then placed in the indicated position on the reinforcement mesh. The straight anchorage bars are inserted through the lower row of round holes beneath the lower layer of the reinforcement mesh.*	
3. *The bent anchorage bars are rotated into a horizontal position and the ends of the bars are tied to the reinforcement mesh using binding wire.*	
4. *The complete reinforcement assembly with the TFA anchor is then placed in the formwork. The concrete for the outer layer is subsequently cast, after which the insulation layer, the reinforcement mesh for the load-bearing layer and the anchorage bars for the upper row of round holes are installed.* ***5.*** *Replace each cut bar of the reinforcement mesh with additional reinforcement of the same diameter.* ***6.*** *Cast the concrete for the inner layer.*	

Table 21 – Second variant

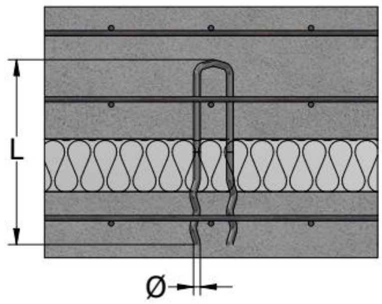
7. *In this case, the reinforcement mesh has already been placed in the formwork. Several anchorage bars are inserted through the lower row of round holes beneath the lower layer of the reinforcement mesh.*	
8. *The remaining anchorage bars are inserted through the upper row of round holes above the reinforcement mesh.*	
9. *These bars are then tied tightly to the reinforcement mesh. The concrete for the facade layer is then cast, after which the insulation layer, the reinforcement mesh for the load-bearing layer and the anchorage bars for the upper row of round holes are installed.* ***10.*** *Replace each cut bar of the reinforcement mesh with additional reinforcement of the same diameter.* ***11.*** *Cast the concrete for the inner layer.*	

3.2.5 *Performances of hairpin anchors or stirrups*

CAVITY ANCHOR: STRAIGHT HAIRPIN 'TVH'

The straight TVH hairpin anchor is manufactured from stainless steel wire, material grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm^2 and fu ≥ 500–700 N/mm^2, grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm^2 and fu ≥ 500–700 N/mm^2, and grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm^2 and fu ≥ 500–700 N/mm^2. It is available in diameters of 3.0, 4.0, 5.0 and 6.5 mm and is bent into a 'U' shape.
The straight TVH hairpin anchor is mainly used in the negative production method for sandwich panels.

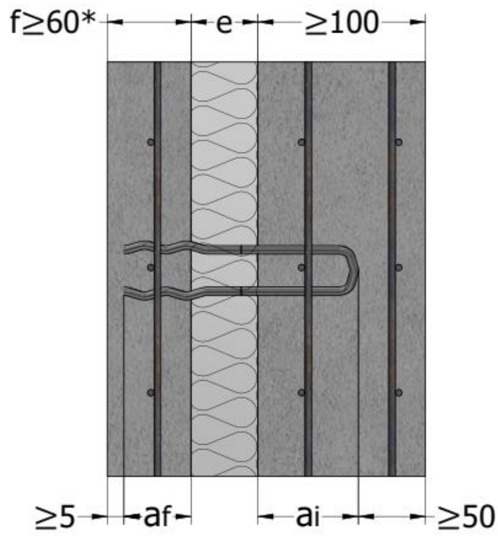
CAVITY ANCHOR: HAIRPIN 'TVH'



The available TVH cavity anchors are shown in the table below.

Table 22

Wire diameter Ø mm	Straight hairpin TVH	Product no.	Length L mm
	3.0 -140	**43375**	140
3	3.0 -160	**43376**	160
	3.0 -200	**43377**	200
	4.0 -160	**43380**	160
	4.0 -200	**43381**	200
4	4.0 -230	**43382**	230
	4.0 -250	**43383**	250
	4.0 -280	**43384**	280
	5.0 -200	**43385**	200
	5.0 -230	**43386**	230
5	5.0 -250	**43387**	250
	5.0 -280	**43388**	280
	5.0 -320	**43389**	320



Remark:
$a_f \geq$ **55 mm,** $a_i \geq$ **50 mm.**
***** In accordance with NEN-EN 1992-1-1/NA:2013-04,
$f_{min} \geq 70$ mm applies to the slab thickness.

Concrete quality:
Facade layer ≥ C30/37
Load-bearing layer ≥ C30/37.

Reinforcement:
Reinforcement mesh B500B
Reinforcing steel B500B

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

The dimensions of the straight TVH hairpin anchor depend on the outer layer thickness and the insulation layer thickness. The maximum value for the distance between the hairpin anchor and the anchorage centre (fulcrum), **S_h** max. (m), is given in Table 23. These values for **'S_h'** ensure sufficient mobility of the TVH hairpin anchor and prevent deterioration caused by additional restraining forces. If the permissible values are exceeded, an additional insulation strip shall be installed at the hairpin anchor in order to guarantee the required mobility.

Table 23

f [mm]		The insulation layer thickness e [mm]												
		30	40	50	60	70	80	90	100	110	120	130	140	150
60	Ø - L	3 -140		3 -160		4 -180		4 -200	4 -220		4 -240		5-260	
	S_h max	1.6	2.6	3.8	4.0	5.3	6.7	8.3	8.3	8.3	8.3	8.3	8.3	8.3
70	Ø - L	3 -160		3 -180		4 -200		4 -220	4 -240		5 -260		5 -280	
	S_h max	1.3	2.0	2.9	4.0	5.3	6.7	8.3	8.3	8.3	8.3	8.3	8.3	7.0
80	Ø - L	3 -160	3 -200			4 -200	4 -240		5 -260		5 -280			5 -320
	S_h max	1.3	2.0	2.9	4.0	5.3	6.7	8.3	7.0	7.0	7.0	7.0	7.0	7.0
90	Ø - L	4 -180		4 -200		4 -220		4 -240	5 -260		5 -280		5 -300	
	S_h max	1.3	2.0	2.9	4.0	5.3	6.7	8.3	7.0	7.0	7.0	7.0	7.0	7.0
100	Ø - L	4 -180	4 -200		4 -220	5 -240			5 -260	5 -280		5 -300		5 -320
	S_h max	1.3	2.0	2.9	4.0	5.3	6.7	8.3	7.0	7.0	7.0	7.0	7.0	7.0
110	Ø - L			5 -240				5 -260	5 -280		5 -300		5 -320	
	S_h max													
120	Ø - L			5 -240			5 -260		5 -280	5 -300		5 -320		6 -340
	S_h max			2.5	3.4	4.4	5.6	6.9	7.0	7.0	7.0	7.0	7.0	7.0

The minimum length of the hairpin anchor can be calculated using the formula:
L = f (facade layer thickness) + e (insulation layer thickness) + a (anchorage depth)

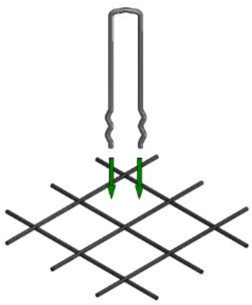
The anchorage depth of the tie anchor – Table 24:

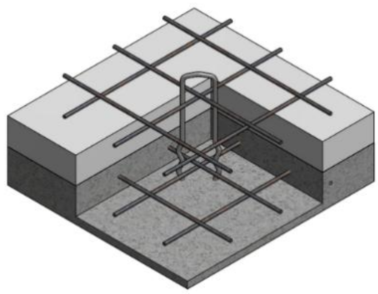
Table 24

e [mm] / f [mm]	30 - 90	100 - 150
60	50	55
70	55	62
80	60	70
90	60	70
100	60	70
120	60	70

INSTALLATION OF STRAIGHT HAIRPIN 'TVH'

The straight TVH hairpin anchor is installed while the concrete of the outer layer is still sufficiently workable. The pin is pushed into the fresh concrete, taking into account the minimum anchorage length for the corrugated end (> 50 mm). The hairpin anchor is then pulled back slightly so that the ends do not become visible when the concrete surface is washed out, blasted, polished or otherwise finished. The minimum anchorage depth of the closed end in the inner layer is equal to the installation depth of the supporting anchor (TFA or TMA). After installation of the pins, the concrete shall be vibrated and compacted to eliminate air voids. Note: contact between the vibrator and the installed sandwich panel anchorage shall be avoided during compaction.

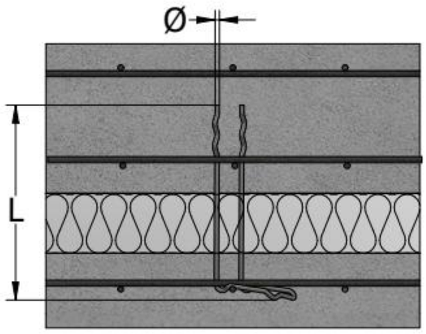




CAVITY ANCHOR: CLIP-ON HAIRPIN 'TVA'

The TVA clip-on hairpin anchor is manufactured from stainless steel wire, material grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm^2 and fu ≥ 500–700 N/mm^2, grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm^2 and fu ≥ 500–700 N/mm^2, and grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm^2 and fu ≥ 500–700 N/mm^2. It is available in diameters of 3.0, 4.0 and 5.0 mm and in a 'U' shape. The closed end is bent at an angle of 90°.
The TVA clip-on hairpin anchor is mainly used in the negative production method for sandwich panels. These hairpin anchors shall be installed at a node of the reinforcement mesh before the concrete is cast. This method of installation ensures the minimum anchorage depth.

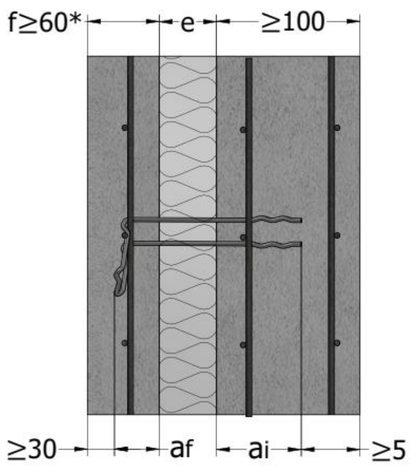
CAVITY ANCHOR: CLIP-ON HAIRPIN 'TVA'



The available TVA cavity anchors are shown in the table below.

Table 25

Wire diameter Ø mm	Clip-on hairpin TVA	Product no.	Length L mm
3	3.0 -120	**43397**	120
	3.0 -140	**43398**	140
	3.0 -160	**43399**	160
4	4.0 -160	**43401**	160
	4.0 -200	**43402**	200
	4.0 -250	**43403**	250
5	5.0 -200	**43405**	200
	5.0 -250	**43406**	250
	5.0 -280	**43407**	280
	5.0 -320	**43408**	320



Remark:
$a_f \geq$ 30 mm, $a_i \geq$ 55 mm.
$a_f \geq$ 35 mm for $f_{min} \geq 70\ mm$
***** In accordance with NEN-EN 1992-1-1/NA:2013-04, $f_{min} \geq$ 70 mm applies to the slab thickness.

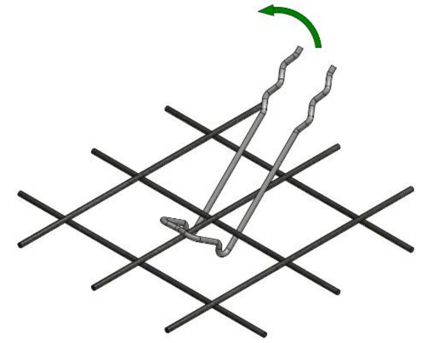
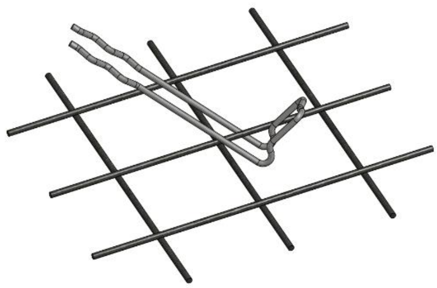
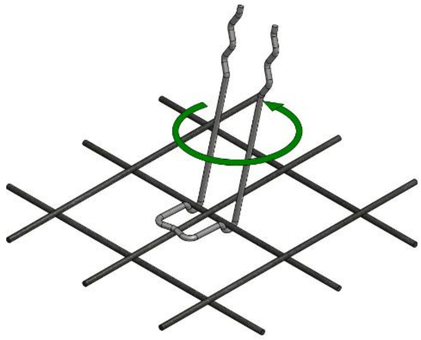
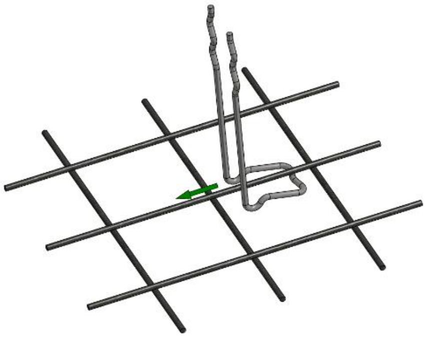
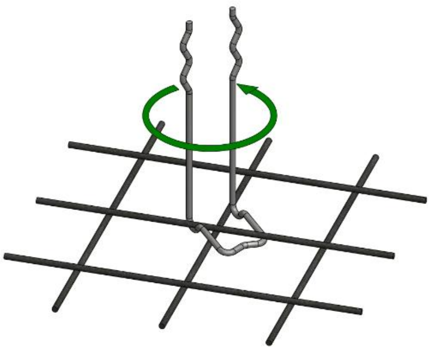
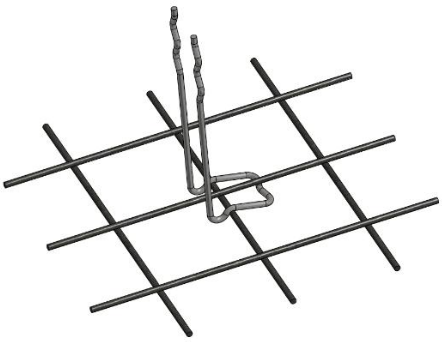
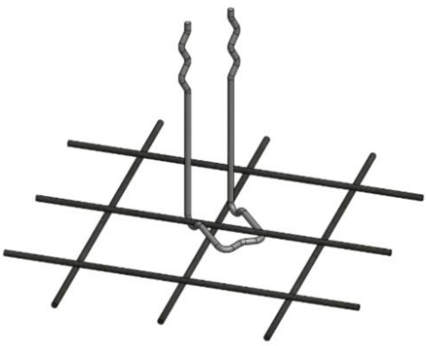
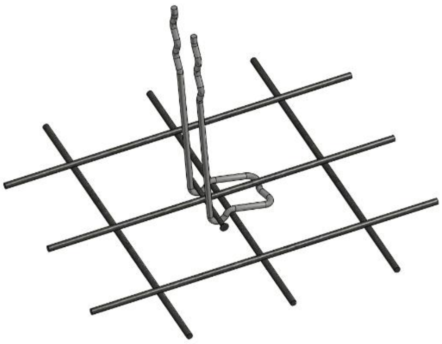
Concrete quality:
Facade layer ≥ C30/37
Load-bearing layer ≥ C30/37.

Reinforcement:
Reinforcement mesh B500B
Reinforcing steel B500B

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

INSTALLATION OF CLIP-ON HAIRPIN 'TVA'

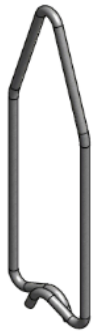
Table 26

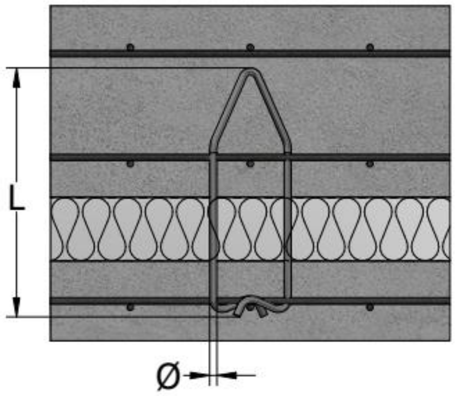
Hairpin TVA with wire diameters of 3.0 and 4.0 mm		Hairpin TVA with wire diameter of 5.0 mm	
1. *The TVA hairpin anchor is slid beneath the upper reinforcement bar and then lifted vertically upwards.*		***1.*** *One leg of the TVA anchor is slid beneath the upper reinforcement bar and then lifted vertically upwards.*	
2. *The anchor is rotated counterclockwise.*		***2.*** *The upright anchor is slid over the lower reinforcement bar.*	
3. *The rotated anchor is held in this position.*		***3.*** *The hairpin anchor is sprung slightly by applying light pressure.*	
4. *In this position, the anchor is secured at the reinforcement intersection.*		***4.*** *In this position, a nail is placed over the notches of the hairpin anchor and beneath the upper reinforcement bar.*	

CAVITY ANCHOR: CLIP-IN HAIRPIN 'TVB'

The TVB clip-in hairpin anchor is manufactured from stainless steel wire, material grade X6CrNiMoTi17-12-2 (number 1.4571) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm² and fu ≥ 500–700 N/mm², grade X2CrNiMo17-12-2 (number 1.4404) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm² and fu ≥ 500–700 N/mm², and grade X5CrNiMo17-12-2 (number 1.4401) in accordance with NEN-EN 10088-1 and NEN-EN 10088-3 with fy ≥ 200 N/mm² and fu ≥ 500–700 N/mm². It is available in diameters of 3.0, 4.0,and 5.0 mm. This stirrup may be used as an alternative to the TVA hairpin anchor.

CAVITY ANCHOR: CLIP-IN HAIRPIN 'TVB'

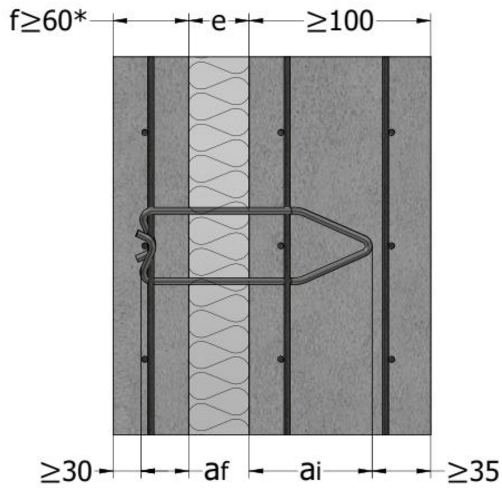




The available TVB tie anchors are shown in the table below:

Table 27

Wire diameter Ø mm	Clip-on hairpin TVB	Product no.	Length L mm
3	3.0 -150	**43390**	150
	3.0 -175	**43391**	175
4	4.0 -160	**43393**	160
	4.0 -175	**43394**	175
	4.0 -200	**43395**	200
	4.0 -250	**43396**	250
5	5.0 -250	**46778**	250
	5.0 -280	**45461**	280
	5.0 -320	**62560**	320



Remark:
$a_f \geq$ **30 mm,** $a_i \geq$ **65 mm.**
$a_f \geq$ **35 mm for** $f_{min} \geq 70\ mm$
* In accordance with NEN-EN 1992-1-1/NA:2013-04, $f_{min} \geq$ 70 mm applies to the slab thickness.

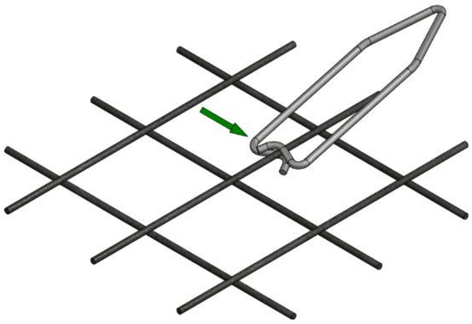
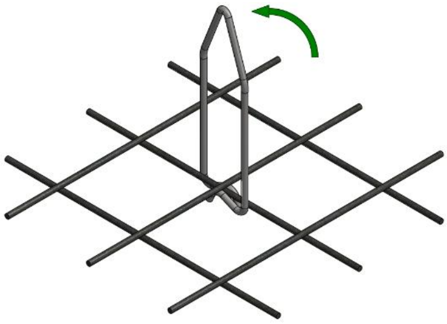
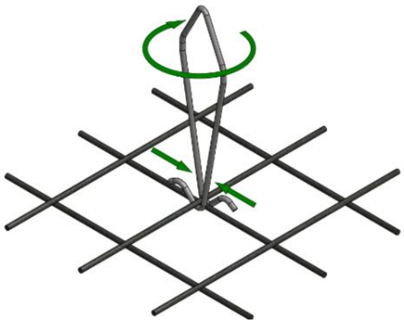
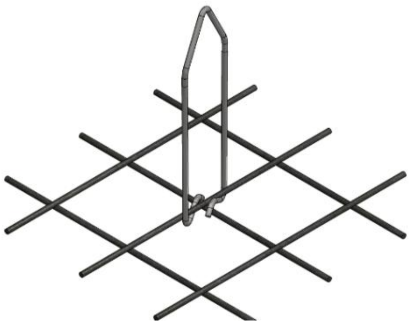
Concrete quality:
Facade layer ≥ C30/37
Load-bearing layer ≥ C30/37.

Reinforcement:
Reinforcement mesh B500B
Reinforcing steel B500B

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

INSTALLATION OF CLIP-IN HAIRPIN 'TVB'

Table 28

1. *The TVB anchor is attached to the upper reinforcement bar. The upper reinforcement bar is clamped between the two arms of the anchor.*	
2. *The anchor is lifted into a vertical position.*	
3. *Apply pressure simultaneously to both arms of the hairpin anchor and secure it to the lower reinforcement bar by rotating it clockwise.*	
4. *Intermediate position after rotation.*	
5. *Final position of the TVB hairpin anchor.*	

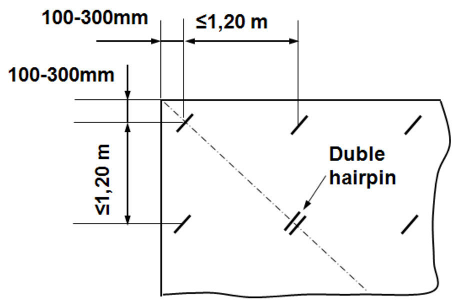
The dimensions of the TVA and TVB tie anchors depend on the outer layer thickness and the insulation thickness. The maximum values for '**S_h**' are the same as those indicated for the straight TVH hairpin anchor.

Table 29

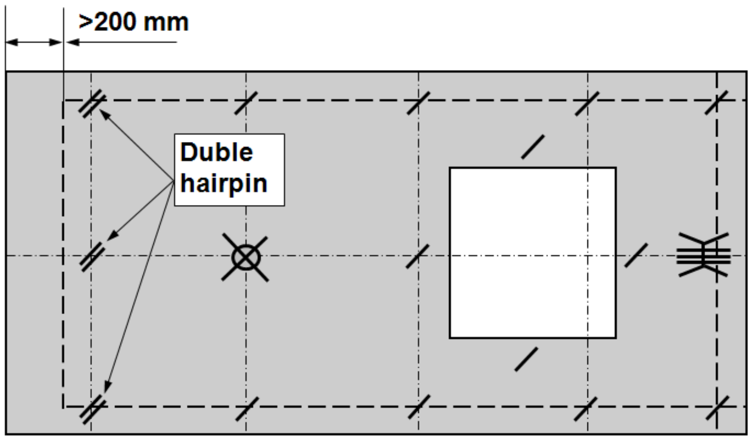
<table>
<tr><th rowspan="2">f [mm]</th><th rowspan="2"></th><th colspan="13">The insulation layer thickness e [mm]</th></tr>
<tr><th>30</th><th>40</th><th>50</th><th>60</th><th>70</th><th>80</th><th>90</th><th>100</th><th>110</th><th>120</th><th>130</th><th>140</th><th>150</th></tr>
<tr><td rowspan="2">60</td><td>TVA</td><td>3 -140</td><td colspan="2">3 -140</td><td>3 -160</td><td colspan="4">4 -200</td><td colspan="5">4 -250</td></tr>
<tr><td>TVB</td><td colspan="4">3 -150</td><td colspan="2">4 -175</td><td colspan="3">4 -200</td><td colspan="4">4 -250</td></tr>
<tr><td rowspan="2">70</td><td>TVA</td><td colspan="4">4 -160</td><td colspan="3">4 -200</td><td colspan="5">4 -250</td><td>5 -280</td></tr>
<tr><td>TVB</td><td colspan="3">4 -160</td><td colspan="2">4 -175</td><td colspan="2">4 -200</td><td colspan="5">4 -250</td><td>5 -280</td></tr>
<tr><td rowspan="2">80</td><td>TVA</td><td colspan="3">4 -160</td><td colspan="4">4 -200</td><td colspan="4">5 -250</td><td colspan="2">5 -280</td></tr>
<tr><td>TVB</td><td colspan="2">4 -160</td><td colspan="2">4 -175</td><td colspan="3">4 -200</td><td colspan="6">The TVA tie hairpin anchor shall be applied.</td></tr>
<tr><td rowspan="2">90</td><td>TVA</td><td colspan="2">4 -160</td><td colspan="4">4 -200</td><td>4 -250</td><td colspan="3">5 -250</td><td colspan="3">5 -280</td></tr>
<tr><td>TVB</td><td colspan="2">4 -160</td><td colspan="2">4 -175</td><td colspan="3">4 -200</td><td colspan="6">The TVA tie hairpin anchor shall be applied.</td></tr>
<tr><td rowspan="2">100</td><td>TVA</td><td colspan="2">4 -160</td><td colspan="2">4 -200</td><td colspan="2">5 -200</td><td colspan="4">5 -250</td><td colspan="3">5 -280</td></tr>
<tr><td>TVB</td><td>4 -160</td><td colspan="2">4 175</td><td>4 -200</td><td colspan="9">The TVA tie hairpin anchor shall be applied.</td></tr>
<tr><td rowspan="2">120</td><td>TVA</td><td colspan="5">5 -200</td><td colspan="4">5 -250</td><td colspan="3">5 -280</td><td>5 -320</td></tr>
<tr><td>TVB</td><td colspan="13">The TVA tie hairpin anchor shall be applied.</td></tr>
</table>

INSTALLATION OF CAVITY ANCHORS

The cavity anchors have been tested per type. Special dimensioning of these wire hairpin anchors is not required when they are used in combination with a supporting anchor, sleeve anchor or plate anchor, provided that the following conditions are observed:



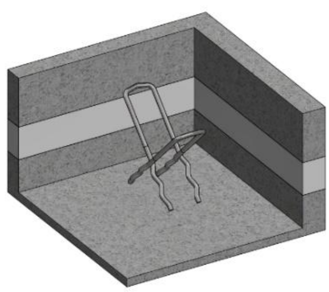
Important! The maximum spacing between hairpin anchors shall not exceed 1.2 m. In the case of high adhesion forces to the formwork, such as textured finishes, the maximum spacing between hairpin anchors shall not exceed 0.9 m.

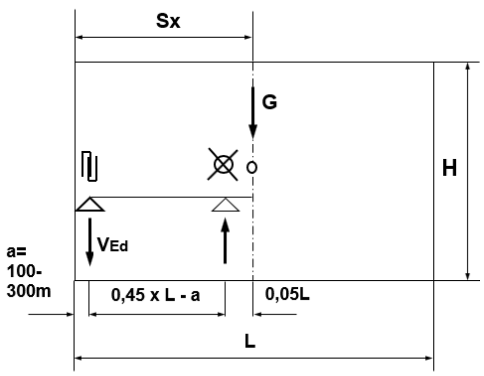


The positioning grid for the hairpin anchors shall not exceed or fall below the respective ratio of 3:4 or 4:3.
The second hairpin anchor along the diagonal line shall be doubled. If a sleeve anchor or plate anchor is installed at that position, a double hairpin anchor is not required.
Where the outer layer projects more than 200 mm, double hairpin anchors with d = 4.0 mm shall be used for the first vertical row.

TORSION ANCHORS

Torsion anchors shall prevent the facade layer from rotating about the load-bearing inner layer. When dimensioning the torsion anchor, account shall be taken of an unintended eccentricity in the installation of the supporting anchor (the supporting anchor is positioned slightly away from the vertical centre of gravity). This eccentricity is assumed to be 5% of the total length of the sandwich panel, with a minimum value of 100 mm. If at least two supporting anchors are used to support the facade layer, installation of a torsion anchor is not required. The rule of thumb for load distribution is then that of a beam on two supports. In addition, the facade layer is connected to the load-bearing layer by means of cavity anchors.





$$V_{Ed,torsion} = \frac{0.05\ x\ L}{0.45\ x\ L - a}\ x\ G\ x\ 1.35$$

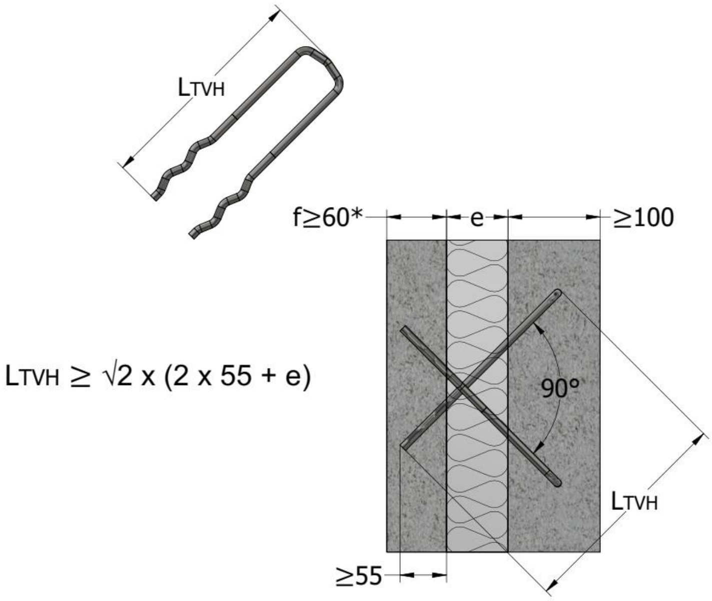
Torsion anchors consist of two hairpin anchors inserted almost perpendicular to each other and positioned at an angle of 45° to the concrete surface. These anchors function as a hinge rod. Two straight TVH hairpin anchors made of stainless steel wire AISI 316 (W1.4401 – A4 quality), available in diameters of 4.0 and 5.0 mm, are used as torsion anchors. The TFA plate anchor may be used as a torsion anchor where the load on the torsion anchor exceeds the load that can be carried by crossed TVH anchors.

Table 30

f [mm]	Ø [mm]	Insulation layer thickness e [mm]										
		30	40	50	60	70	80	90	100	110	120	130 - 240
60	4.0	3.3	3.3									A TFA plate anchor is indicated.
	5.0	6.9	6.9									
	4.0			3.3	3.1	2.7	2.2	1.9	1.6			
	5.0			6.9	6.7	6.1	5.5	4.9	4.4			
	4.0											
	5.0									3.9	3.5	
70	4.0	3.0	3.0									
	5.0	6.6	6.6									
	4.0			3.0	2.7	2.2	1.8	1.4	1.1			
	5.0			6.6	6.3	5.6	5.0	4.5	3.9			
	4.0											
	5.0									3.4	3.0	
80	4.0	2.4	2.4									
	5.0	6.0	6.0									
	4.0			2.4	2.0	1.6	1.1					
	5.0			6.0	5.6	5.0	4.4	3.8	3.3			
	4.0											
	5.0									2.8	2.2	
90	4.0		3.1	2.6								
	5.0		7.2	6.4								
	4.0				2.1	1.7	1.3	0.9				
	5.0				5.8	5.1	4.5	4.0	3.4			
	4.0											
	5.0									2.5	1.8	
120	4.0											
	5.0		5.8	5.0								
	4.0											
	5.0				4.4	3.7	3.1	2.6	2.0			
	4.0											
	5.0									1.1	1.1	

The permissible load on the crossed hairpin anchors is given in Table 30. In the calculation, account shall be taken of the most unfavourable load due to wind and temperature. Taking into consideration the above instructions, the load on the torsion anchor is calculated in accordance with the formula above.

The length L_{TVH} is calculated in accordance with the figure below.



3.2.6 Strength in case of fire

The aspect 'Strength in case of fire' has not been assessed for anchors for concrete sandwich constructions. Where necessary, the strength of anchors for concrete sandwich constructions in application in case of fire may be determined at project level.

Sandwich panels that do not form part of the main load-bearing structure and cannot obstruct an escape route are not required to comply with a fire resistance requirement. Sandwich panels that may obstruct an escape route are subject to a fire resistance requirement of 30 minutes.

A fire resistance of at least 30 minutes is achieved if the following guidelines are met:
- The minimum cover to the bars to the heated surface is 15 mm.
- With a minimum anchorage depth of 50 mm, the minimum thickness of the inner leaf is 65 mm.
- Fire gaps, i.e. joints > 20 mm at the inner and underside of the facade, shall be sealed.

A higher fire resistance may be achieved by increasing the thickness of the inner leaf and/or by applying a fire-resistant insulation material in the cavity.

3.3 Technical building regulations with regard to health

3.3.1 Resistance to moisture

The aspect 'Resistance to moisture' has not been assessed for anchors for concrete sandwich constructions. Where necessary, the watertightness, air volume flow, internal surface temperature factor and water absorption of anchors for concrete sandwich constructions in application may be determined at project level.

3.4 Technical building regulations with regard to energy efficiency and environment

3.4.1 Energy efficiency, new construction

The aspect 'Energy efficiency, new construction' has not been assessed for anchors for concrete sandwich constructions. Where necessary, the thermal resistance and air volume flow of anchors for concrete sandwich constructions in application may be determined at project level.

4 PROCESSING INSTRUCTIONS

4.1 General

The processing instructions drawn up by the manufacturer and authenticated by Kiwa form part of this attestation with product certificate as if they were literally included herein.

4.2 Installation

The products shall be installed in accordance with the drawings prepared by or on behalf of the supplier, or in accordance with the supplier's written instructions. Installation and processing are the responsibility of the purchaser.

Dimensional deviations from the nominal embedment depth have a significant influence on the performance of the anchor. The tolerances for the embedment depth are therefore set at 0 mm/+10 mm, with the exception of the embedment depth of sleeve anchors. These shall be installed at the nominal dimension in accordance with Table 1, page 8.
Sleeve anchors and plate anchors, as well as closed hairpin anchors/stirrups, shall be cast into the concrete structure.
Straight hairpin anchors may either be cast in or inserted directly after the concrete has been poured.
If straight hairpin anchors are inserted directly after concrete casting, the concrete shall be vibrated again.
Note: In self-compacting concrete, it is not permitted to insert straight hairpin anchors more than one hour after concrete casting.

4.3 TRANSPORT AND STORAGE

Transport and storage of the products shall be carried out in such a manner that no damage and/or deformation can occur. Responsibility for storage and transport 'ex works' rests with the manufacturer and, during transport and installation on the construction site or prefabrication location, with the purchaser.

4.4 Specifications

4.4.1 Strength class

The concrete of the sandwich elements shall have a strength class of at least C28/35.

4.4.2 Durability

Concrete cover
The concrete cover to the non-stainless parts, being the reinforcing steel, as well as to the stainless steel parts, shall comply with the nominal concrete cover in accordance with NEN 1992-1-1.

4.5 Area of application

The anchoring products are applied under conditions up to and including exposure class C4 of NEN-EN-ISO 12994-2.

Application is not permitted:
- In an environment with an increased chloride concentration, such as direct exposure to salt-saturated air, swimming pools, in seawater or in the splash zone of seawater.
- In a highly aggressive environment (strongly acidic and/or strongly alkaline), such as in heavy chemical industry.

5 TIPS FOR THE BUYER

You must inspect the products listed under “technical specification” to make sure:
- the delivery matches the order
- the mark and the way in which the mark is applied are correct
- the products do not show any visible defects (as a result of transport, for example)

If you reject the products based on the aforementioned, please contact:
- Terwa B.V.

and, if necessary:
- Kiwa Nederland B.V.

The products must be stored, transported and processed in accordance with the provisions stated in this attestation with product certificate.
Observe the application conditions and processing instructions included in this attestation with product certificate.
Check whether this attestation with product certificate is still valid by referring to the Kiwa website: www.kiwa.nl.

6 LIST OF DOCUMENTS MENTIONED

Building decree 2012
Building Decree 2012 Stb. 2011, 416, 676, Stb. 2012, 441, Stb. 2013, 75, 244, 462, Stb. 2014, 51, 232 and 342, Stb. 2015, 92, 249 and 425 and the Building Decree 2012 Regulation Stcrt. 2011, 23914, Stcrt. 2012, 13245, Stcrt. 2013, 5457, 16919, Stcrt. 2014, 4057, 34076, 37003 and Stcrt. 2015, 17338 and 45221.

Standards/normative documents:

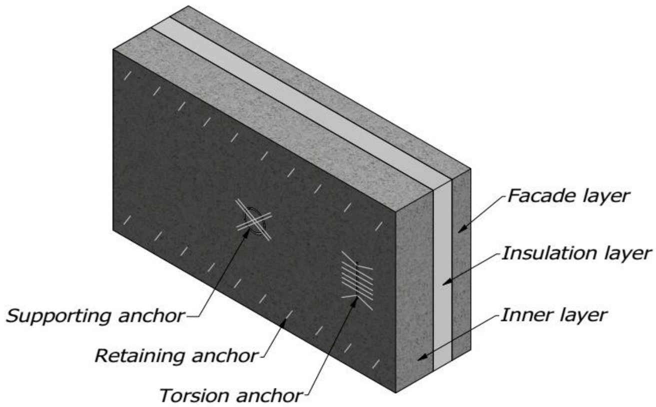
Standard	Title
BRL 0501:2010	Reinforcing steel dated 2010-09-01
BRL 0513:2015	Glass fibre bars for application as reinforcement in concrete, including amendment dated July 24, 2015
NEN 1068:2014	Thermal insulation of buildings – Calculation methods, including correction sheet C1 dated January 2014
NEN 2686:2008	Air permeability of buildings – Test method, including amendment A2 dated December 2008
NEN 2690:2008	Air permeability of buildings – Test method for the specific air volume flow between crawl space and dwelling, including amendment A2 dated December 2008
NEN 2778:2015	Moisture control in buildings, dated June 2015
NEN 6069:2011	Testing and classification of the fire resistance of building elements and building products, including amendment A2 dated December 2011
NEN-EN 1990:2011	Euro Code: Basis of structural design, including amendment A1 and correction sheet C2 and National Annex, dated December 2011
NEN-EN 1991-1-1:2011	Euro Code 1: Loads on constructions - Part 1-1: General actions – Densities, self-weight and imposed loads for buildings, including correction sheet C1 and National Annex, dated December 2011
NEN-EN 1991-1-2:2011	Euro Code 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire, including correction sheet C1 and National Annex, dated December 2011
NEN-EN 1991-1-4:2011	Euro Code 1: Actions on structures – Part 1-4: General actions – Wind actions, including amendment A1 and correction sheet C2 and National Annex, dated December 2011
NEN-EN 1991-1-5:2011	Euro Code 1: Actions on structures – Part 1-5: General actions – Thermal actions, including correction sheet C1 and National Annex, dated December 2011
NEN-EN 1992-1-1:2011	Euro Code 2: Design and calculation of concrete structures – Part 1-1: General rules and rules for buildings, including correction sheet C2 and National Appendix, dated November 2011
NEN-EN 1992-1-2:2011	Euro Code 2: Design of concrete structures – Part 1-2: General rules – Structural fire design, including correction sheet C1 and National Annex, dated November 2011
NEN-EN 1993-1-1:2014	Euro Code 3: Design and calculation of steel constructions- Part 1-1: General rules and rules for buildings, including amendment A1 and correction sheet C2 and National Annex, dated June 2014
NEN-EN 1993-1-4:2012	Euro Code 3: Design and calculation of steel constructions- Part 1-4: General rules – Supplementary rules for stainless steels, including correction sheet C2 and National Annex, dated September 2012
NEN-EN 10088-1:2014	Stainless steels – Part 1: List of stainless steels, dated November 2014
NEN-EN 10088-2:2014	Stainless steels – Part 2: Technical delivery conditions for sheet/plate and strip of corrosion-resistant steels for general purposes, dated November 2014
NEN-EN-ISO 6892-1:2009	Metallic materials – Tensile testing – Part 1: Method of test at room temperature, dated September 2009
NEN-EN-ISO 9606-1:2013	Qualification testing of welders – Fusion welding – Part 1: Steels, dated October 2013
NEN-EN-ISO 12994-2:1998	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classification of environments, dated August 1998
NEN-EN-ISO 14732:2013	Welding personnel – Qualification testing of welding operators and weld setters for mechanised and automatic welding of metallic materials, dated August 2013
NEN-EN-ISO 15607:2003	Specification and qualification of welding procedures for metallic materials – General rules, dated December 2003

NEN-EN-ISO 15609-1:2004	Specification and qualification of welding procedures for metallic materials – Welding procedure specification – Part 1: Arc welding, dated October 2004
NEN-EN-ISO 15614-1:2004	Specification and qualification of welding procedures for metallic materials – Welding procedure test – Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys, including amendment A2 dated February 2012
NPR 2652:2008	Moisture control in buildings – Protection against moisture from outside and protection against moisture from inside – Examples of building details, dated October 2008

7 TECHNICAL AND STRUCTURAL ADVICE

Sandwich panels are mainly large, multi-layer facade elements made of reinforced concrete. They consist of a facade layer of architectural or structural concrete, an insulation layer and a load-bearing inner layer (panel consisting of three layers). In order to prevent condensation problems, a ventilated cavity may be provided between the insulation layer and the facade layer (panel consisting of four layers). The facade layer is connected to the load-bearing layer by means of sandwich panel anchors. Sandwich panel anchors are a combination of tie anchors, torsion anchors and cavity anchors.
The anchors shall be dimensioned on the basis of the following:

- weight of the facade layer
- insulation thickness and width of the ventilated cavity
- adhesion forces to the formwork
- wind pressure and suction
- eccentricities, particularly for asymmetrical elements
- temperature effects on the facade layer
- temperature difference between the inner layer and the facade layer
- transport and installation of the sandwich panel
- expansion and shrinkage forces



ANCHORING SYSTEM

- **SUPPORTING ANCHORS**

These anchors shall be dimensioned on the basis of the self-weight of the facade layer. Eccentric loading and horizontal loading due to wind, bowing, etc., shall also be taken into account. Tie anchors shall be positioned in such a way that only one anchor point (fulcrum) per facade layer is available. If only one tie anchor is used for load transfer, a torsion anchor is also required.

- **TORSION ANCHORS (HORIZONTAL ANCHORS)**

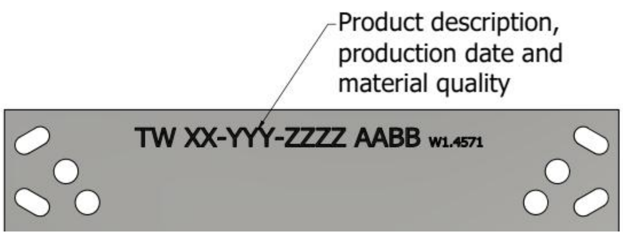
Torsion anchors shall prevent the facade layer from rotating about the load-bearing inner layer. When dimensioning the torsion anchor, account shall be taken of an unintended eccentricity in the installation of the tie anchor (the tie anchor is positioned slightly away from the vertical centre of gravity). This eccentricity is assumed to be 5% of the total length of the sandwich panel, with a minimum value of 100 mm. A torsion anchor is not required if at least two tie anchors are used to support the outer layer. In that case, the rule of thumb for load distribution is that of a beam on two supports. The facade layer is additionally connected to the load-bearing layer by means of retaining anchors.

- **CAVITY ANCHORS**

The retaining anchors carry the normal forces caused by wind, adhesion to formwork and deformation, etc.

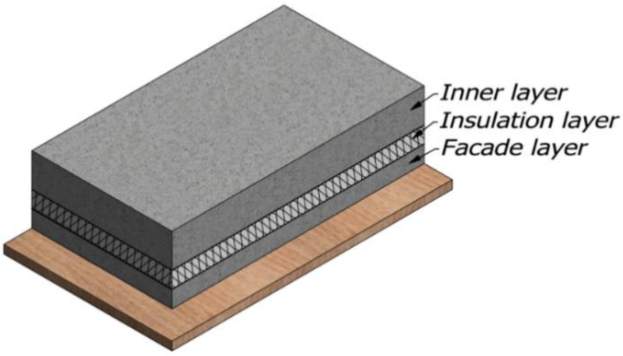
Quality
Terwa continuously monitors the production process of the anchors for strength, dimensions and material quality and carries out all required inspections in order to guarantee a system of superior quality. All products are traceable from the procurement of raw materials through to the finished product ready for use.

Marking and traceability
All TFA and TMA sandwich panel anchors are provided with all necessary information for traceability, product identification, material quality and date of manufacture.

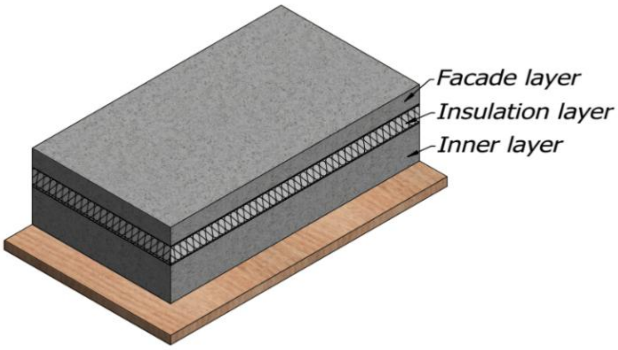


TECHNICAL CONSIDERATIONS – SANDWICH PANEL PRODUCTION METHODS

In principle, there are two production methods:
- The negative process: facade layer facing downwards (standard).
- The positive process: facade layer facing upwards.



Negative process



Positive process

FACADE LAYER FACING DOWNWARDS: NEGATIVE PRODUCTION METHOD

Production of facade layer:

Reinforcement is placed in the formwork.
- It is recommended that the tie anchor be installed on the reinforcement in accordance with the instructions.
- Concrete is evenly poured into the formwork.
- The concrete is compacted using concrete vibrators.

Installation of insulation layer

The insulation layer shall be fully installed in the area around the anchor. The insulation layer may be pressed onto the anchor until the anchor penetrates the insulation material. When using highly compressed insulation material (hard polystyrene or expanded polystyrene foam), pre-cuts shall be made so that the insulation layer can be properly installed. No voids or gaps shall be present in the insulation layer. During casting of the second layer, these voids would be filled with concrete, resulting in thermal bridges and weak points.
It is recommended to install the insulation layer in two layers with staggered joints. If a single insulation layer is used, the joints shall be rebated or sealed with tape. This prevents concrete from penetrating the joints.

Installation of separation foil

A separation foil may be used to prevent concrete from entering the butt joints of the insulation layer. At the same time, it prevents the insulation material from bonding to the load-bearing inner layer. This is important when rough expanded polystyrene is used as insulation material. A foil between the facade layer and the insulation layer ensures adequate flexibility of the facade layer, allowing proper thermal expansion and contraction. If a high-quality insulation material with a smooth surface is used, this foil is not required.

Production of inner layer

Place the reinforcement mesh and the additional reinforcement bars through the anchor holes in the sandwich panel.
Recommendation: use compressive-strength insulation material that can be walked on, which facilitates installation of the reinforcement.

FACADE LAYER FACING UPWARDS: POSITIVE PRODUCTION METHOD

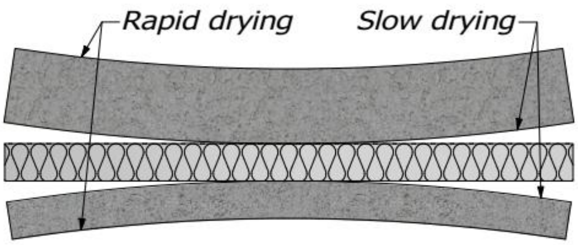
This method is identical to the method described above, but carried out in reverse order.

STRUCTURAL ADVICE

DEFORMATION OF SANDWICH PANELS

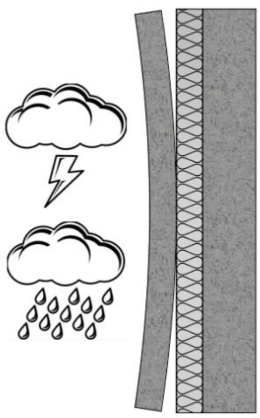
Shrinkage of sandwich panel systems

Deformations caused by the curing of concrete may affect panels longer than 6 metres. The curing process progresses from the outside inwards. The inner layer and the facade layer of the sandwich element may bow in opposite directions. Deformation occurs most frequently in sandwich panels that are exposed to direct sunlight and wind during the first few days after production. In order to prevent the concrete from drying too quickly, appropriate measures are recommended, such as the use of insulation with low water absorption. It is recommended to produce the concrete using appropriate technology to reduce shrinkage (i.e. by using admixtures, a low water–cement ratio and the maximum aggregate size suitable for the dimensions of the reinforcement and the sandwich panels).

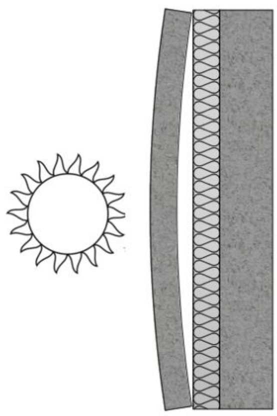


Deformation due to temperature differences

Significant temperature differences between the facade layer and the inner layer may lead to deformation of the facade layer. Deformation due to temperature differences includes either expansion caused by exposure to direct sunlight in winter or contraction caused by a sudden drop in temperature in summer.



Sudden drop in temperature in summer



Sudden rise in temperature in winter

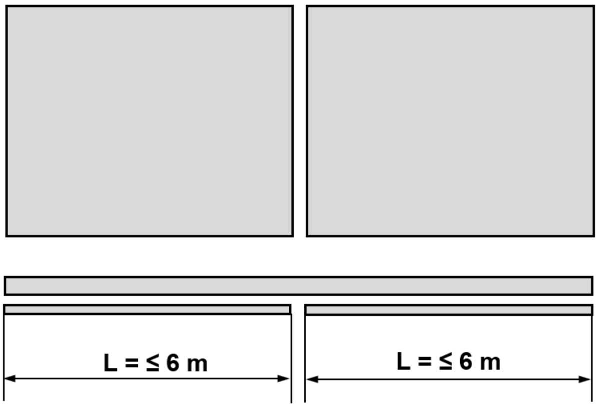
Factors influencing the deformation forces include:
- temperature variations in the facade layer
- the shape and thickness of the facade layer
- the concrete quality
- the type and arrangement (grid) of the sandwich panel anchors

The deformation forces due to temperature differences can be significantly reduced by:
- using a light-coloured facade layer
- using a thin facade layer ***d = 70–80 mm***
- properly distributing the anchors (cavity anchors in a ratio of 1:1)

Installation of windows and doors
When the connection between the facade layer and the inner layer is flexible, cracking can be prevented. In order to achieve this flexibility, window and door elements shall be structurally connected to the inner layer only.

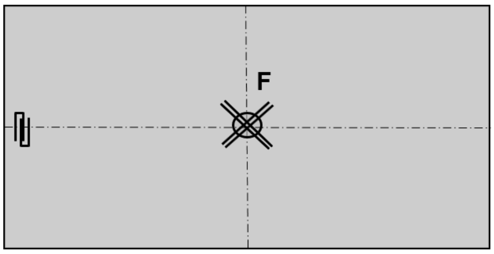
DIMENSIONING OF SANDWICH PANELS

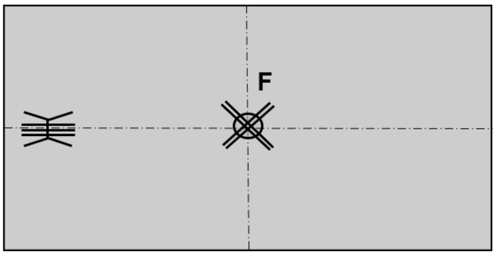
In principle, large sandwich panels longer than 6 metres should be avoided. If an element exceeds 6 metres in length, the risk of cracking increases, particularly in the case of thinner panels.
In general, the recommended maximum length is 7.5 metres.
If longer panels are required for architectural or structural reasons, it is recommended to divide the facade layer by means of an expansion joint, while the inner layer is constructed as a single continuous element.



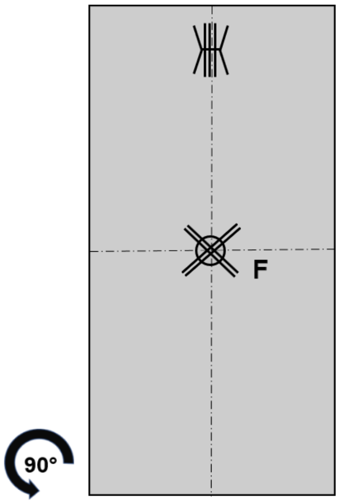
ANCHORAGE CENTRE (FULCRUM)

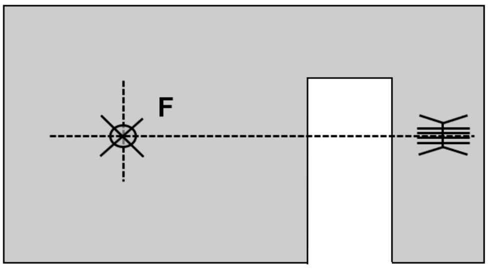
The anchorage centre ‘F’ is the anchor point from which all lateral movements of the facade layer originate.
In the most common scenario, the anchorage centre coincides with the centre of gravity.
In systems with a sleeve anchor (TMA) as tie anchor, the anchorage centre is always located at the same position as the TMA. As a torsion anchor, a double crossed TVH pin or a single TFA plate anchor may be used.





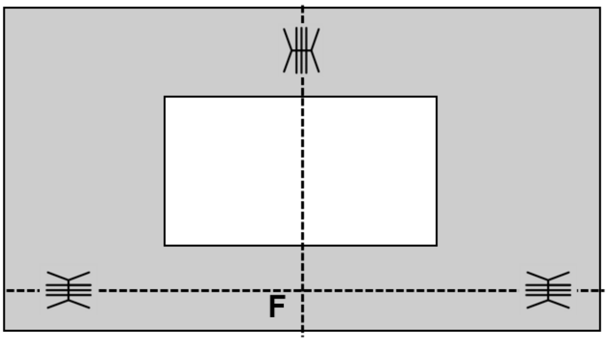
For sandwich panels that are rotated during transport, the same system is used: one sleeve anchor and one torsion anchor.

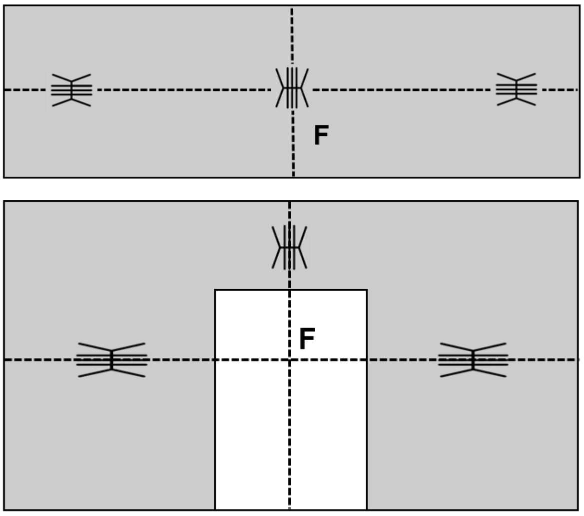




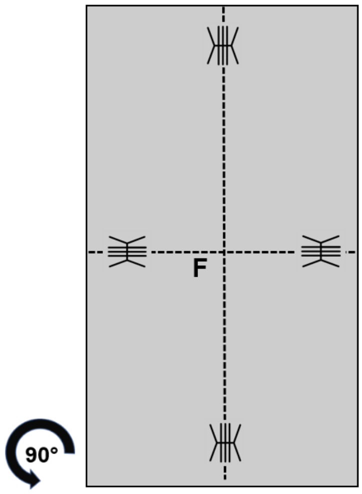
In tie systems consisting of TFA plate anchors, at least two of these are used as tie anchors and one as a horizontal anchor. These anchors are positioned on two axes perpendicular to each other. The anchorage centre is always located at the intersection of these axes.

TFA – TFA anchor arrangement

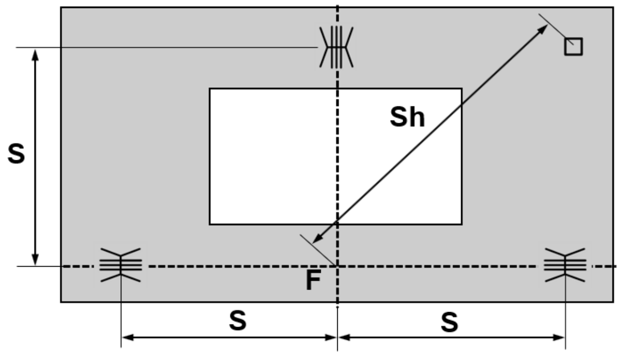




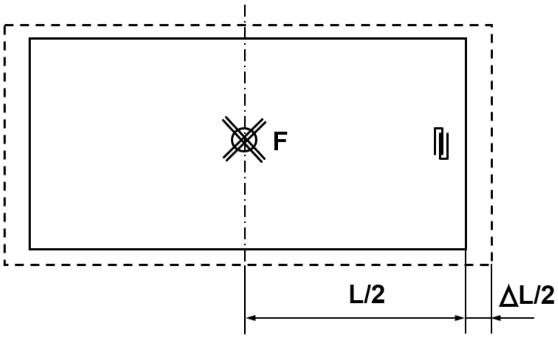
TFA – TFA anchor arrangement for panels that are rotated during transport



Important! When positioning the TFA, TVH, TVA or TVB sandwich panel anchors, account shall be taken of the permissible distances 'S' and 'Sh' from the anchorage centre.



The change in length **ΔL** due to temperature effects increases as the distance from the anchorage centre (fulcrum) increases. In order to maintain a minimum value for **ΔL**, the anchorage centre may be located at the centre of the panel.
The stiffness of the anchorage (tie anchors and retaining anchors) prevents the sandwich panel from deforming. The resulting restraining forces acting against the panel may cause damage. These restraining forces can be reduced by using a greater insulation layer thickness, thereby allowing greater mobility of the connecting anchors. The maximum permissible distances of the anchors from the anchorage centre therefore depend on the thickness of the insulation layer.



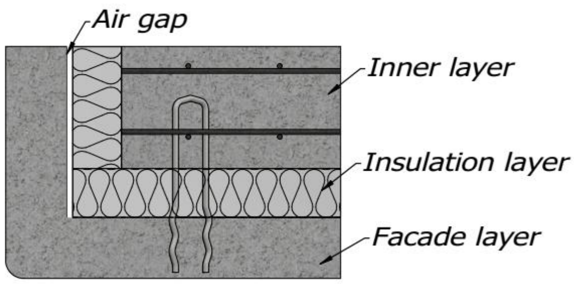
THERMAL INSULATION LAYER

It is recommended that the insulation layer be made of highly compressed material with low thermal conductivity. The material shall have a smooth surface with minimal adhesion between the concrete and the insulation. Extruded rigid polystyrene boards are recommended in this case. If the surface of the insulation material is rough, the use of a separation foil between the concrete and the insulation layer is recommended. In order to prevent thermal bridges, the insulation layer shall be installed in two staggered layers. An alternative solution is to seal the joints by taping.

STRUCTURAL SOLUTIONS FOR CORNERS

If the sandwich panel turns the corner at the edge of a building, the following points shall be taken into account:

- An air cavity shall be created in the area where the facade layer turns the corner.
- Alternatively, a material made of a soft fibre, such as mineral wool, may be used in that area.
- Hairpin anchors (cavity anchors) shall not be used in the sharp corner section of the facade layer.



INNER LAYER: LOAD-BEARING LAYER

The inner layer is stiffer than the facade layer and transfers deformation to the facade layer. In order to minimise these deformations, the load-bearing inner layer shall be at least 50% thicker than the facade layer.

OUTER LAYER: FACADE LAYER

In accordance with EN 1992-1-1, the facade layer shall have a minimum thickness of 70 mm. For TMA and TFA anchors, a minimum reinforcement of 188 mm²/m applies. The tables indicate the additional reinforcement required in the sandwich anchor zone in the facade layer.

CONCRETE QUALITY

The permissible load-bearing capacities for sandwich panel anchorage indicated in the tables are based on a minimum concrete quality of C30/37.

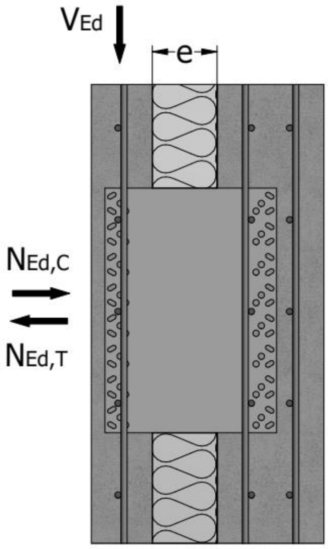
SANDWICH PANEL WITH ADDITIONAL LAYER FOR VENTILATION

In four-layer sandwich panels, an additional air layer of 40 mm is provided between the outer layer and the insulation layer in order to prevent condensation problems. For this purpose, a special PVC foil may be used. This foil is placed on the outer concrete layer during production of the sandwich panel (with the studs facing upwards). The foil shall be provided with openings at the supporting and torsion anchors. The insulation material is then installed and the inner layer can be cast.
Important: for four-layer panels, it shall be taken into account that the permissible load-bearing capacity of the sleeve anchors is reduced.

CALCULATION OF SANDWICH PANEL ANCHORS

BASIC INFORMATION

The design values of the load-bearing capacities V_{Rd}, N_{Rd} and M_{Rd} are resistance values in which the partial safety factor has been taken into account. The resistance values V_{Rd}, N_{Rd} and M_{Rd} shall be compared with the design actions increased by the partial safety coefficient: V_{Ed} (vertical loads: self-weight of the facade layer and other applicable loads), N_{Ed} (horizontal load: wind load and deformation) and M_{Ed} (only for TFA anchors), as described in the relevant approval. The horizontal loads depend on the panel geometry, the grid spacing and the anchor positions.



Design loads

- ***Vertical load:*** the load exerting a vertical force shall be taken as the self-weight of the facade layer, plus any other applicable loads.

- ***Deformation loads:*** several factors influence deformation, such as anchor arrangement in a grid with a side ratio of 0.75 ≤ l_x/l_y ≤ 1.33, facade layer thickness (70–120 mm) and thermal actions.
  In the Terwa sandwich calculation software, the heat transfer coefficient is calculated in accordance with NEN-EN-ISO 13789.
  The direction of heat flow is assumed by default to be horizontal for heat transfer coefficients of reinforced concrete with one or two layers and high-quality insulation.

- ***Wind loads:*** in accordance with EN 1991-1-4 and the National Annexes.
  A sandwich panel with an anchor grid of maximum 1.20 m × 1.20 m is assumed.
  For the wind loads calculated in the table [kN/m^2], the following assumptions have been used:
  - dynamic pressure for a building height up to 30 m
  - inland regions and wind zones I, II and III – Netherlands
  - urban region and rural region

  The standard wind loads in the calculation software are based on a building with a height ≤ 20 m in an urban region in wind zone II (1.12, –1.23).

Building height	Wind zone I		Wind zone II		Wind zone III	
	Urban region	Rural region	Urban region	Rural region	Urban region	Rural region
≤ 10 m	0.95	1.39	0.80	1.16	0.66	0.96
	-1.05	-1.94	-0.88	-1.63	-0.73	-1.34
≤ 20 m	1.34	1.77	**1.12**	1.49	0.92	1.22
	-1.47	-2.48	**-1.23**	-2.08	-1.01	-1.71
≤ 30 m	1.58	2.01	1.32	1.69	1.09	1.39
	-1.74	-2.82	-1.46	-2.36	-1.20	-1.94

- ***Distance of the anchor from the anchorage centre (fulcrum):*** the permissible distances depend on a number of factors, namely the thickness of the thermal insulation and the thermal load.

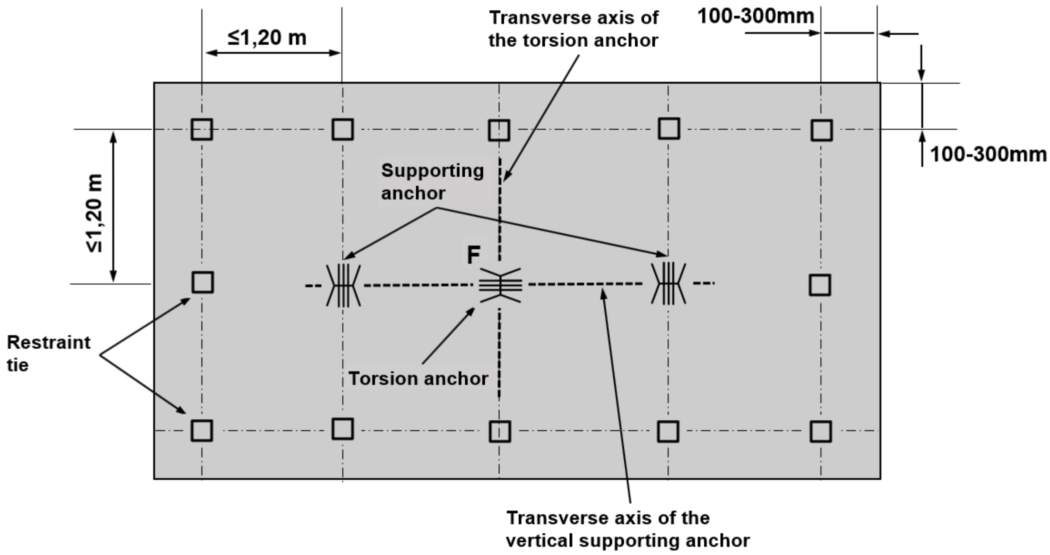
EXPLANATION OF SYMBOLS

H: Height of the sandwich anchor.
L: Length of the sandwich anchor.
a_f: Anchorage length of a sandwich panel anchor in the facade layer.
a_i: Anchorage length of a sandwich panel anchor in the inner layer.
f: Thickness of the facade layer.
e: Thickness of the insulation layer.
F: Anchorage centre (fulcrum).

S_x, S_y: Horizontal and vertical coordinates of the centre of gravity.
s_h: Distance between the cavity anchors and the anchorage centre (fulcrum).
s: Distance between the supporting anchor and the anchorage centre (fulcrum).
V_{Ed}: Shear load acting on the sandwich panel anchor.
V_{adm}: Permissible shear load acting on the sandwich panel anchor.
N_{Ed}: Normal force acting on the sandwich panel anchor.
G: Net weight of the facade layer.

TIE SYSTEMS FOR SANDWICH PANELS

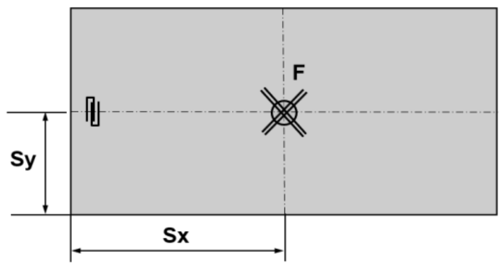
RULES FOR POSITIONING TMA AND TFA SANDWICH ANCHORS



The transfer of load from the facade layer through the insulation layer to the load-bearing inner layer is clarified below for a number of tie systems.

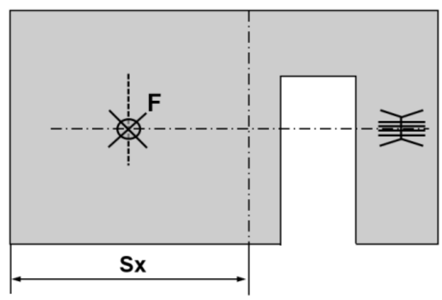
SUPPORTING SYSTEM: CENTRAL SLEEVE ANCHOR ‘TMA’

This system consists of a sleeve anchor used as a tie anchor, positioned at the anchorage centre (fulcrum). Two crossed TVH cavity anchors are used as torsion anchors. In this configuration, the element can be rotated during transport without the need for additional anchors. Alternatively, a TFA anchor may also be used as a torsion anchor.
Application: rectangular sandwich panels without openings.

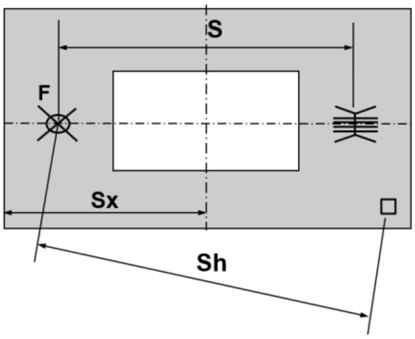


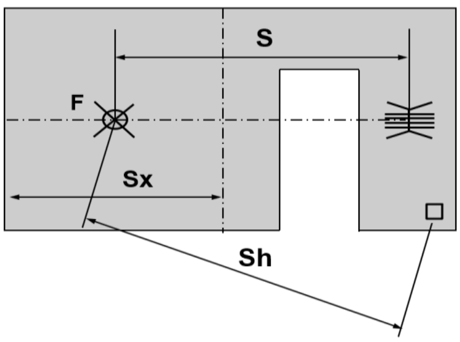
SUPPORTING SYSTEM: SLEEVE ANCHOR ‘TMA’ AND PLATE ANCHOR ‘TFA’

This system consists of two anchors: a TMA sleeve anchor and a TFA plate anchor used as tie anchors. This system is suitable for an asymmetrical load distribution. The TMA sleeve anchor carries the greater load.
Application: large rectangular sandwich panel with a heavy outer layer or rectangular panels with openings.



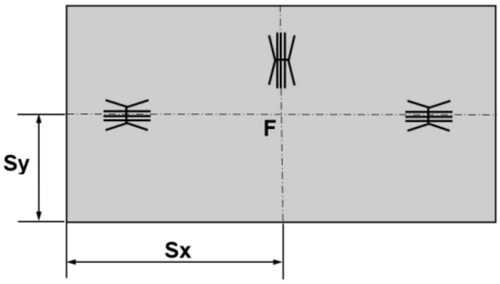
Window or door openings may prevent the anchorage centre from being positioned at the centre of the sandwich panel. The maximum distance between the anchors and the anchorage centre is determined by the permissible deformation of the anchors. In order to determine which tie system and anchorage components shall be used, the stated maximum distances from the anchorage centre for the retaining anchors (**S_h**) and plate anchors (**S**) shall not be exceeded.
The values for '**S_h**' and '**S**' may be increased by installing an additional strip of insulation material in the area of the retaining anchor or plate anchor.



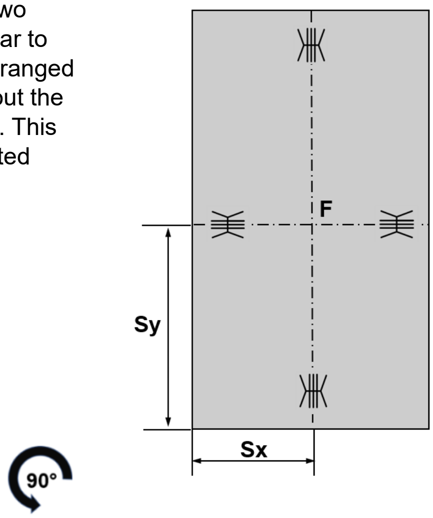


SUPPORTING SYSTEM: PLATE ANCHOR 'TFA' IN PANELS WITHOUT OPENINGS

Two TFA plate anchors used as tie anchors (to avoid confusion, plate anchors from the same load range shall be used in the case of an asymmetrical load distribution). Use one plate anchor positioned horizontally for stiffening.
Application: long, thin, rectangular sandwich panels.

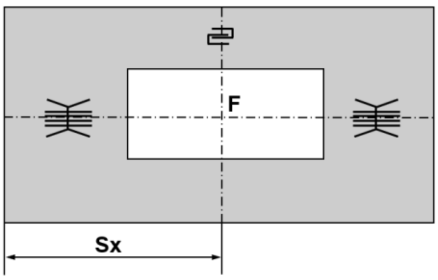


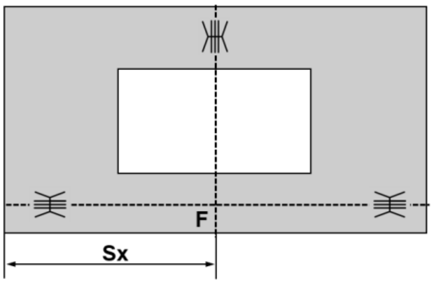
Sandwich panels with TFA anchors on two axes, perpendicular to each other and arranged symmetrically about the anchorage centre. This panel can be rotated during transport.

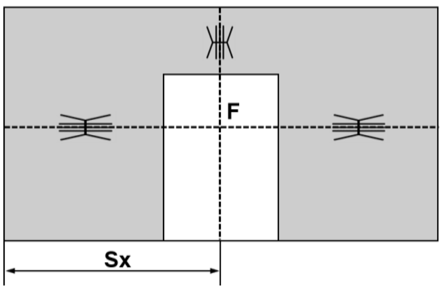


SUPPORTING SYSTEM: PLATE ANCHOR 'TFA' IN PANELS WITH OPENINGS

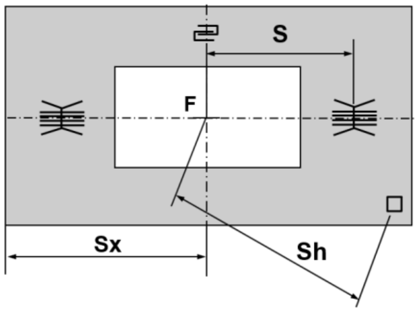
Two TFA plate anchors are used as tie anchors and two crossed TVH cavity anchors are used as torsion anchors. These anchors are positioned on two axes perpendicular to each other. The anchorage centre is always located at the intersection of these axes. Note: for thin insulation layers, the distance '**S**' between the plate anchor and the anchorage centre shall be checked.
Application: sandwich panels with large openings in the centre.

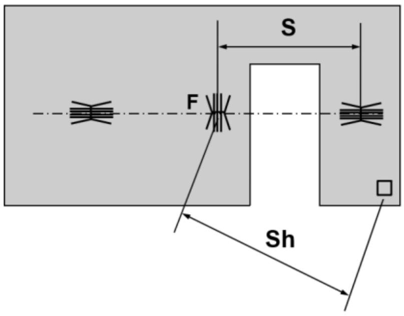


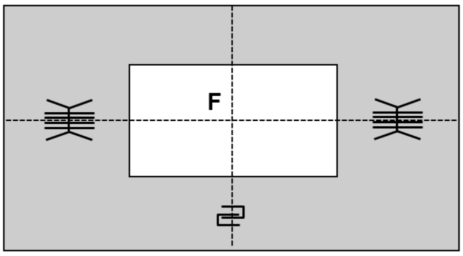
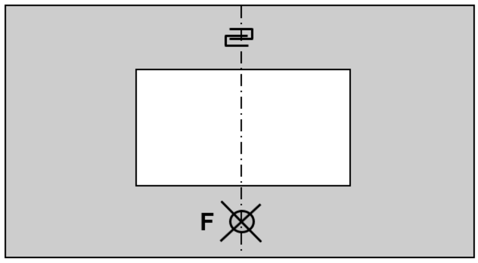
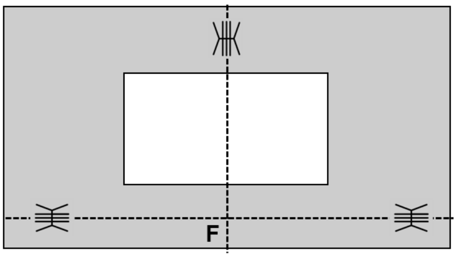
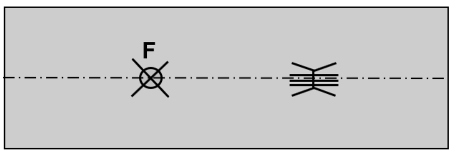
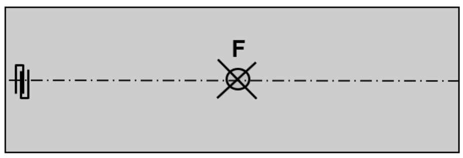




For low-height elements and balustrade panels, load transfer shall not take place via a single tie anchor.
By using an alternative supporting system, the anchorage centre can be moved towards the centre of the panel and the values for '**S_h**' and '**S**' can be reduced.

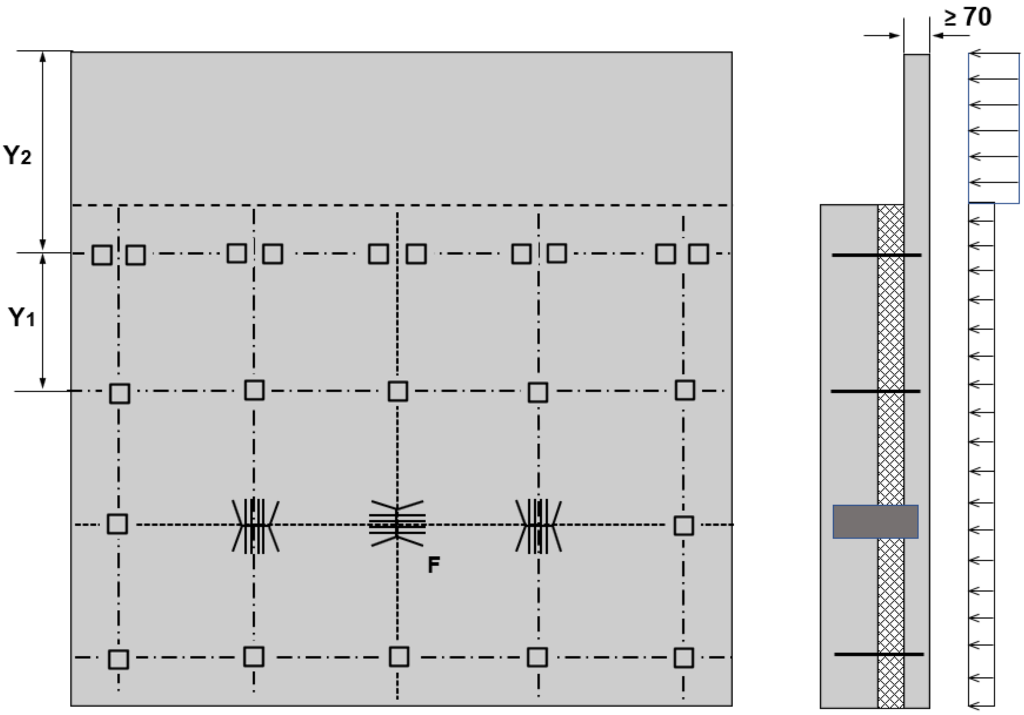




<table>
<tr><th>CORRECT</th><th>INCORRECT</th></tr>
<tr><td>Load transfer using two tie anchors</td><td>Load distribution using one tie anchor with a high risk of cracking</td></tr>
<tr><td>
✓</td><td rowspan="2">
✗</td></tr>
<tr><td>
✓</td></tr>
<tr><th>CORRECT</th><th>INCORRECT</th></tr>
<tr><td>Load transfer using two tie anchors</td><td>Load distribution using one tie anchor with a high risk of cracking</td></tr>
<tr><td>
✓</td><td>
This solution is not permitted for panels longer than 3000 mm.
✗</td></tr>
</table>

Large tensile forces transferred via a single tie anchor may lead to a high risk of cracking. It is recommended to use two tie anchors.
Where necessary, the supporting system shall be modified or an additional insulation strip shall be installed in the area of the anchors. When calculating a sandwich panel anchorage system, the weight and the position of the centre of gravity shall first be determined. The supporting system can then be selected. In the next step, the permissible loads per anchor are determined and, on this basis, the required anchor types are selected from the tables.

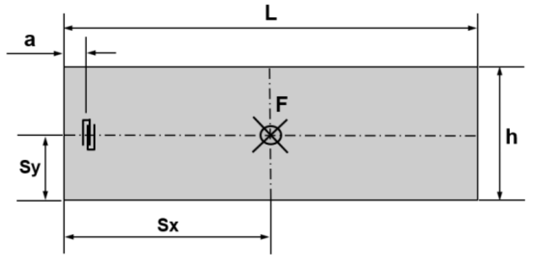
FACADE LAYERS WITH A LARGE OVERHANG

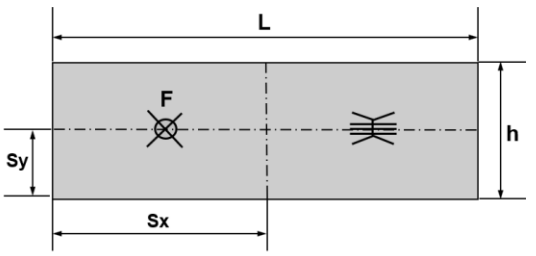


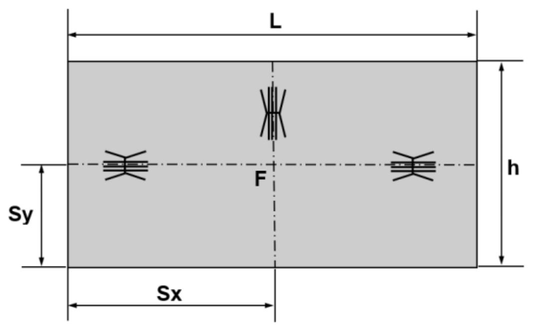
The significant projection (‘Y_2’ = 300–900 mm) of the facade layer results in high loads at the upper row of cavity anchors due to wind actions. The wind causes deformation of the facade layer around the area where the upper cavity anchors are located. In order to accommodate these forces, two wire anchors shall be installed at each grid point, at a reduced distance ‘Y_1’ from the adjacent row.

BASIC CALCULATIONS: STATIC MODELS

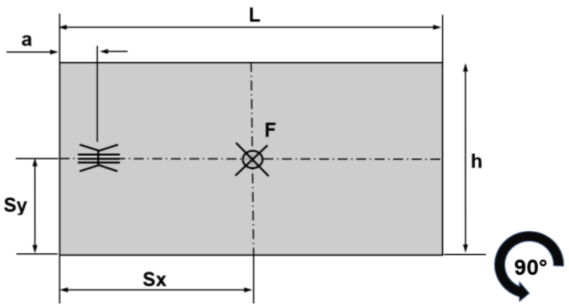
1) **Without rotating the element**

Calculation of the load for supporting anchors and torsion anchors		
	Supporting anchor – TMA	$V_{Ed} = L\ x\ h\ x\ f\ x\ 25\frac{kN}{m^3}x\ 1.35$
	Torsion anchor – TVH crossed pin	$V_{Ed,torsion} = \frac{0.05\ x\ L}{0.45\ x\ L - a}(L\ x\ h\ x\ f\ x\ 25\frac{kN}{m^3}\ x\ 1.35)$

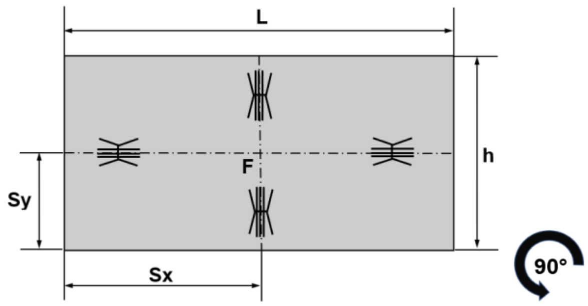
	Supporting anchor – TMA Supporting anchor – TFA	$V_{Ed} = (L\ x\ h\ x\ f\ x\ 25\frac{kN}{m^3}x\ 1.35)/2$
		No torsion anchor required

	Supporting anchor – TFA Supporting anchor – TFA	$V_{Ed} = (L\ x\ h\ x\ f\ x\ 25\frac{kN}{m^3}x\ 1.35)/2$
	Horizontal anchor – TFA	$V_{Ed,horizontal} = 0.1\ x\ (L\ x\ h\ x\ f\ x\ 25\frac{kN}{m^3}x\ 1.35)$

2) **With rotation of the element**



Rotation of the elements with one supporting anchor and one torsion anchor



Rotation of the elements with the supporting anchors arranged on both axes

Compare the loads calculated on the basis of the net weight of the facade layer with the design resistances; see tables.

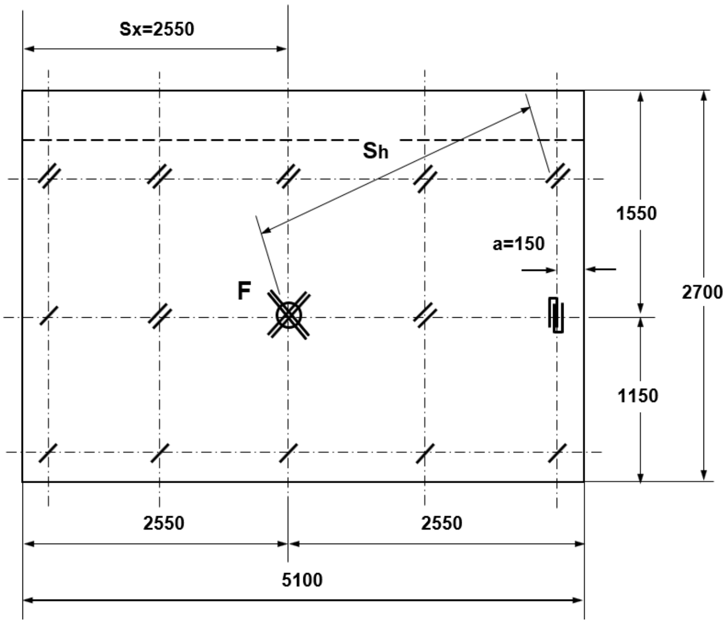
$$V_{Ed} \leq Vadm$$

V_{Ed}: Shear load acting on the sandwich panel anchor.
V_{adm} : Permissible shear load acting on the sandwich panel anchor.

Where:
L: Length of the facade layer
H: Height of the facade layer
f: Thickness of the facade layer
a: Distance between the torsion anchor and the edge
Sx, Sy: Horizontal and vertical coordinates of the centre of gravity

CALCULATION EXAMPLES

EXAMPLE 1 – SANDWICH PANEL WITHOUT OPENINGS



Dimensions of sandwich panel:

Length L = 5.1 m; height h = 2.7 m.
Facade layer thickness f = 70 mm
Insulation layer thickness e = 60 mm
Height of inner layer = 2.2 m

Weight of outer layer:

$$G = 5.1\,m\,x\,2.7\,m\,x\,0.07m\,x\,25\frac{kN}{m^3} = 24.1\,kN$$

$$Sx = \frac{5,1m}{2} = 2.55\,m$$

SPECIFICATION OF ANCHORING SYSTEM:

Tie anchor: sleeve anchor TMA.
Load on the anchor = weight of outer layer 24.1 kN × 1.35
$V_{Ed} = G\ x\ 1.35 = 24.1\ x\ 1.35 = 32.54\ kN$
Table 5 indicates the required anchor diameter depending on the insulation layer thickness of 60 mm and the permissible load 38.1 kN > 32.54 kN, which results in a TMA anchor with D = 153 mm.
Table 2 gives the anchor height H = 175 mm (e = 60 mm; f = 70 mm).
The anchorage bars are selected from Table 4 according to anchor diameter D = 153 mm, namely 2 × 4 bars with a diameter of 6 mm and a length of 700 mm.
According to Table 1, the designated TMA anchor is TMA–1.5–175–153 (e.g. product no. 43419).
Required torsion anchor in accordance with Table 30.

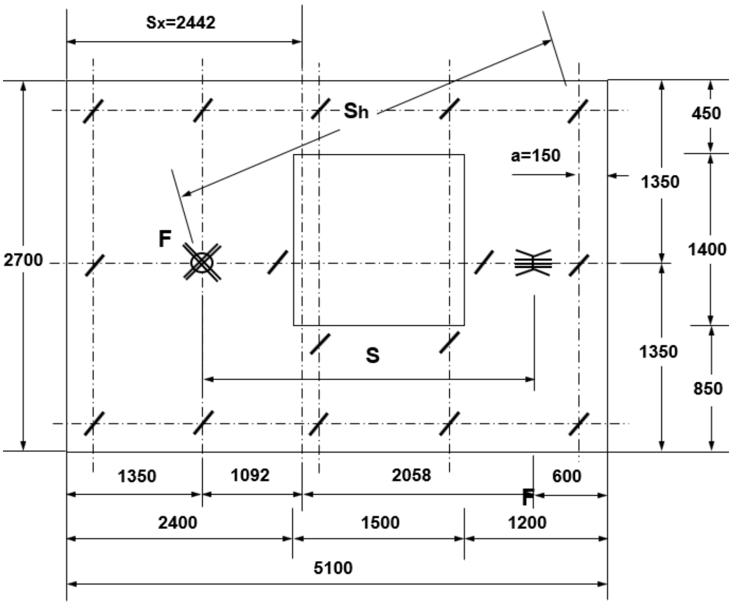
$$V_{Ed,torsion} = \frac{0.05\ x\ L}{0.45\ x\ L - a}\ x\ G\ x\ 1.35 = \frac{0.05\ x\ 5.1}{0.45\ x\ 5.1 - 0.15}\ x\ 24.1\ x\ 1.35 = 3.87\ kN$$

For e = 60 mm, f = 70 mm, and a permissible load V_{adm} = 6.3 kN > 3.87 kN, the result is two crossed TVH anchors of 5.0 mm with L = 250 mm.
The cavity anchors are straight TVH hairpin anchors.
Since the inner layer is shorter in height than the outer layer (2.7 m – 2.2 m = 0.5 m > 0.2 m) in the upper row, the tie anchors shall be doubled.
Table 23 specifies TVH anchor 3.0 – 180.
Check the distance to the anchorage centre ‘S_h’. S_h = 2.6 m< $S_{h\,max}$ = 4 m (Table 23).
20 TVH anchors are required.
Conclusion: the anchoring system for this sandwich panel without openings consists of:

Table 31

Anchoring system	Quantity	Anchor type
Supporting anchor	1	TMA – 1.5 - 175 - 153
Torsion anchors	2	TVH – 5.0 – 250
Cavity anchors	20	TVH – 3.0 - 180

EXAMPLE 2 – SANDWICH PANEL WITH A WINDOW OPENING



Dimensions of sandwich panel:

Length L = 5.1 m; height h = 2.7 m,
Facade layer thickness f = 70 mm
Insulation layer thickness e = 60 mm
Dimensions of opening: l_d= 1.5 m; h_d = 1.4 m

$A = 5.1m \, x \, 2.7 \, m = 13.77 \, m^2$; $Ad = 1.5m \, x \, 1.4m = 2.1m^2$

Weight of outer layer:

$$G = (13{,}77m^2 - 2{,}1m^2) \, x \, 0.07 \, m \, x \, 25 \frac{kN}{m^3} = 20.4 \, kN$$

$$Sx = \frac{\left[13{,}77 \, x \frac{5{,}1}{2} - 2.1 \, x \left(2.4 + \frac{1{,}5}{2}\right)\right]}{13{,}77 - 2{,}1} = 2.442 \, m$$

SPECIFICATION OF ANCHORING SYSTEM:

Tie anchors: one TMA sleeve anchor and one TFA plate anchor.
The TMA anchor is positioned on the left at a distance from the edge x = 1.35 m. The TFA anchor is positioned on the right at x = 4.5 m.

Load on the TMA anchor $V_{Ed} = 20.4 \, x \frac{(4.5-2.442)}{4.5-1.35} \, x \, 1.35 = 17.99 \, kN$

Load on the TFA anchor $V_{Ed} = 20.4 \, x \frac{2.442-1.35}{4.5-1.35} x \, 1.35 = 9.54 \, kN$

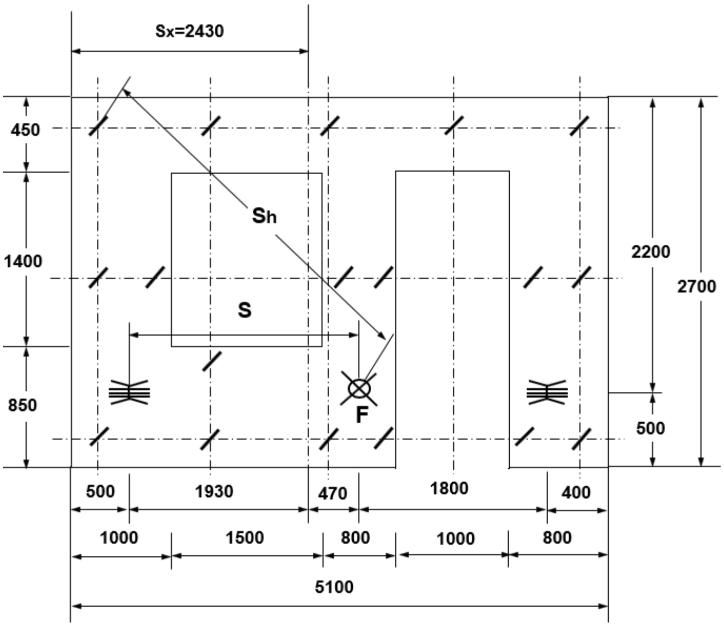
Tie anchor on the left: sleeve anchor TMA.
Table 5 indicates the required anchor diameter depending on the insulation layer thickness of 60 mm and the permissible load 18.9 kN > 17.99 kN, which results in a TMA anchor with D = 76 mm.
Table 2 gives the anchor height H = 175 mm (e = 60 mm; f = 70 mm).
The anchorage bars are selected from Table 4 according to anchor diameter D = 76 mm, namely 2 × 2 bars with a diameter of 6 mm and a length of 500 mm.
According to Table 1, the designated TMA anchor is TMA–1.5–175–76 (e.g. product no. 43416).

Tie anchor on the right: plate anchor TFA.
Table 15 indicates the required anchor length depending on the insulation layer thickness of 60 mm and the permissible load 10.0 kN > 9.54 kN, which results in a TFA anchor with t = 1.5 mm and L = 120 mm.
Table 13 gives the anchor height H = 175 mm (e = 60 mm; f = 70 mm).
The anchorage bars are selected from Table 14 according to length L = 120 mm, namely 2 × 5 bars with a diameter of 6 mm and a length of 400 mm.
Check the distance between the TFA anchor and the anchorage centre F.
The cavity anchors are straight TVH hairpin anchors.
Table 23 specifies TVH anchor 3.0 – 180.
Check the distance to the anchorage centre 'S_h'. S_h = 3.795 m< $S_{h \, max}$ = 4 m
16 TVH anchors are required.
Conclusion: the anchoring system for this sandwich panel with a window opening consists of (Table 32):

Table 32

Anchoring system	Quantity	Anchor type
Supporting anchor – left	1	TMA – 1.5 - 175 - 76
Supporting anchor – right	1	TFA – 1.5 - 175 - 120
Cavity anchors	16	TVH – 3.0 - 180

EXAMPLE 3 – SANDWICH PANEL WITH TWO OPENINGS FOR WINDOW AND DOOR



Dimensions of sandwich panel:
Length L = 5.1 m; height h = 2.7 m.
Facade layer thickness f = 70 mm
Insulation layer thickness e = 60 mm
Dimensions of window: l_d*= 1.5 m;* h_d *= 1.4 m*
Dimensions of door: l_u*= 1.0 m;* h_u*= 2.25 m*

$A = 5.1m\ x\ 2,7\ m = 13.77\ m^2$; $Ad = 1.5\ m\ x\ 1,4\ m = 2.1m^2$; $Au = 1.0\ m\ x\ 2,25\ m = 2.25\ m^2$

Weight of the facade layer:

$G = (13,77\ m^2 - 2,1\ m^2 - 2,25\ m^2)x\ 0.07mx\ 25\frac{kN}{m^3} = 16.5\ kN$

$Sx = \frac{\left[13,77\ x\ \frac{5,1}{2} - 2.1\ x\left(1.0+\frac{1,5}{2}\right) - 2.25\ x\left(3.3+\frac{1,0}{2}\right)\right]}{13,77-2,1-2,25} = 2.43\ m$

SPECIFICATION OF ANCHORING SYSTEM:

Tie anchors: one TFA plate anchor and one TMA sleeve anchor.
The TFA anchor is positioned on the left at a distance from the edge x = 0.5 m. The TMA anchor is positioned on the right at x = 2.9 m.

Load-bearing capacity of the TFA anchor $V_{Ed} = 16.5\ x\ \frac{2.9-2.43}{2.9-0.5}\ x\ 1.35 = 4.36\ kN$

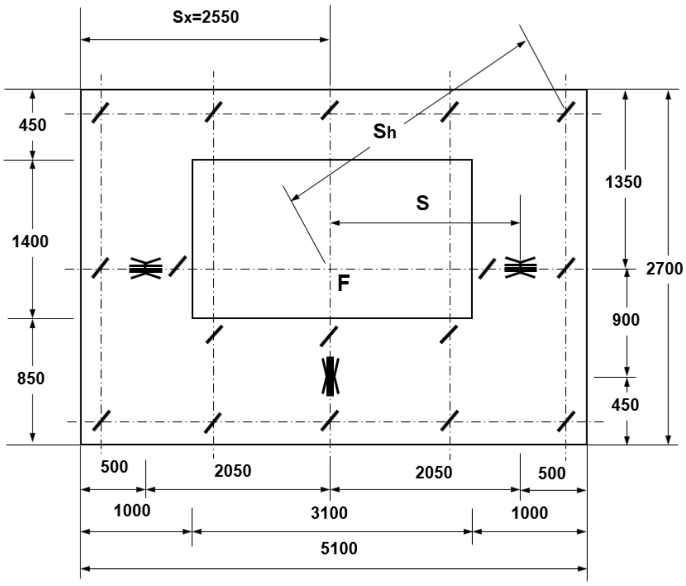
Load-bearing capacity of the TFA anchor $V_{Ed} = 16.5\ x\frac{2.43-0.5}{2.9-0.5}\ x\ 1.35 = 17.91\ kN$

Tie anchor on the left: TMA sleeve anchor.
Table 15 indicates the required anchor length depending on the insulation layer thickness of 60 mm and the permissible load 6.1 kN > 4.36 kN, which results in a TFA anchor with t = 1.5 mm and L = 80 mm.
Table 13 gives the anchor height H = 175 mm (e = 60 mm; f = 70 mm).
The anchorage bars are selected according to length L = 80 mm, namely 2 × 4 bars with a diameter of 6 mm and a length of 400 mm.
Check the distance between the TFA anchor and the anchorage centre F.
Tie anchor on the right: a TMA plate anchor.
Table 5 indicates the required anchor diameter depending on the insulation layer thickness of 60 mm and the permissible load 18.9 kN > 17.91 kN, which results in a TMA anchor with D = 76 mm and t = 1.5 mm.
Table 2 gives the anchor height H = 175 mm (e = 60 mm, f = 70 mm).
The anchorage bars are selected from Table 4 according to anchor diameter D = 76 mm, namely 2 × 2 bars with a diameter of 6 mm and a length of 500 mm.
According to Table 1, the designated TMA anchor is TMA–1.5–175–76 (e.g. product no. 43416).
NOTE: in order to prevent cracking around the door opening, an additional plate anchor shall be installed on the right-hand side of the door opening.
The cavity anchors are straight TVH hairpin anchors.
Table 23 specifies TVH anchor 3.0 – 180.
Check the distance to the anchorage centre 'S_h':S_h = 3.41 m< $S_{h\ max}$ = 4 m (Table 23).
18 TVH anchors are required.
Conclusion: the anchoring system for this sandwich panel with two openings for window and door – Table 33 – consists of:

Table 33

Anchoring system	Quantity	Anchor type
Supporting anchor – left	1	TFA – 1.5 - 175 - 80
Supporting anchor – right	1	TMA – 1.5 - 175 - 76
Supporting anchor – additional	1	TFA – 1.5 - 175 - 80
Cavity anchors	18	TVH – 3.0 - 180

EXAMPLE 4 – SANDWICH PANEL WITH A LARGE WINDOW OPENING



Dimensions of sandwich panel:

Length L = 5.1 m, height h = 2.7 m
Facade layer thickness f = 70 mm
Insulation layer thickness e = 60 mm
Dimensions of opening: l_d= 3.1 m; h_d= 1.4 m

$$A = 5.1m \; x \; 2.7 \; m = 13.77m^2; Ad = 3.1m \; x \; 1.4m = 4.34m^2$$

Weight of outer layer:

$$G = (13,77m^2 - 4,34m^2) \; x \; 0.07m \; x \; 25\frac{kN}{m^3} = 16.5 \; kN$$

$$Sx = \frac{\left[13,77 \; x\frac{5,1}{2} - 4.34 \; x \left(1.0 + \frac{3,1}{2}\right)\right]}{13,77 - 4,34} = 2.55 \; m$$

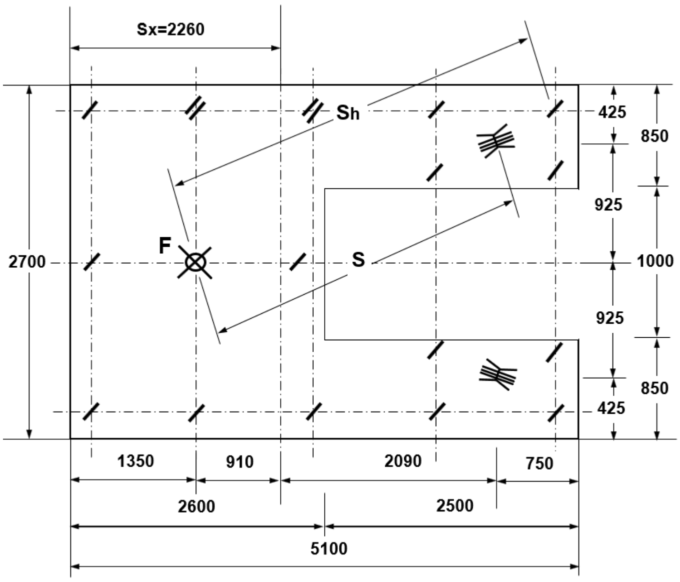
SPECIFICATION OF ANCHORING SYSTEM:

Tie anchors: two TFA anchors.
The TFA anchor is positioned on the left at a distance from the edge x = 0.5 m and the TFA anchor is positioned on the right at x = 4.6 m.
Load-bearing capacity of the left TFA anchor V_{Ed} = 165 $x \frac{(4.6-2.55)}{4.6-0.5}$ *x 1.35 = 11.14 kN*
Load-bearing capacity of the right TFA anchor V_{Ed} =165 $x \frac{(2.55-0.5)}{4.6-0.5}$ *x 1.35 = 11.14 kN*
Tie anchors: one TFA plate anchor on the left and one TFA plate anchor on the right.
Table 15 indicates the required anchor length depending on the insulation layer thickness of 60 mm and the permissible load 13.6 kN > 11.14 kN, which results in a TFA anchor with L = 120 mm and t = 2.0 mm.
Alternative: two TFA anchors with L = 160 mm and t = 1.5 mm with a permissible load 13.9 kN > 11.14 kN.
Table 13 gives the anchor height H = 175 mm (e = 60 mm; f = 70 mm).
The anchorage bars are selected from Table 15 according to anchor length L = 120 mm, namely 2 × 5 bars with a diameter of 6 mm and a length of 400 mm. If a TFA plate anchor with L = 160 mm is selected, the anchorage bars are: 2 × 6 bars with a diameter of 6 mm and a length of 400 mm.
According to Table 12, the designated TFA anchor is TMA–2.0–175–120 (e.g. product no. 44209).
Check the distance between the TFA anchor and the anchorage centre F in accordance with Table 19.
NOTE: according to the drawing, an additional TFA plate anchor is required to stiffen the supporting anchor. This anchor takes approximately 10% of the load on the other anchors, namely 2.23 kN.
Table 15 indicates the required anchor length depending on the insulation layer thickness of 60 mm and the permissible load 4.5 kN > 2.23 kN, which results in a TFA anchor with L = 80 mm and t = 1.5 mm.
Table 13 gives the anchor height H = 175 mm (e = 60 mm, f = 70 mm).
The anchorage bars are selected from Table 14 according to length L = 80 mm, namely 2 × 4 bars with a diameter of 6 mm and a length of 400 mm.
The cavity anchors are straight TVH hairpin anchors.
Table 23 specifies TVH 3.0 – 180.
Check the distance to the anchorage centre ‘S_h’. S_h = 2.68 m< $S_{h\ max}$ = 4 m (Table 23)
17 TVH anchors are required.
Conclusion: the anchoring system for this sandwich panel with a large window opening – Table 34 – consists of:

Table 34

Anchoring system	Quantity	Anchor type
Supporting anchor – left	1	TFA - 2.0 - 175 -120
Supporting anchor – right	1	TFA - 2.0 - 175 -120
Supporting anchor – additional	1	TFA – 1.5 - 175 - 80
Cavity anchors	17	TVH – 3.0 - 180

EXAMPLE 5 – SANDWICH PANEL WITH LARGE SIDE OPENING



Dimensions of sandwich panel:

Length L = 5.1 m, height h = 2.7 m
Facade layer thickness f = 70 mm
Insulation layer thickness e = 60 mm
Dimensions of opening: l_d = 2.5 m; h_d = 1.0 m

$\boldsymbol{A = 5.1m\,x\,2.7\,m = 13.77m^2}$; $\boldsymbol{Ad = 2.5m\,x\,1.0m = 2.5m}$

Weight of outer layer:

$$\boldsymbol{G = \left(13{,}77m^2 - 2{,}5m^2\right) x\,0.07m\,x\,25\frac{kN}{m^3} = 19.72\,kN}$$

$$Sx = \frac{\left[13{,}77\,x\frac{5{,}1}{2} - 2.5\,x\left(2.6 + \frac{2{,}5}{2}\right)\right]}{13{,}77 - 2{,}5} = 2.26\,m$$

SPECIFICATION OF ANCHORING SYSTEM:

Tie anchors: one TMA sleeve anchor and two TFA anchors.
One TFA anchor is positioned on the left at a distance from the edge x = 1.35 m; two TFA anchors are positioned on the right at x = 4.35 m.

Load-bearing capacity of the TMA anchor $V_{Ed} = 19.72\,x\,\frac{4.35-2.26}{4.35-1.35}\,x\,1.35 = 18.55\,kN$

Load-bearing capacity of the TFA anchors $V_{Ed} = 19.72\,x\,\frac{2.26-1.35}{4.35-1.35}\,x\,1.35 = 8.07\,kN$

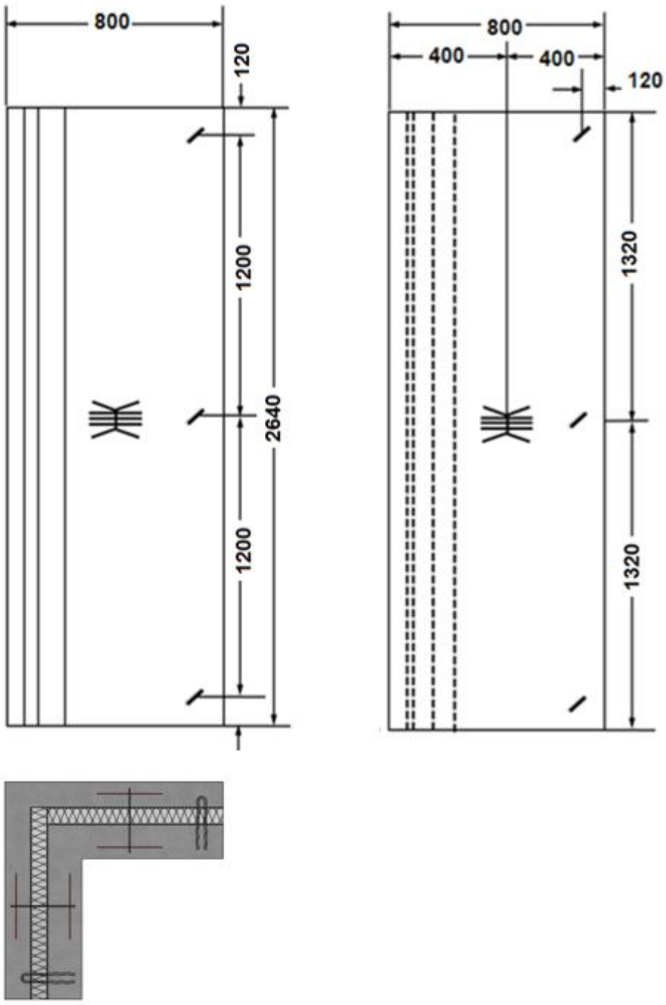
Tie anchor on the left: one TMA sleeve anchor.
Table 5 indicates the required anchor diameter depending on the insulation layer thickness of 60 mm and the permissible load 18.9 kN > 18.55 kN, which results in a TMA anchor with D = 76 mm.
Table 2 gives the anchor height H = 175 mm (e = 60 mm, f = 70 mm).
The anchorage bars are selected from Table 4 according to anchor diameter D = 76 mm, namely 2 × 2 bars with a diameter of 6 mm and a length of 500 mm.
According to Table 1, the designated TMA anchor is TMA–1.5–175–76 (e.g. product no. 43416).
Tie anchors on the right: two TFA plate anchors positioned at an angle α = atn(0.925/3) = 17,1° from the vertical. The load on one TFA anchor is: = 8.07/(2xcos17.1°) = 4.22 kN
Table 15 indicates the required anchor length depending on the insulation layer thickness of 60 mm and the permissible load 6.1 kN > 4.22 kN, which results in a TFA anchor with t = 1.5 mm and L = 80 mm.
Table 13 gives the anchor height H = 175 mm (e = 60 mm, f = 70 mm).
The anchorage bars are selected from Table 14 according to length L = 80 mm, namely 2 × 4 bars with a diameter of 6 mm and a length of 400 mm.
The cavity anchors are straight TVH hairpin anchors.
Table 23 specifies TVH 3.0 – 180.
Check the distance to the anchorage centre 'S_h'. S_h = 3.795 m< $S_{h\,max}$ = 4 m (Table 23)
18 TVH anchors are required.

Conclusion: the anchoring system for this sandwich panel with a large side opening – Table 35 – consists of:

Table 35

Anchoring system	Quantity	Anchor type
Supporting anchor – left	1	TMA – 1.5 - 175 - 76
Supporting anchor – right	2	TFA – 1. 5 - 175 - 80
Cavity anchors	18	TVH – 3.0 - 180

EXAMPLE 6 – ANCHORAGE OF A CORNER ELEMENT



Dimensions of sandwich panel:

Facade layer thickness f = 60 mm
Insulation layer thickness e = 50 mm

$$\boldsymbol{A = (0.8m + 0.74m)x\ 2.64m = 4.06m^2}$$

Weight of outer layer:

$$\boldsymbol{G = 4.06m^2\ x\ 0.06m\ x\ 25\frac{kN}{m^3} = 6.1\ kN}$$

SPECIFICATION OF ANCHORING SYSTEM:

Tie anchors: two TFA anchors.
A force acts on each anchor:

$$V_{Ed} = \frac{G}{2}\ x\ 1.35 = \frac{6,1}{2}\ x\ 1.35 = 4.12kN$$

Table 15 indicates the required anchor length depending on the insulation layer thickness of 50 mm and the permissible load 6.5 kN > 4.12 kN, which results in a TFA anchor with t = 1.5 mm and L = 80 mm.
Table 13 gives the anchor height H = 175 mm (e = 50 mm, f = 60 mm).
The anchorage bars are selected from Table 14 according to length L = 80 mm, namely 2 × 4 bars with a diameter of 6 mm and a length of 400 mm.

The cavity anchors are straight TVH hairpin anchors.
Table 23 specifies TVH anchor 3.0 – 160.
6 TVH anchors are required.