Ties and Connector Pins

Connectors for precast concrete sandwich panels

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Technical Manual

Ties and Connector Pins

Connectors for precast concrete sandwich panels

Benefits of Ties and Connector Pins

- Coverage of all thermal insulation thicknesses and materials for the future energy saving constructions
- Reliable, familiar connectors for precast concrete sandwich panels with over 50 years of usage experience
- Easy to install between insulation plates
- Benefits of stainless steel
- Sizes according to insulation thicknesses
- Beam Tie for low elements and openings
- Prefabricated products guarantee stable, high-quality, accurate deliveries
- Provides effective workflow for the customer
- Low maintenance, low life-cycle costs

Ties and Connector Pins are used to connect the inner and outer layers of precast concrete sandwich panels.

Ties and Connector Pins are most commonly used in sandwich panels with insulation thicknesses of 40–390 mm and recommended dimensions up to 3 m high and 7 m wide.

Prefabrication allows the use of precise formworks with a high quality of surfaces and dimensions, high repeatability of formwork and production of concrete elements. Production is plan-placed in factory conditions with a controlled indoor environment where the mixing, placing, and curing of the concrete is easy to control. Prefabrication enables sandwich panels to be created with high-quality wall surfaces.

Contents

1 PRODUCT PROPERTIES

Ties and Connector Pins are bent and welded wire connectors used to connect concrete layers of precast sandwich panels. Ties and Connector Pins are usually uniformly distributed through thermal insulation plates and anchored in both of the layers of a sandwich panel.

The product range consists of four types of connector, which are available in several standard models to cover a wide range of precast panel thicknesses:

- Diagonal Tie
- PPA Beam Tie
- PPI Connector Pin
- PDQ Connector Pin

Figure 1. Types of ties and connectors: Diagonal Tie, PPA Beam Tie, PPI/PDQ Connector Pin.

The **Diagonal Tie** is a single lattice girder used to connect the outer and inner layers of sandwich panels. The lattice girder consists of stainless diagonals and flanges made either of stainless or reinforcing steel. The flange material depends on the exposure class and concrete cover of the flanges.

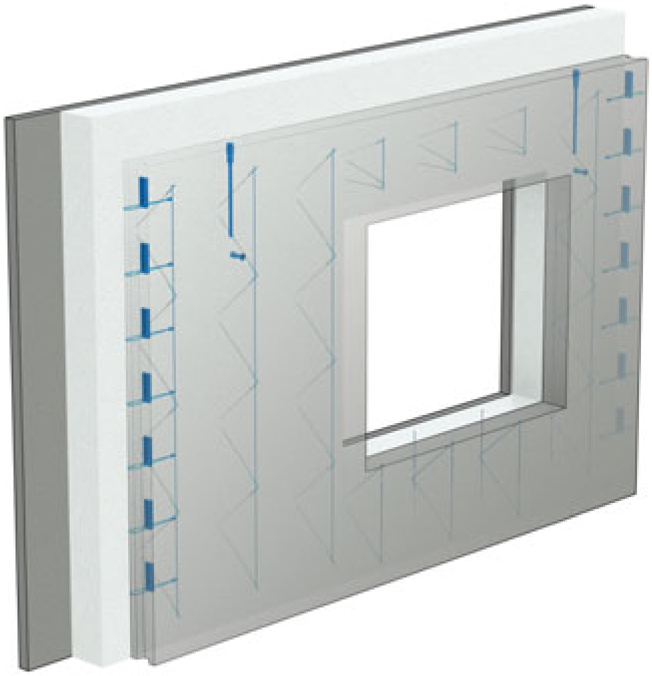
PDM Diagonal Tie: both flanges are made of reinforcing steel. The PDM Diagonal Tie is used in cases where concrete cover is adequate for both flanges.

PD Diagonal Tie: the outer flange is made of stainless reinforcing steel for cases when the concrete cover in the outer layer is not sufficient. The inner flange of the PD Diagonal Tie is made of reinforcing steel.

PDR Diagonal Tie: both flanges are made of stainless reinforcing steel.

The **PPA Beam Tie** is a single connector used in cases where the height of concrete layers does not allow the use of Diagonal Ties (window lintels or low socle elements). The PPA Beam Tie is made of stainless reinforcing steel.

PPI and PDQ Connector Pins are single connectors typically used in combination with Diagonal Ties to restrain deformation perpendicular to the outer layer, such as warping.



1.1 Structural behaviour

Ties and Connector Pins are used to provide structural interaction between the concrete layers of sandwich panels and enable the sandwich panel to transfer loads and displacements that are most typically imposed to the structure by the following effects:

- Lifting and transport
- Self-weight of concrete layer
- Shrinkage deformation
- Wind load
- Temperature deformation
- Adhesion of the formwork

The structural effects are likely to be combined during the different stages of the life cycle of the precast sandwich panel. The precast panel must be designed to withstand the effects of the most unfavourable load combinations.

In the manufacturing stage, the Ties and Connector Pins will be subject to tensile forces resulting from the self-weight of the sandwich panel during lifting and transportation.

In normal use cases, Ties and Connector Pins are likely to be exposed to the action of self-weight of the outer layer, shrinkage deformation in the outer and inner layers, and environmental loads such as wind load and deformation of the outer layer due to temperature changes.

Self-weight during lifting and transportation.

In the manufacturing stage, adhesion between the sandwich panel and the formwork will result in tensile forces in the connectors while the panel is lifted from the formwork. Once the sandwich panel is lifted from the formwork, the tensile forces in the connectors will correspond to the self-weight of the layer that is hanged on them (*Figure 2*). During the transportation stage, the forces in the connectors due to self-weight must be multiplied due to dynamic effects.

Figure 2. Principle of adhesion between concrete and formwork.

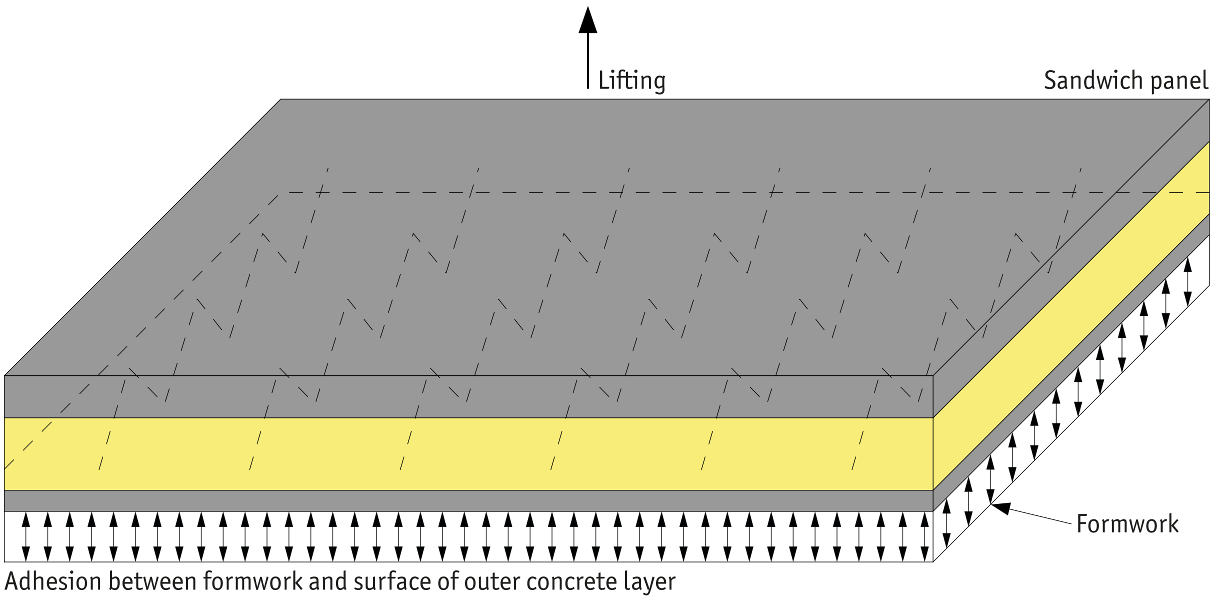
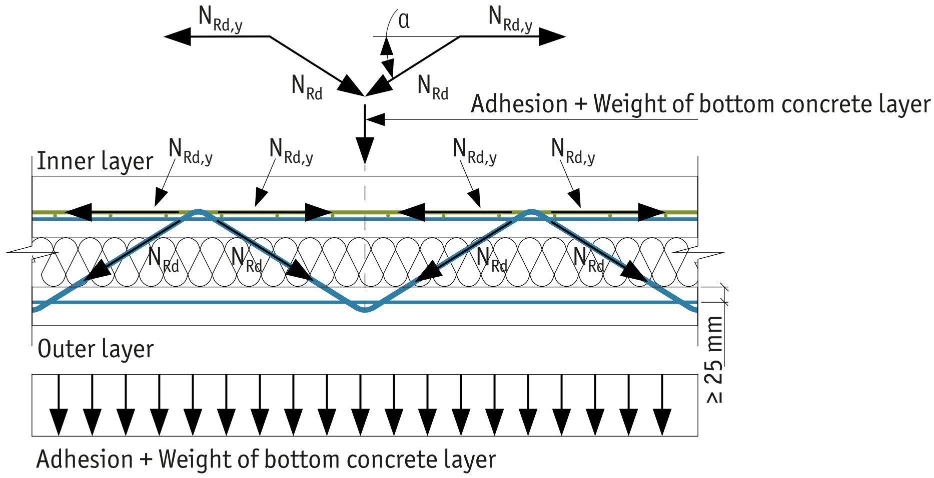


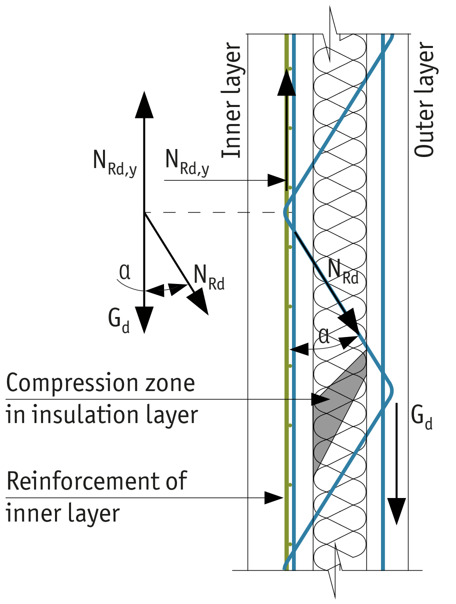
Figure 3. Force flow in Diagonal Ties related to formwork adhesion.



Self-weight of the concrete layer

The outer layer of the sandwich panel is most typically hanged on the inner layer (*Figure 4*). The self-weight of the outer layer acts as a dead load and generates vertical forces G_d in the sandwich panel. These vertical forces are resisted by the tensile resistance of diagonals and compression resistances of the thermal insulation layer (*Figure 4*).

Figure 4. Forces resulting from the effects of dead load.

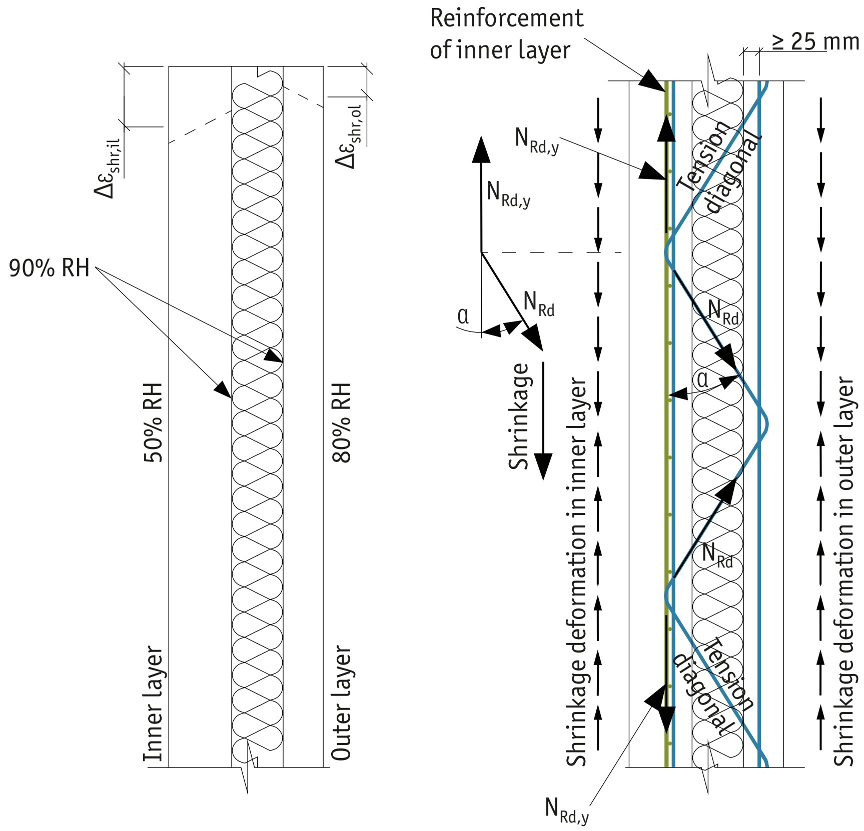


Shrinkage deformation

Shrinkage is a time-dependent deformation of concrete that is mainly influenced by the properties of the precast element (material, dimensions) and humidity of the precast element and surrounding environment. The outer and inner layers of the sandwich panels usually have a different thickness and are exposed to environments with different humidity. As a result, they are subjected to different shrinkage deformations. Diagonal Ties are used to ensure the compatibility of shrinkage deformations and prevent interface slip between the two concrete layers of the sandwich panel (see *Figure 5*).

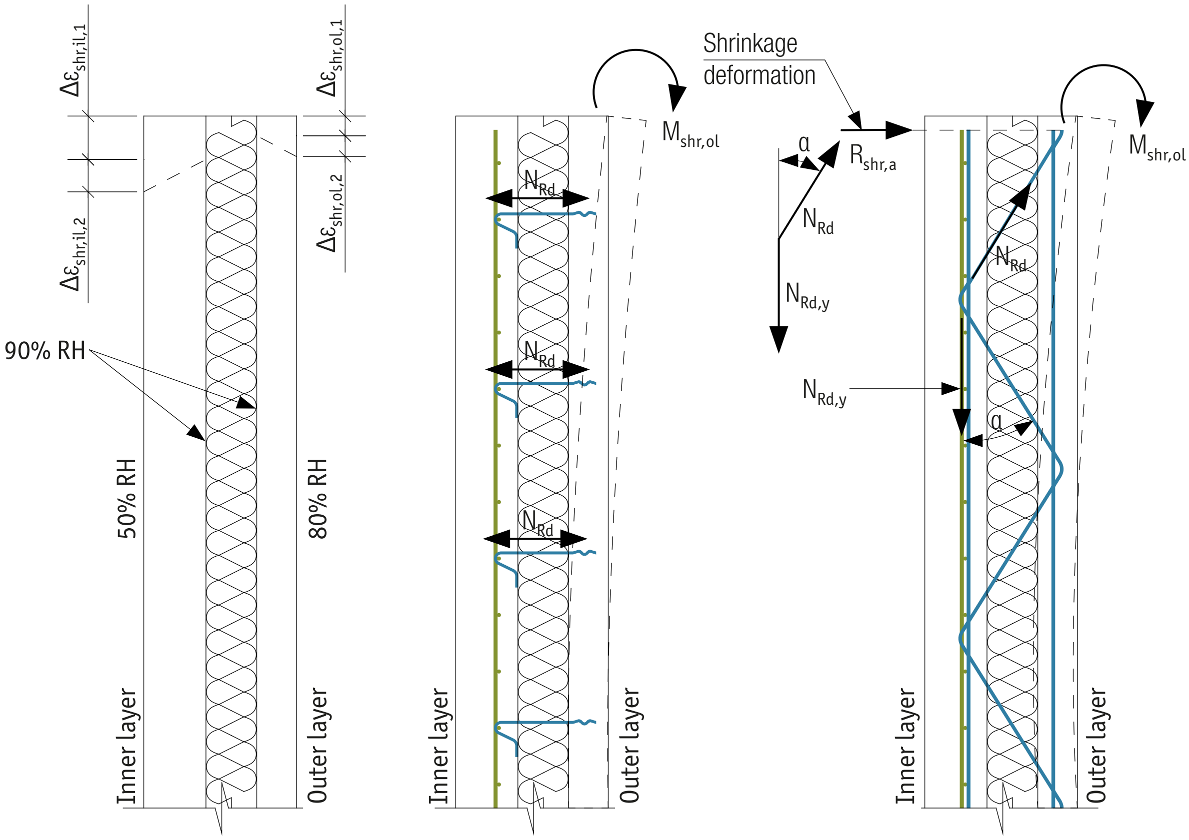
A humidity gradient also exists within the inner and outer side of each concrete layer of the precast element (*Figure 6*). This is mainly due to the fact that the evaporation of water is faster on the side of the layer that is exposed to the external environment compared to the side that is in contact with the thermal insulation layer. The difference between shrinkage strains that is related to this humidity gradient may cause local deformations of the sandwich panel (*Figure 6*). These deformations may be prevented placing Diagonal Ties or Connector Pins around the edges of the sandwich panel (*Figure 6*).

Figure 5. Linear shrinkage deformation in sandwich panel.



Reinforcement of the inner concrete layer restricts the effects of flexural shrinkage deformation, which nullifies this effect on the Diagonal Ties. Diagonal Ties are then loaded by flexural shrinkage deformation from the outer concrete layer.

Figure 6. Shrinkage flexural deformation at the end on the outer concrete layer.



Wind load

The outer layer of the sandwich panel may be exposed to wind action, which usually acts as a uniform pressure or suction load perpendicular to the panel surface. Uniform pressure load is transferred from the outer concrete layer via the insulation layer to the inner layer and supports. For this reason, the thermal insulation must have adequate compression strength. The tension loads caused by suction are resisted by diagonals (see *Figure 7*). In both cases, wind load will result in the sandwich panel bending.

Figure 7. Transfer of wind suction to inner layer.

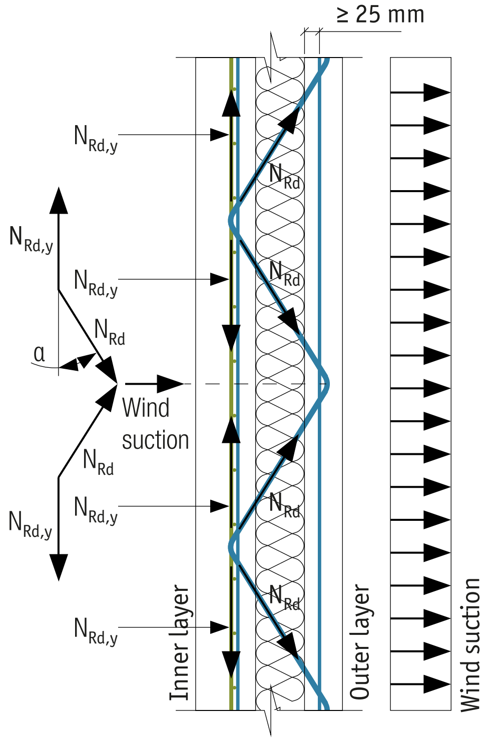


Figure 8. Transfer of wind pressure to inner layer.

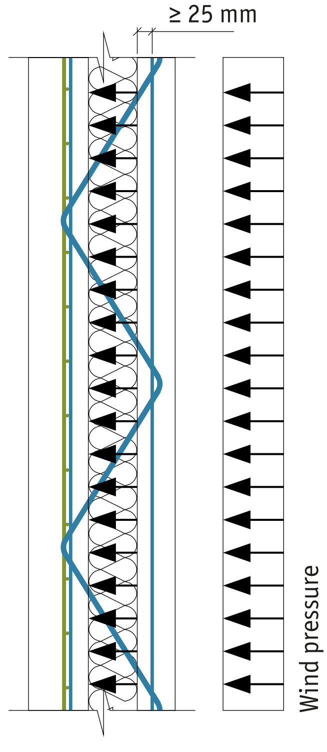
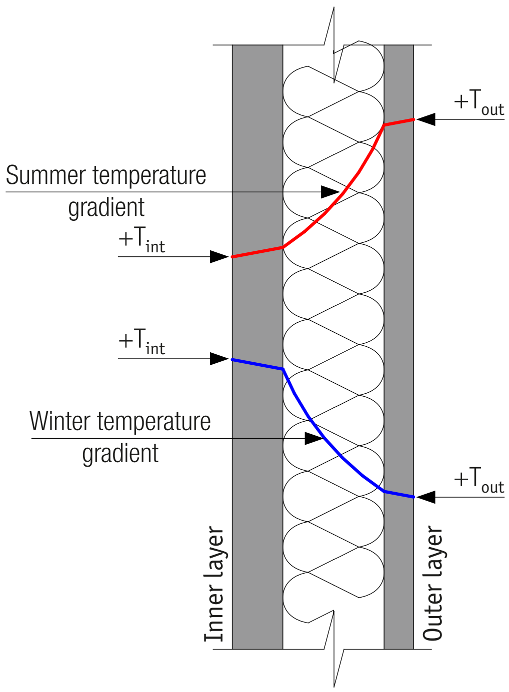


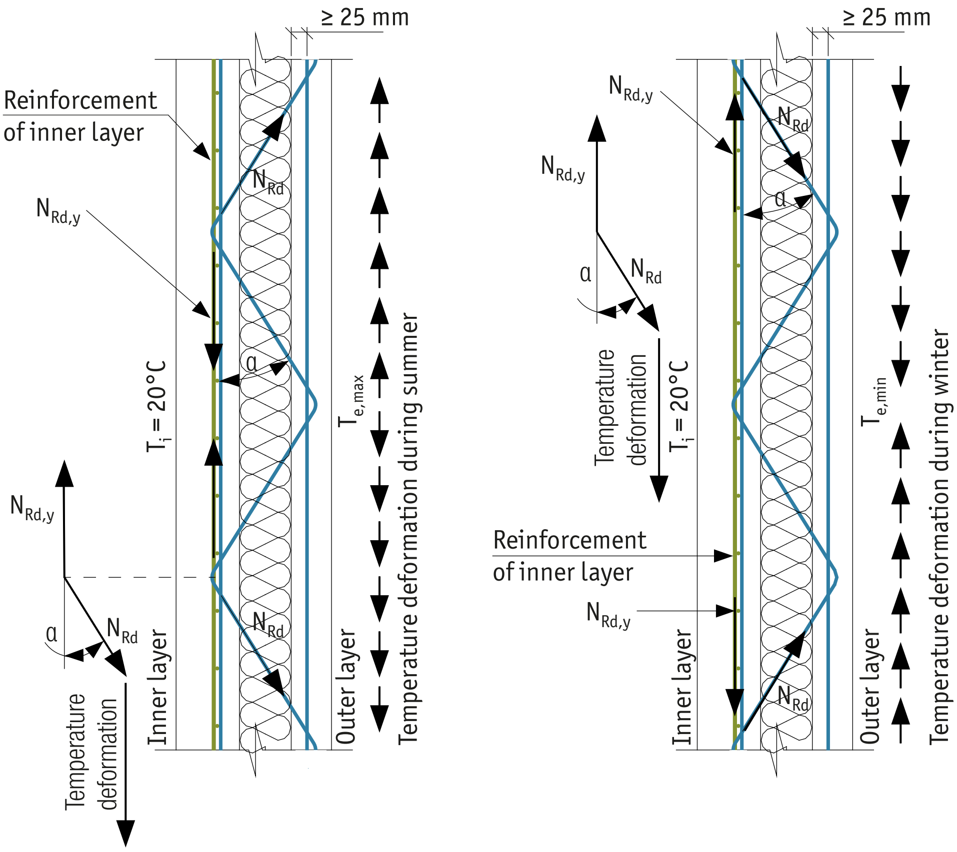
Figure 9. Seasonal temperature gradient in sandwich panel.



Temperature deformation

As a building envelope, the sandwich panel is exposed to frequent temperature changes during day and night and during different seasons. An example of the temperature flow in a sandwich panel is shown in *Figure 9*. Since the temperature variations in the inner layer of the sandwich panel (inside the building) are assumed to be relatively low, the temperature gradient of the sandwich panel principally depends on the daily or annual temperature fluctuation in the outer layer. Linear temperature deformation causes extension (during summer) and contraction (during winter) of the outer concrete layer. Diagonal Ties are used to resist the deformations of the outer concrete layer and prevent movement differences between layers of sandwich panels (*Figure 10*).

Figure 10. Force flow during summer and winter season in sandwich panel.



A certain temperature gradient exists also through the depth of each concrete layer. This temperature gradient may result in local deformations of the concrete layers. The orientation of deformation depends on the season and ambient temperature (see *Figure 11*). Such local bending may be prevented by placing Diagonal Ties or Connector Pins near the edges of the precast panel (*Figure 12*).

Figure 11. Annual temperature deformation of a sandwich panel.

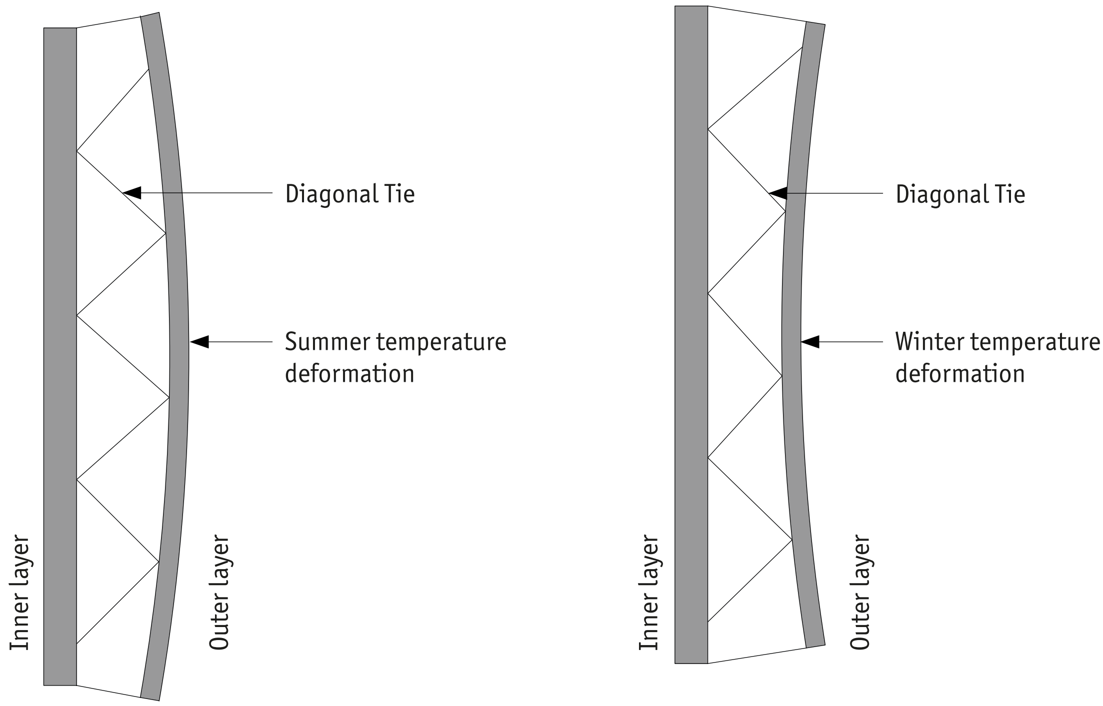
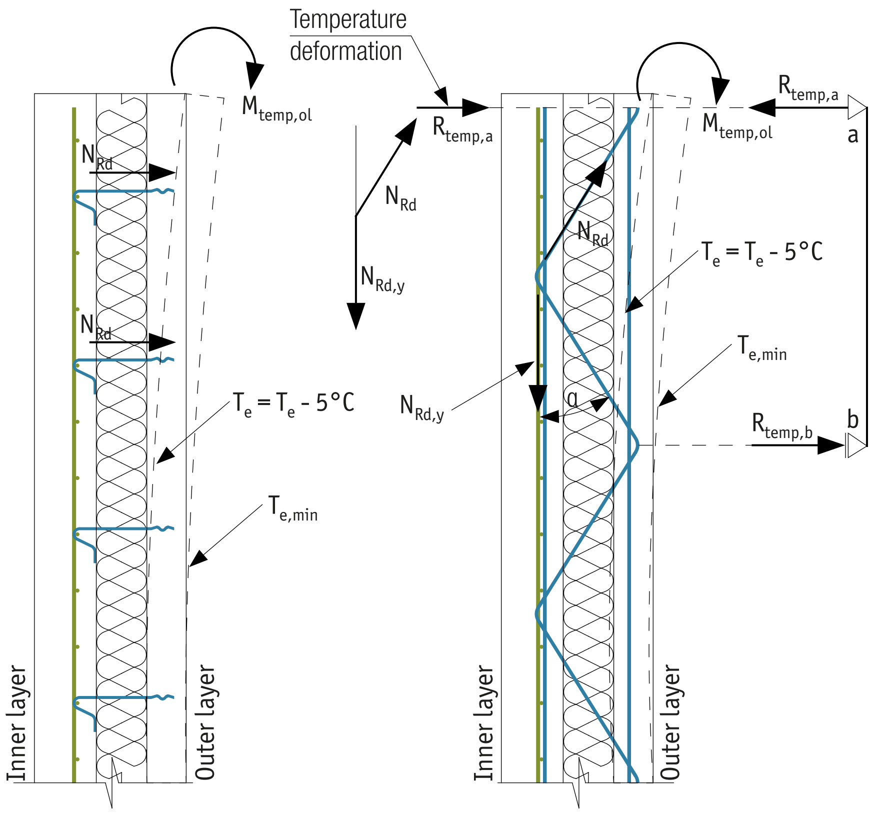


Figure 12. Temperature flexural deformation in the outer layer during winter.

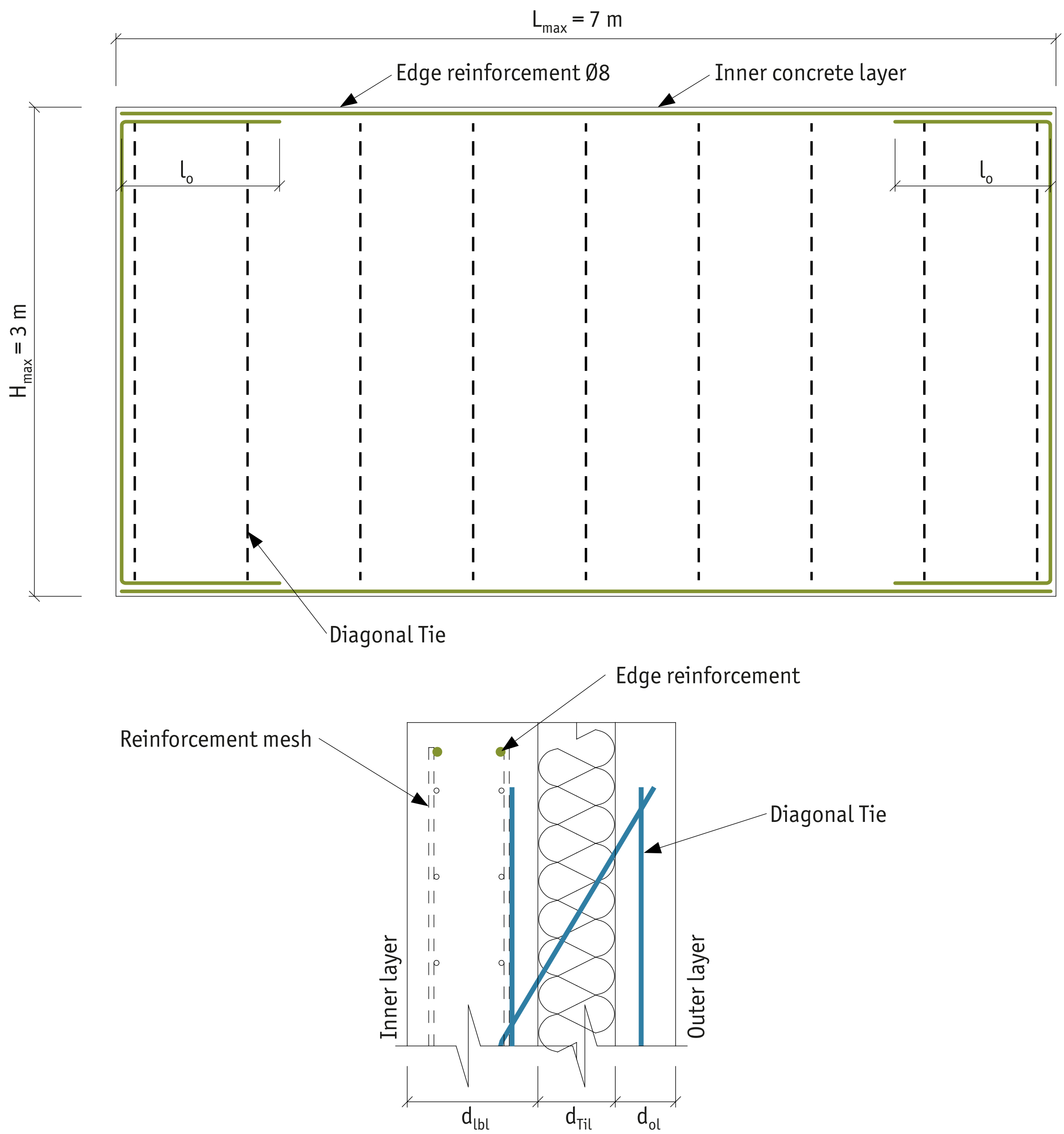


1.2 Application conditions

The Ties and Connector Pins were developed for use in precast sandwich panels assuming the following limitations:

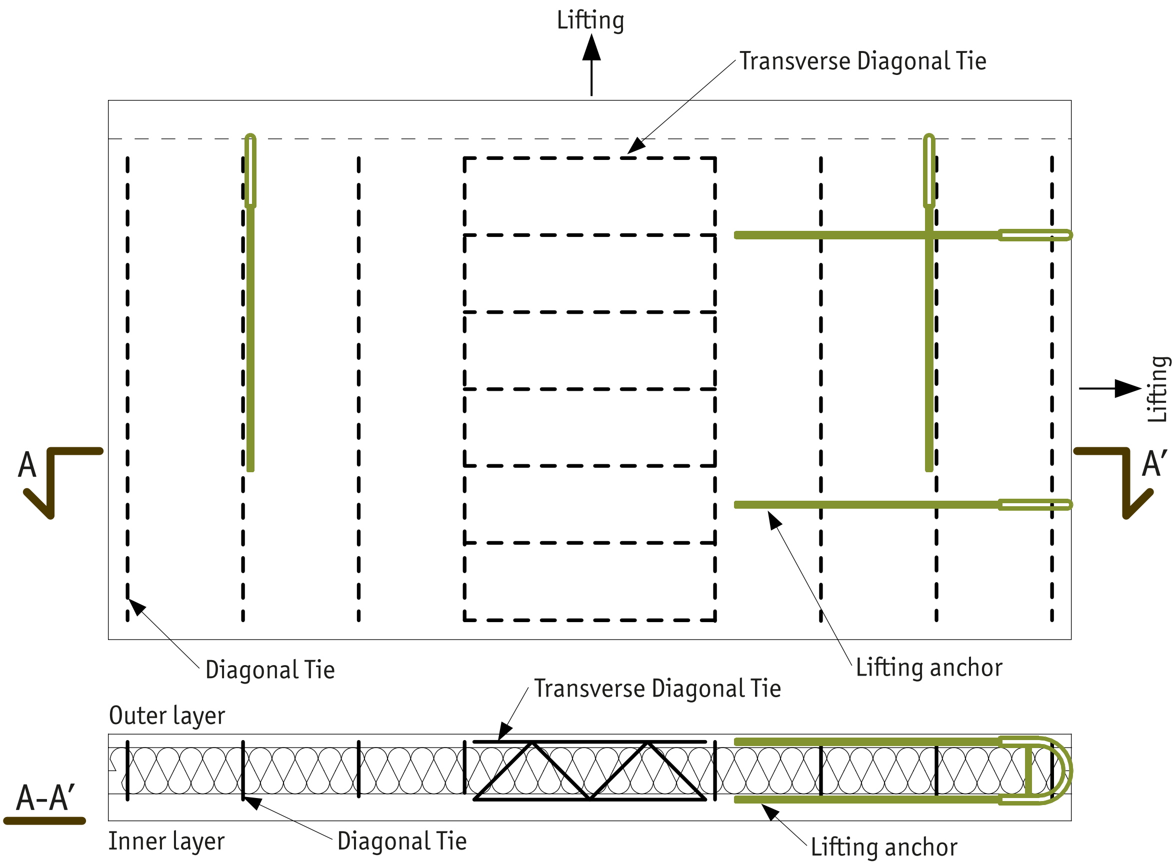
- Recommended maximum dimensions of the precast panel: 3 x 7 m
- Minimum concrete grade in accordance with Table 1
- Minimum anchorage depth in accordance with Table 1
- Recommended minimum thickness of outer concrete layer: 70 mm
- Recommended minimum mesh reinforcement of outer concrete layer: 133 mm²/m (when d_{ol}≤70 mm)
- Recommended minimum edge reinforcement of inner concrete layer: Ø8 (see *Figure 13*)
- Design of transverse Diagonal Ties if panel is rotated during lifting (see *Figure 14*)
- Uniform casting of top concrete layer to avoid local differences in thickness and compression of thermal insulation
- The use of plasticizer is recommended to reduce the water-to-cement (w/c) ratio

Figure 13. Placement of the edge reinforcement in the inner layer.



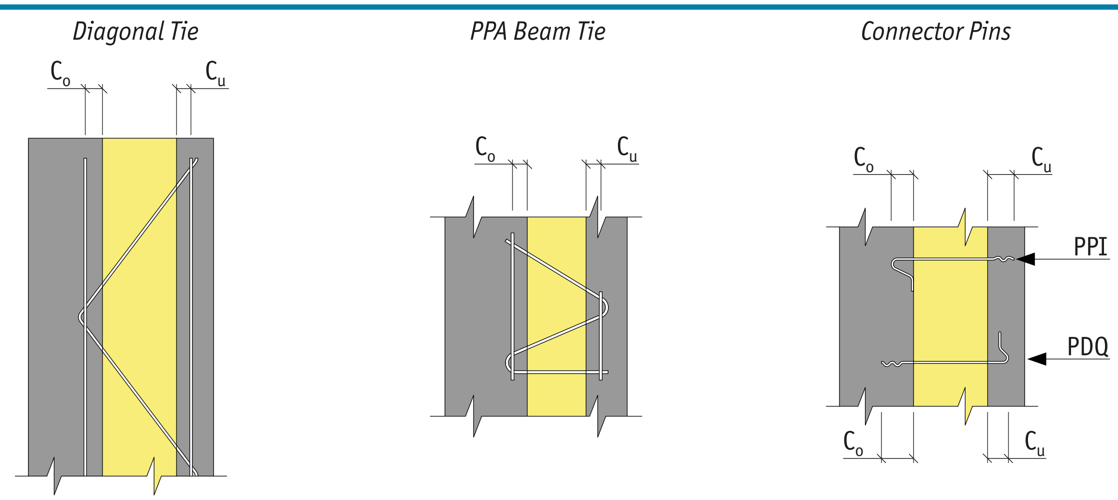
l_o is calculated according to EN 1992-1-1

Figure 14. Using transverse Diagonal ties during lifting.



The minimum anchorage depth and material properties of concrete in accordance with Table 1 must be secured to provide proper functioning of Ties and Connector Pins.

Table 1. Concrete cover of Ties and Connector Pins with minimum concrete grades.



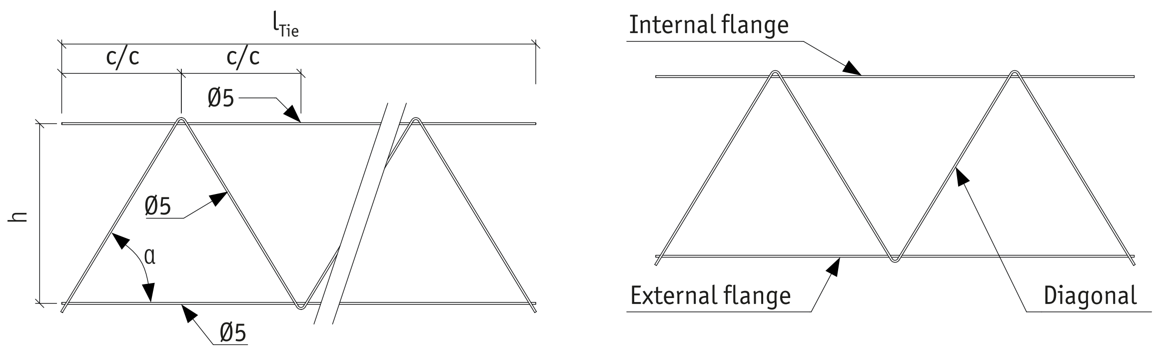
Type of connector	Anchorage depth (c_o/c_u)	Minimum concrete grade (Anchorage point of view)
Diagonal Tie	≥ 25/25	≥ 20/25*
PPA Beam Tie	≥ 35/35	≥ 20/25
PPI Connector Pin	≥ 40/50	≥ 25/30
PDQ Connector Pin	≥ 50/40	≥ 25/30

**Minimum compressive strength of concrete before stripping from the formwork is f_{ck} = 16MPa.*

1.3 Other properties

The dimensions of standard models of Ties and Connector Pins are summarized in Table 2, Table 3, and Table 4.

Table 2. Dimensions of Diagonal Tie.

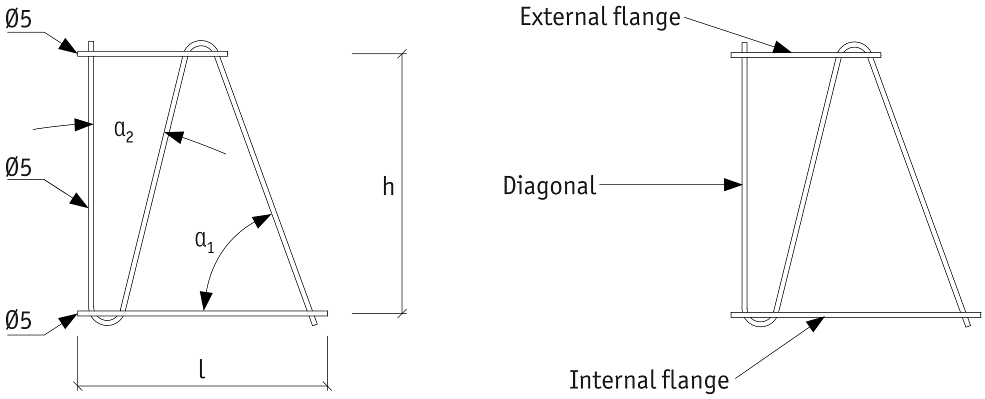


Diagonal Tie model	h [1] [mm]	c/c [mm]	Recommended insulation thickness [mm]	Length [2] [mm]	α [deg]	Weight [kg]
PD/PDM/PDR 100	100		40		23	1.17
PD/PDM/PDR 120	120		60		26	1.18
PD/PDM/PDR 140	140		80		29	1.19
PD/PDM/PDR 150	150		90		31	1.20
PD/PDM/PDR 180	180		120		35	1.22
PD/PDM/PDR 200	200		140		38	1.23
PD/PDM/PDR 210	210		150		39	1.27
PD/PDM/PDR 220	220		160		40	1.27
PD/PDM/PDR 240	240		180		42	1.27
PD/PDM/PDR 260	260	300	200	2400	44	1.28
PD/PDM/PDR 280	280		220		46	1.30
PD/PDM/PDR 300	300		240		48	1.32
PD/PDM/PDR 320	320		260		50	1.34
PD/PDM/PDR 340	340		280		52	1.36
PD/PDM/PDR 360	360		300		53	1.38
PD/PDM/PDR 380	380		320		55	1.40
PD/PDM/PDR 400	400		340		56	1.42
PD/PDM/PDR 420	420		360		57	1.44
PD/PDM/PDR 440	440		380		58	1.46
PD/PDM/PDR 450	450		390		59	1.47

1) The standardized height h of ties is based on anchorage depths 30 + 30 mm into the concrete layers. Dimension h is measured from the central axis to the central axis of flanges.

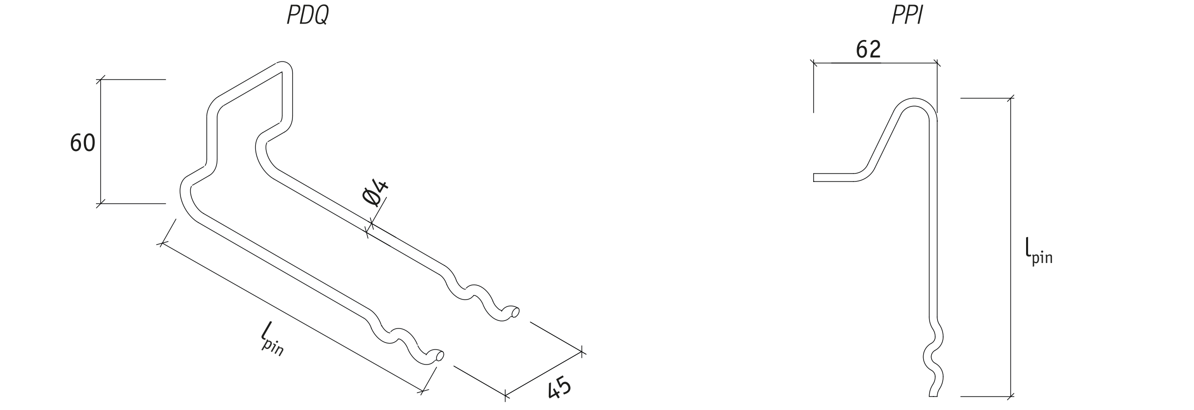
2) The standard length of Diagonal Ties l_{Tie} is 2400 mm. Ties can be manufactured in multiples of 300 mm.

Table 3. Dimensions of PPA Beam Tie.



Beam Tie model	h [mm]	l [mm]	Recommended insulation thickness [mm]	α_1 [deg]	α_2 [deg]	Weight [kg]
PPA 150	150		90	59	23	0.16
PPA 180	180		120	63	20	0.17
PPA 200	200		140	65	18	0.18
PPA 210	210		150	66	17	0.18
PPA 220	220	250	160	67	16	0.19
PPA 240	240		180	69	15	0.20
PPA 260	260		200	70	14	0.21
PPA 280	280		220	71	13	0.21
PPA 300	300		240	67	15	0.24
PPA 320	320	300	260	68	14	0.25
PPA 340	340		280	69	13	0.25
PPA 360	360		300	65	14	0.28
PPA 380	380	350	320	66	13	0.28
PPA 400	400		340	67	13	0.29
PPA 420	420		360	65	15	0.32
PPA 440	440	400	380	66	14	0.33
PPA 450	450		390	66	14	0.33

Table 4. Dimensions of PPI and PDQ Connector Pins.



Connector Pin model	l_{pin} [3]	Recommended insulation thickness: 90° angle installation (PPI & PDQ)	Recommended insulation thickness: 45° angle installation (PPI)	Weight: PPI	Weight: PDQ
	[mm]	[mm]	[mm]	[mm]	[mm]
PPI/PDQ 170	170	80	-	0.03	0.05
PPI/PDQ 190	190	100	-	0.03	0.05
PPI/PDQ 210	210	120	-	0.03	0.06
PPI/PDQ 230	230	140	80	0.03	0.06
PPI/PDQ 250	250	160	100	0.03	0.06
PPI/PDQ 280	280	190	120	0.04	0.07
PPI/PDQ 300	300	210	140	0.04	0.07
PPI/PDQ 320	320	230	160	0.04	0.08
PPI/PDQ 340	340	250	170	0.04	0.08
PPI/PDQ 360	360	270	190	0.04	0.09
PPI/PDQ 380	380	290	200	0.05	0.09
PPI/PDQ 400	400	310	210	0.05	0.09
PPI/PDQ 420	420	330	230	0.05	0.10
PPI/PDQ 440	440	350	240	0.05	0.10
PPI/PDQ 450	450	360	250	0.05	0.10

[3] Length of Connector Pins can be manufactured in multiples of 10 mm.

Manufacturing tolerances

Tie length	± 10 mm
Tie width	± 5 mm
Diagonal or cross bar distance	± 5 mm
Diagonal's straightness between bars	± 2 mm
Connector Pin length	± 5 mm

Materials

Types of connectors		Type of steel	Standard
Diagonal Ties	Diagonals	1.4301 (smooth)	EN 10088-2
	Flanges	B500B (ribbed) B600KX (ribbed)	EN 10080 SFS 1259
PPA Beam Tie		B600KX (ribbed)	SFS 1259
PDQ/PPI Connector Pin		B600KX (ribbed)	SFS 1259

Figure 15. Marking of the stainless flanges

The material properties of the flanges of the Diagonal Tie depend on the environment exposure class and concrete cover of the flange (Table 5). Stainless diagonals and flanges may be identified by yellow painting at both ends of the bar (see *Figure 15*).

Table 5. Material options of flanges of Diagonal Ties.

Type	Structural part	Material		
		B500B	B600KX	1.4301
PDM	External flange	x		
	Diagonal			X
	Internal flange	x		
PD	External flange		x	
	Diagonal			X
	Internal flange	x		
PDR	External flange		x	
	Diagonal			X
	Internal flange		x	

Diagonals are mechanically bent and welded to flanges by using a resistance welding process. The lattice girder is cut mechanically to the correct length. The Connector Pins are cut and bent mechanically. Each package of Ties bears the mark of Inspecta Certification, the emblem of Peikko Group, the type and quality of the product and the manufacturing date. Package sizes: Connector Pins: 500pcs, Diagonal Ties: 500–900pcs, and PPA Beam Ties: 240–500pcs.

Peikko Group units are externally controlled and periodically audited on the basis of production certifications and product approvals by various organizations, including Inspecta Certication, VTT Expert Services, Nordcert, SLV, TSUS, and SPSC among others.

2 Resistances

The resistances of Ties and Connector Pins are determined by a design concept that makes reference to the following standards:

- EN 1992-1-1:2004/AC:2010
- EN 10080:2005

The tensile resistance of one single diagonal in a Diagonal Tie is given in Table 6. The characteristic value of the tensile resistance is defined as the minimum of the steel resistance of the diagonal, the welding joint resistance between the diagonal, or the anchorage resistance of the diagonal into concrete. The resistances of PPI/PDQ Connector Pins and PPA Beam Ties are given in Table 7 and Table 8. The load bearing direction of the sandwich panel connectors is shown in Table 9.

Table 6:.Resistance of Diagonal Ties.

	Design value N_{Rd}
Tension resistance of Diagonal Ties	5.6

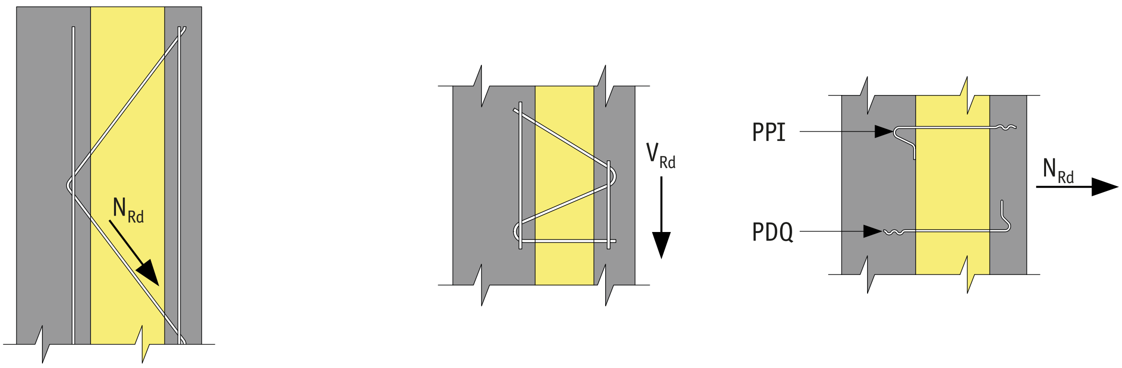
Table 7. Resistance of PPI and PDQ Connector Pins.

	Design value N_{Rd}
Tension resistance of PPI/PDQ Connector Pins	3.5

Table 8. Resistance of PPA Beam Ties.

	Design value V_{Rd}
Shear resistance of PPA Beam Ties	1.1

Table 9. Load bearing direction of the sandwich panel connectors.



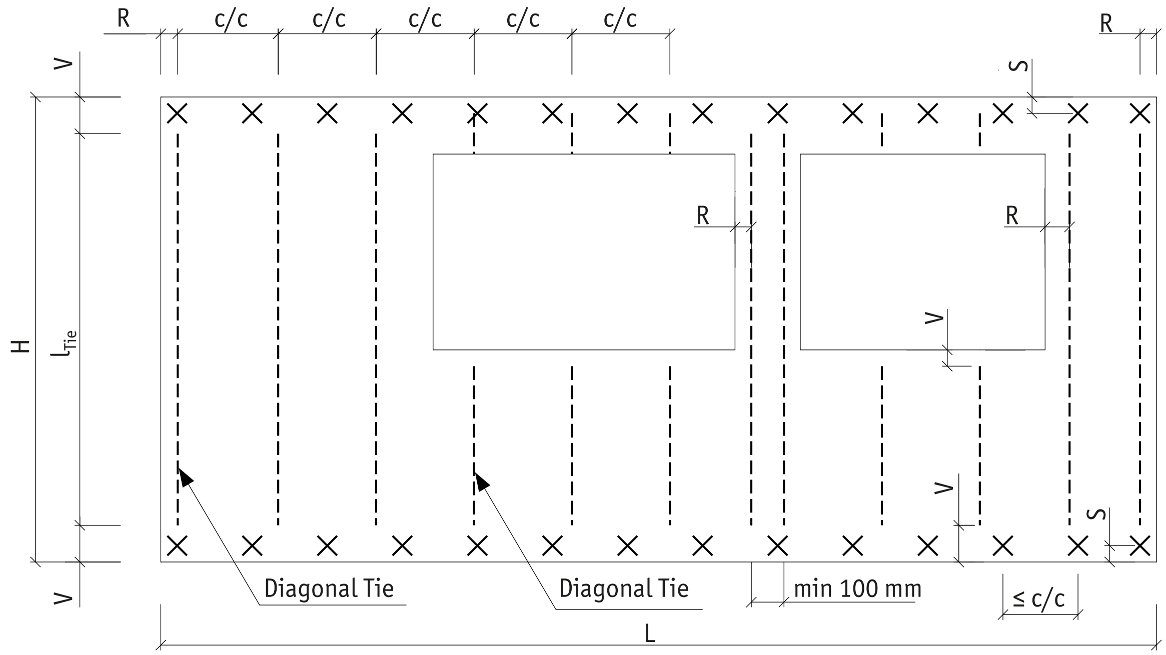
Diagonal Tie	PPA Beam Tie	PPI and PDQ Connector Pins

The height (h dimension) of the Tie is selected according to the insulation thickness and required anchoring depth. The recommended height for the Tie is the insulation thickness plus the concrete cover ($c_u + c_o$) for anchoring (see Table 1, Table 2, and Table 3).

The horizontal edge distance R (see *Figure 16*) must be 100–300 mm. The vertical distance V (see *Figure 16*) from the upper and bottom edges should be $c_{min,dur} \leq V \leq 200$ mm, where $c_{min,dur}$ is determined according to EN 1992-1-1.

The c/c spacing of the ties is typically the same as the width of the thermal insulation panels to simplify assembly and minimize wastage. The recommended c/c spacing is 100–600 mm. In narrow spaces such as columns (width of column zone 300–600 mm), it is recommended to use two ties to eliminate the risk of the column buckling (see *Figure 16*).

Figure 16. Placement of the Ties in the panel.



The spacing rules for PPA Beam ties are identical to those of Diagonal Ties. Diagonal Ties should be placed near the horizontal edges of the panel (R ≤ 100 mm) to prevent deformations of the panel edges due to temperature and shrinkage effects. Connector Pins may be used instead of Diagonal Ties (see *Figure 16*). The edge distance of pins must be S ≤ 150 mm (see *Figure 16*). Pins may be installed perpendicular to the concrete layer of the panel or at a 45° angle.

For panels within the scope of application defined in part 1.2 of this technical manual, it is recommended that the resistance of the Diagonal Ties be verified with regard to the effects of structural actions using the interaction curves in Annex A.

After selecting the dimension and model of Ties or Connector Pins, a product code describing the product may be defined according to the description in *Figure 17*, *Figure 18*, and *Figure 19*. Please use this code when ordering the product from Peikko's Sales Service.

Figure 17. Product code of Diagonal Ties.

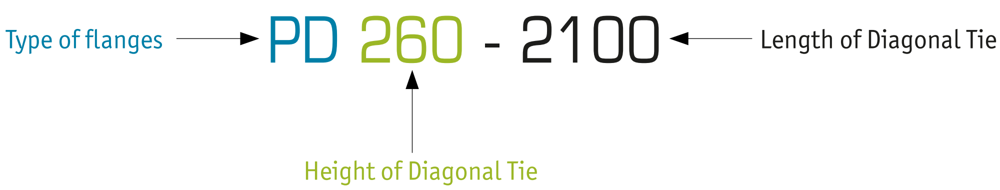


Figure 18. Product code of PPA Beam Ties.

Figure 19. Product code of Connector Pins

The design curves may be used to verify the resistance of Diagonal Ties in sandwich panels with a scope of application as defined in part 1.2 (Application conditions) of this technical manual. Additional application conditions are defined separately for each design curve. The following design example is used to illustrate the use of design curves.

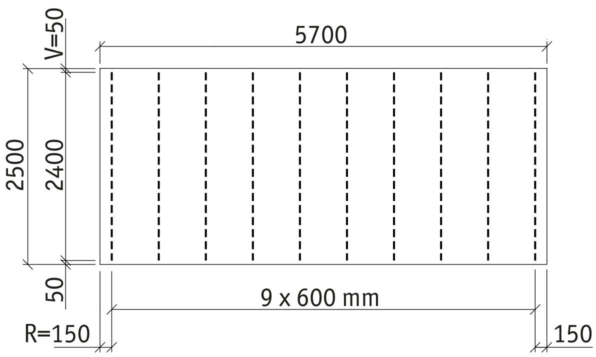
Properties of sandwich panel

Length of the panel	5700 mm
Height of the panel	2500 mm
Thickness of the inner layer	140 mm
Thickness of the thermal insulation layer	120 mm
Thickness of the outer layer	80 mm
Spacing of the Ties	600 mm
Concrete grade of the outer layer	C30/37
Concrete grade of the inner layer	C30/37
Thermal insulation	Mineral wool
Environment class	XC4
Reinforcing mesh in the outer layer	150x150 - Ø6 (as=188 mm²/m)

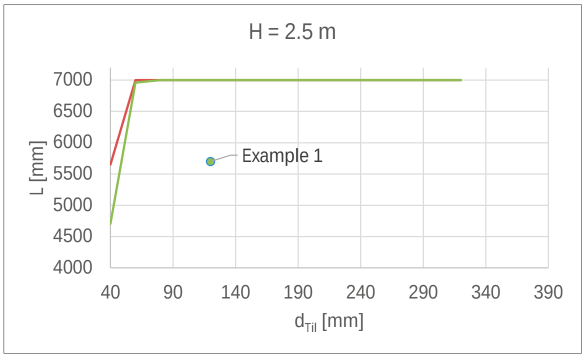
Loads:	
Wind suction:	-0.5kN/m²
Maximum temperature of the outer layer	82°C
Minimum temperature of the outer layer	-30°C
Adhesion of the formwork	2kN/m²
Dynamic factor during transportation	2.5

The properties and loads of the sandwich panel fulfil the conditions of the design curve on page 25.

Placing of Diagonal Ties in sandwich panel.



Verification for the resistance of the Diagonal.



Minimum concrete cover of reinforcement for exposure class XC4 is $c_{min,dur}$ = 25 mm
Concrete grade of outer layer doesn't fulfil requirements for environment class XC4, stainless steel shall be used in outer layer.

Selection of Diagonal Tie height h:
$d_{Til} + c_u + c_o$ = 120 + 25 + 25 = 170 mm → standardized height h of Diagonal Tie 180 (concrete cover 30 mm)
Outer concrete cover $c_{o,out}$ = 80 - 30 - Ø5/2 - 2 x Ø6 = 35 mm > $c_{min,dur}$ → Unfavourable placing of mesh reinforcement is assumed.

Selection of PD Diagonal Tie length:
Maximum Tie length → minimum edge distance $V_{min} = _{cmin,dur}$
$l_{Tie,max}$ = H - 2 x V_{min} = 2500 - 2 x 30 = 2440 mm → round down to a multiple of 300 mm → **l_{Tie} = 2400 mm**
Verification of vertical edge distances
V = (H - l_{Tie}) / 2 = (2500 - 2400) / 2 = 50 mm → OK, distance V is in interval $c_{min,dur}$ ≤ V ≤ 200 mm

Selected model of Diagonal Ties: **PD 180 - 2400**

Application conditions of the design curve

Design boundaries:

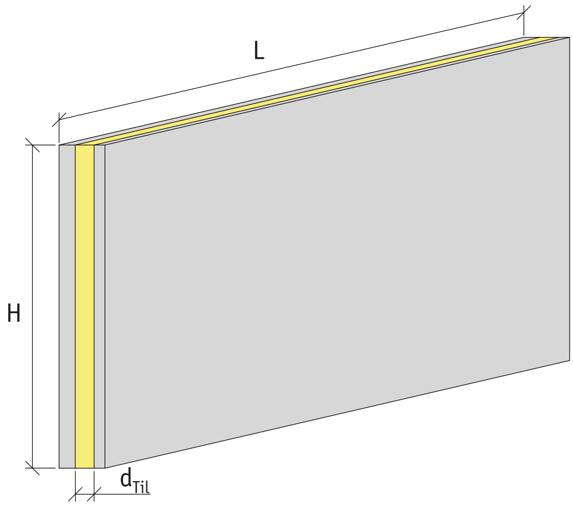
Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	400 mm
Maximal surface temperature:	70°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.6kN/m²
Adhesion of formwork:	2kN/m²
Dynamic factor:	2.5

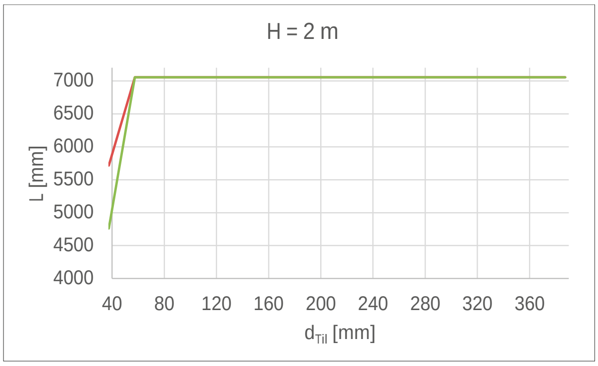
Minimum surface temperature of outer concrete layer:

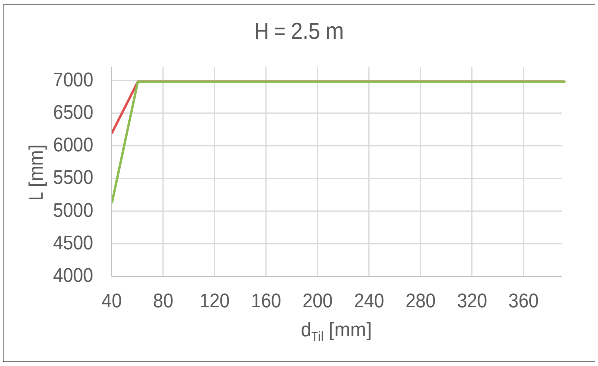
-30°C (red line)

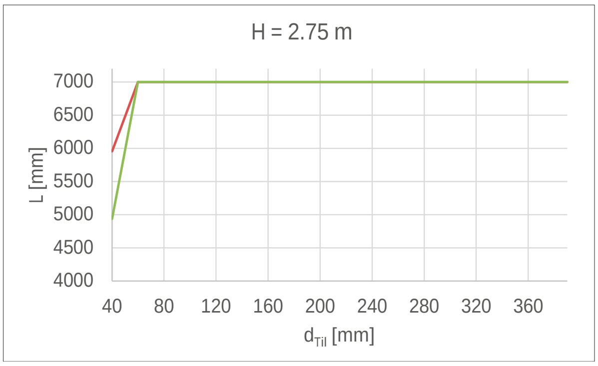
-40°C (green line)

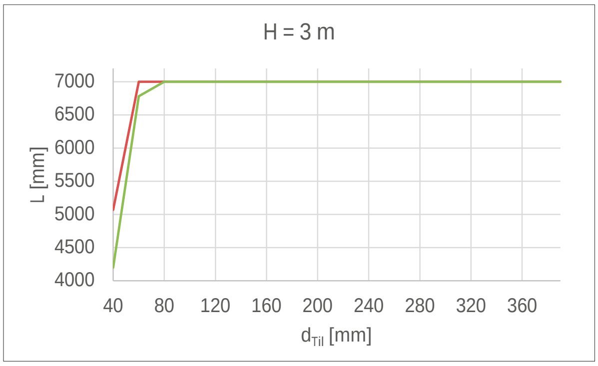
L - Length of the panel
H - Height of the panel
d_{Til} - Thickness of thermal insulation

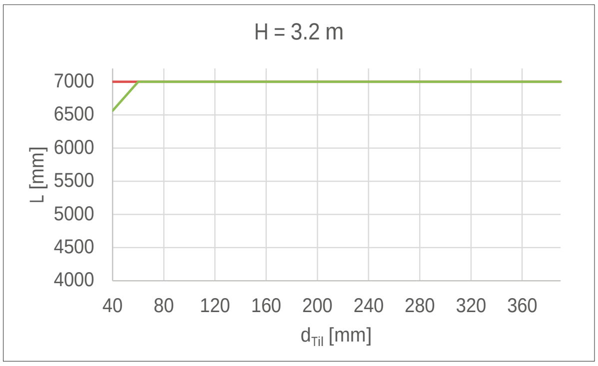










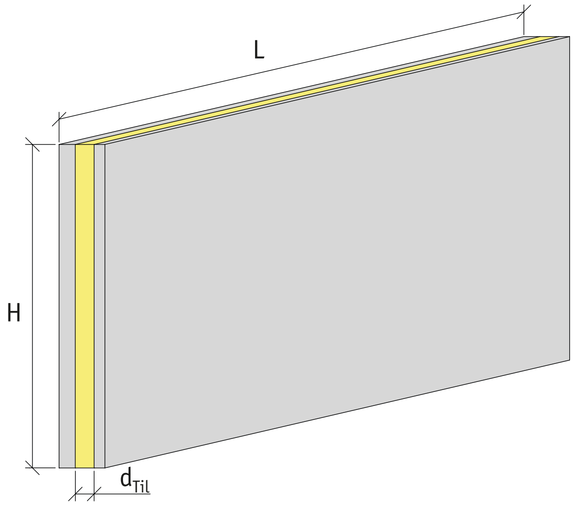


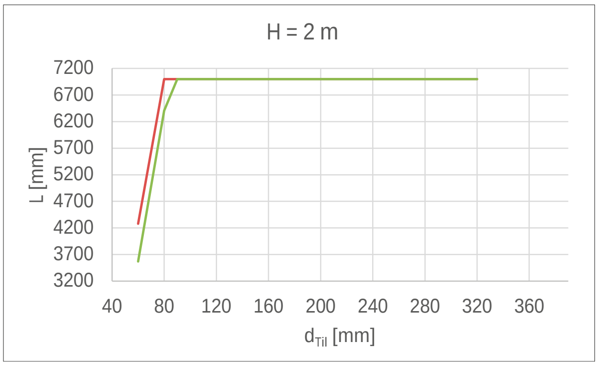
Design boundaries:	
Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	600 mm
Maximal surface temperature:	70°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.6kN/m²
Adhesion of formwork:	2kN/m²
Dynamic factor:	2.5

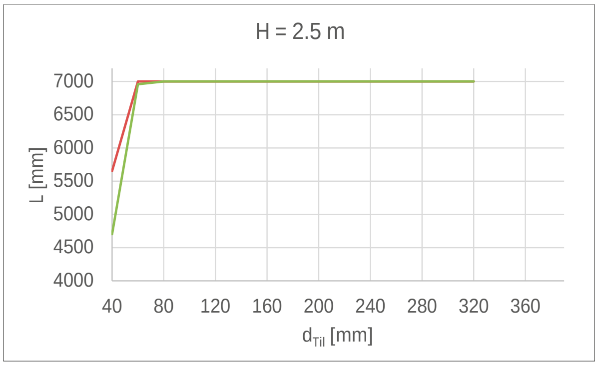
Minimum surface temperature of outer concrete layer:

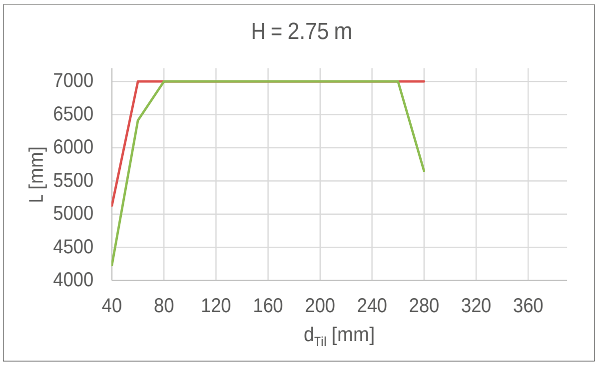
- -30°C (red)
- -40°C (green)

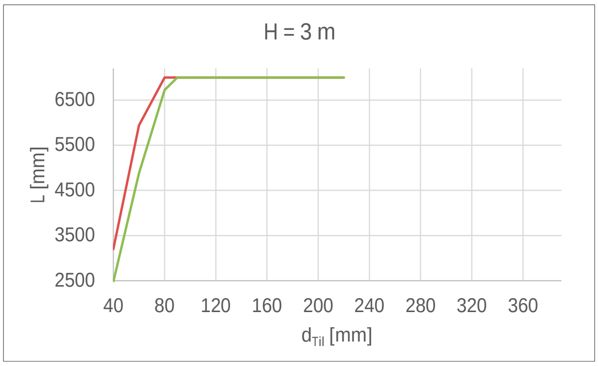
L - Length of the panel
H - Height of the panel
d_{Til} - Thickness of thermal insulation

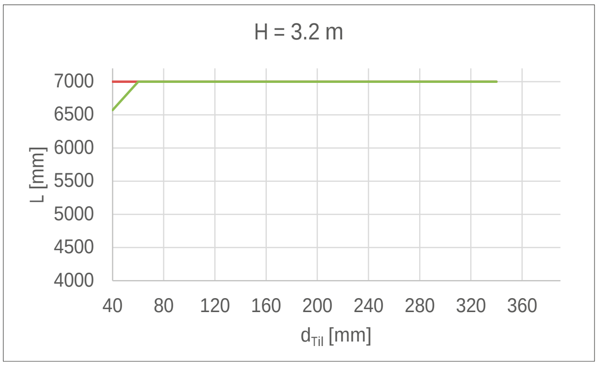












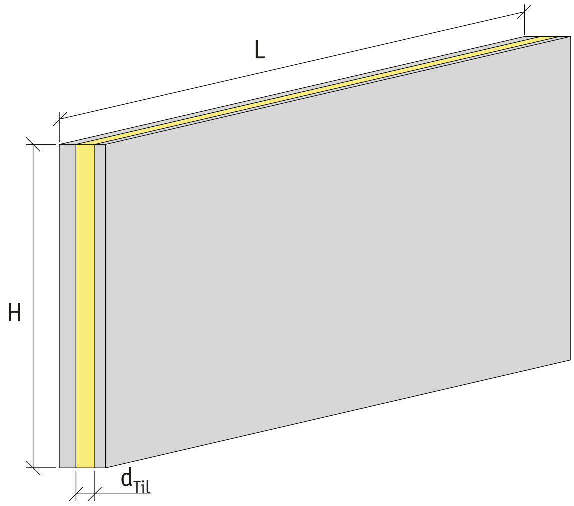
Design boundaries:

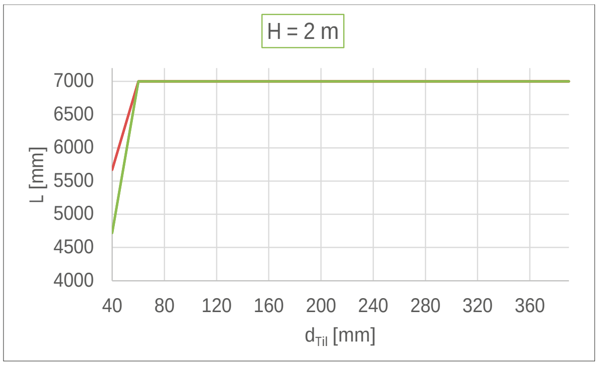
Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	400 mm
Maximal surface temperature:	80°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.6kN/m²
Adhesion of formwork:	2kN/m²
Dynamic factor:	2.5

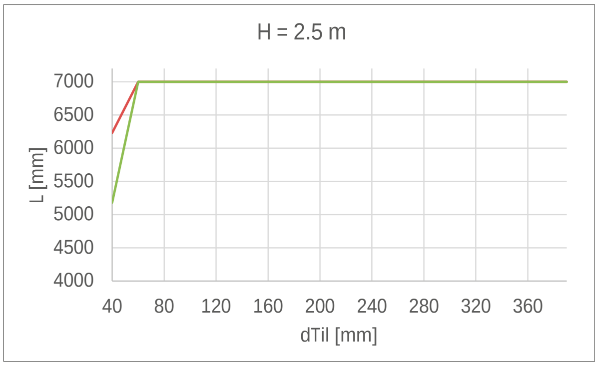
Minimum surface temperature of outer concrete layer:

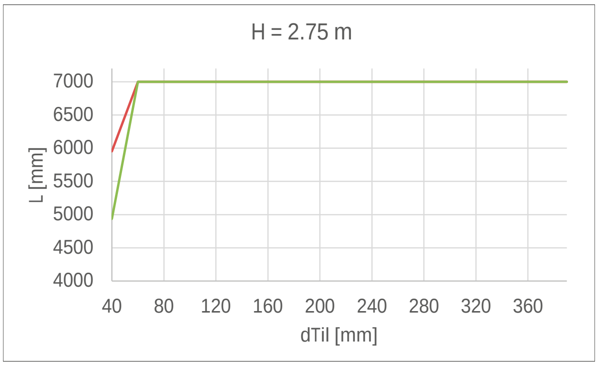
- -30°C (red)
- -40°C (green)

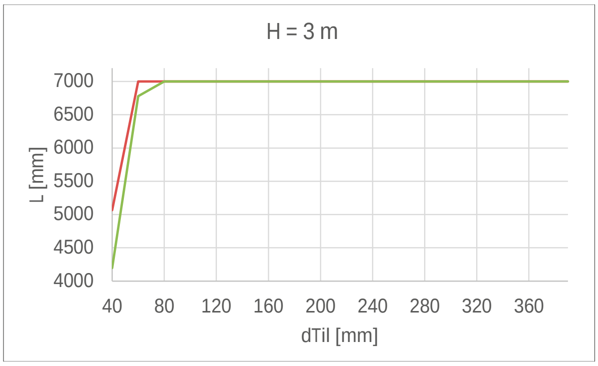
L - Length of the panel
H - Height of the panel
d_{Til} - Thickness of thermal insulation

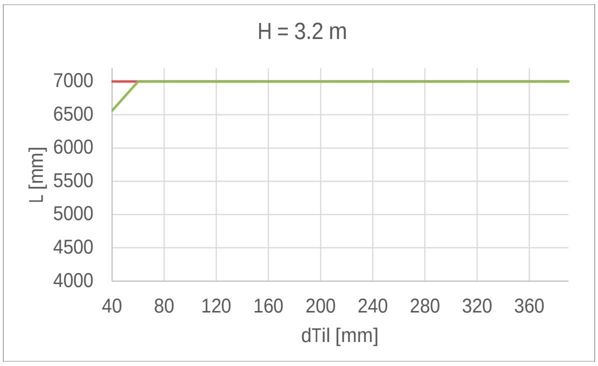












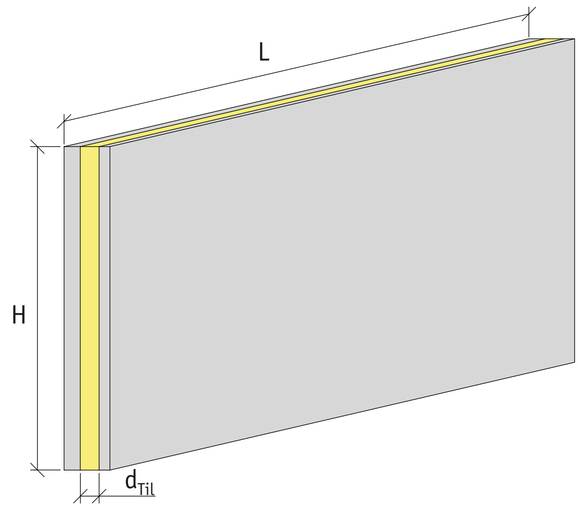
Design boundaries:		
Concrete grade:	C30/37	
Thickness of outer layer:	80 mm	
Spacing of Diagonal Ties:	600 mm	
Maximal surface temperature:	82°C	
Temperature gradient:	ΔT= ±5°C	
Wind suction:	$-0.6kN/m^2$	
Adhesion of formwork:	$2kN/m^2$	
Dynamic factor:	2.5	

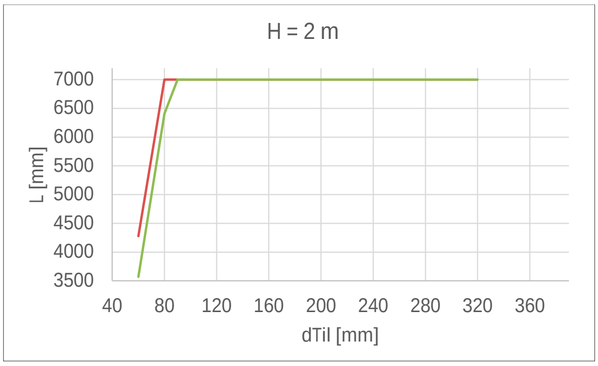
Minimum surface temperature of outer concrete layer:

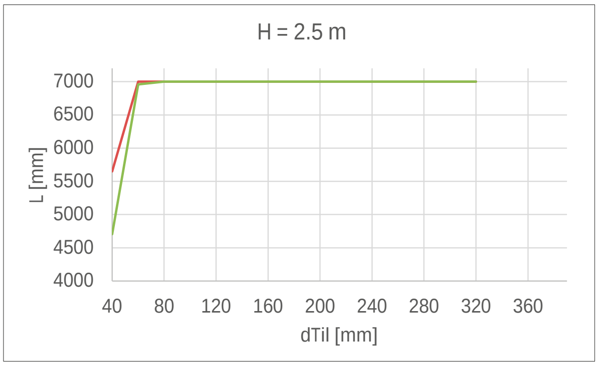
-30°C

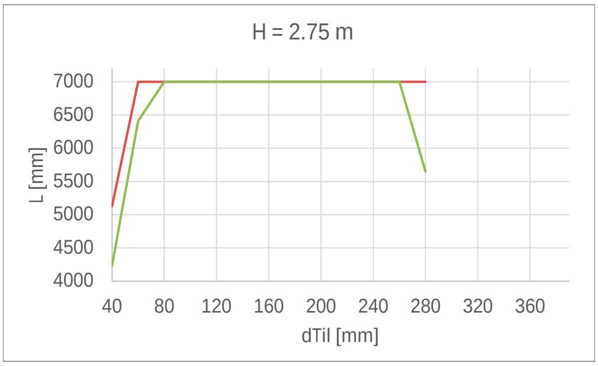
-40°C

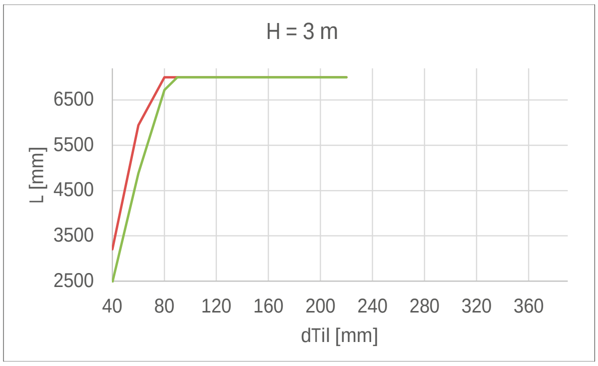
L - Length of the panel
H - Height of the panel
d_{Til} - Thickness of thermal insulation

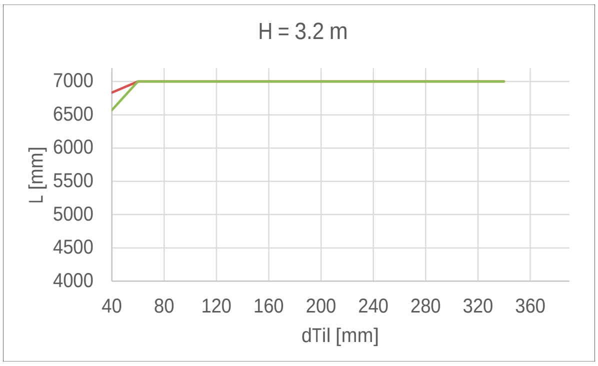












Design boundaries:

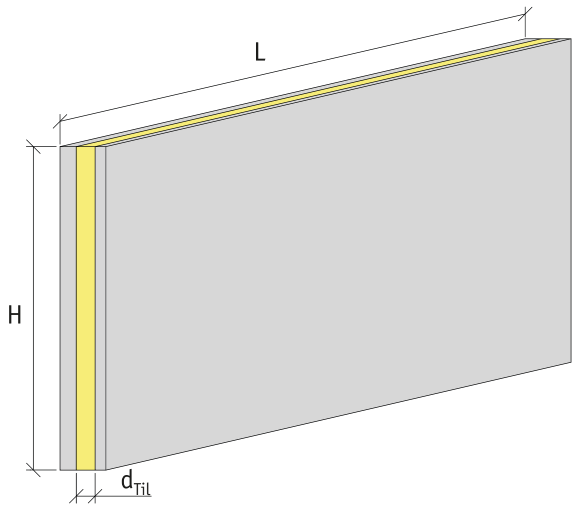
Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	400 mm
Maximal surface temperature:	70°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.8kN/m^2
Adhesion of formwork:	2kN/m^2
Dynamic factor:	2.5

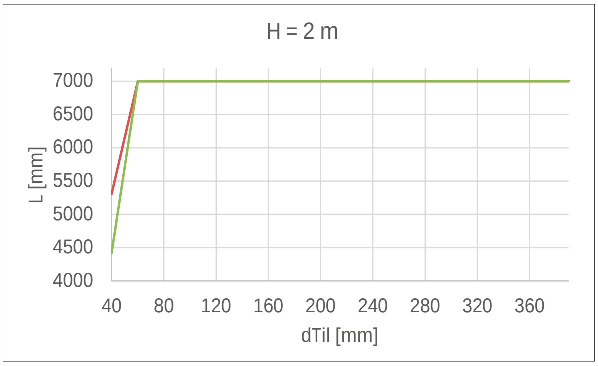
Minimum surface temperature of outer concrete layer:

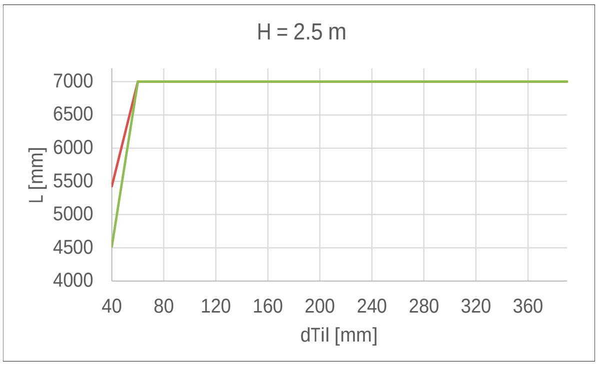
-30°C

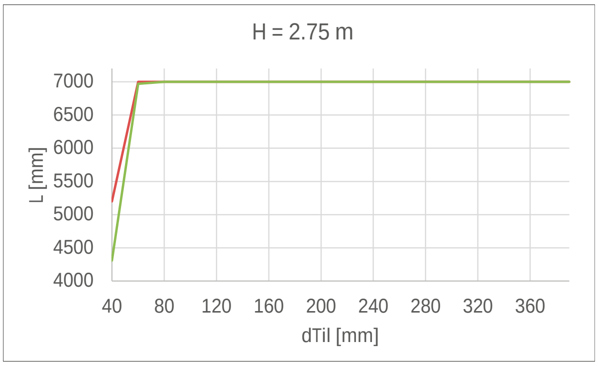
-40°C

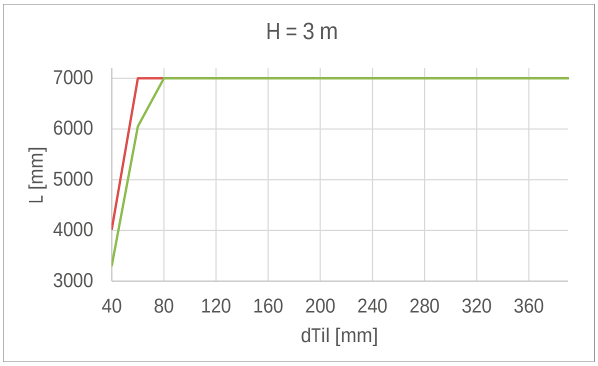
L - Length of the panel
H - Height of the panel
d_{Til} - Thickness of thermal insulation

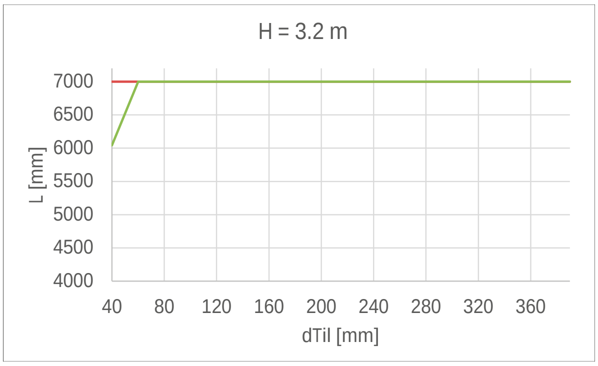












Design boundaries:

Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	600 mm
Maximal surface temperature:	70°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.8kN/m²
Adhesion of formwork:	2kN/m²
Dynamic factor:	2.5

Minimum surface temperature of outer concrete layer:

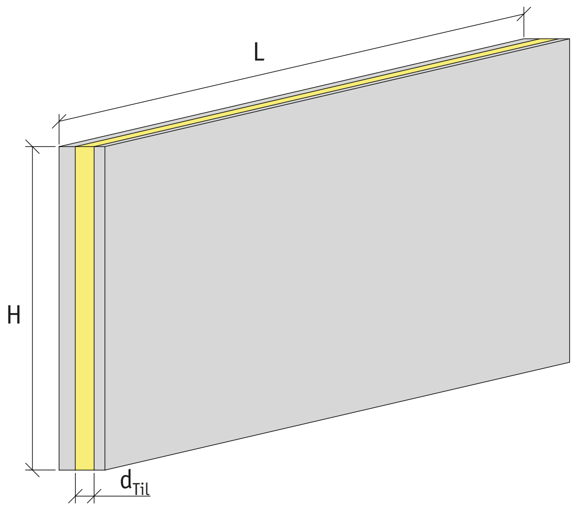
-30°C (red)

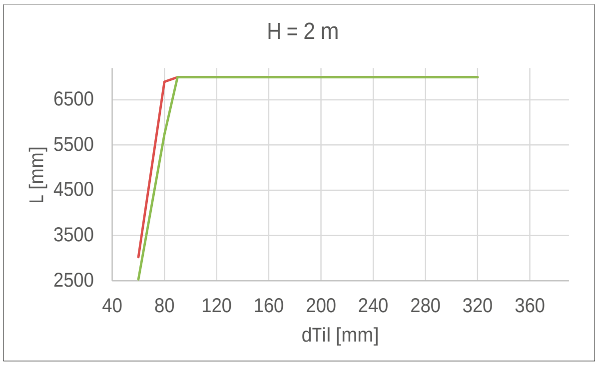
-40°C (green)

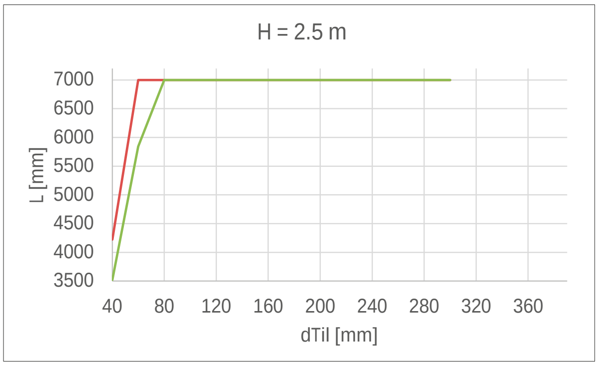
L - Length of the panel

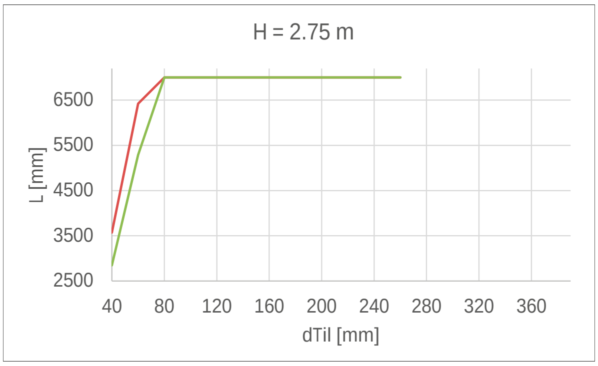
H - Height of the panel

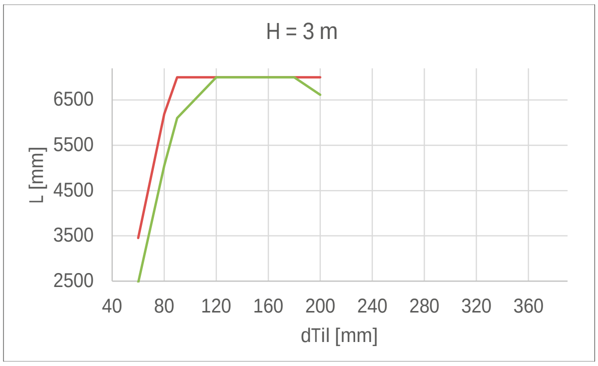
d_{Til} - Thickness of thermal insulation

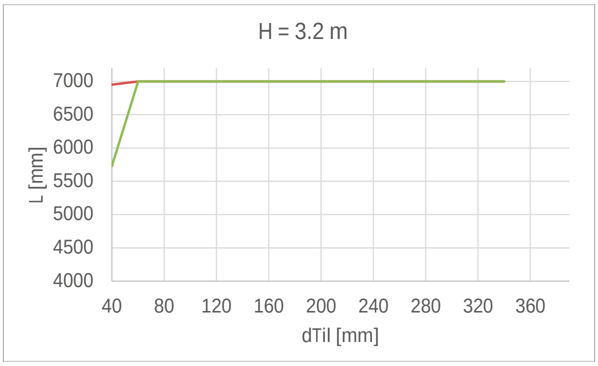












Design boundaries:

Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	400 mm
Maximal surface temperature:	82°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.8kN/m²
Adhesion of formwork:	2kN/m²
Dynamic factor:	2.5

Minimum surface temperature of outer concrete layer:

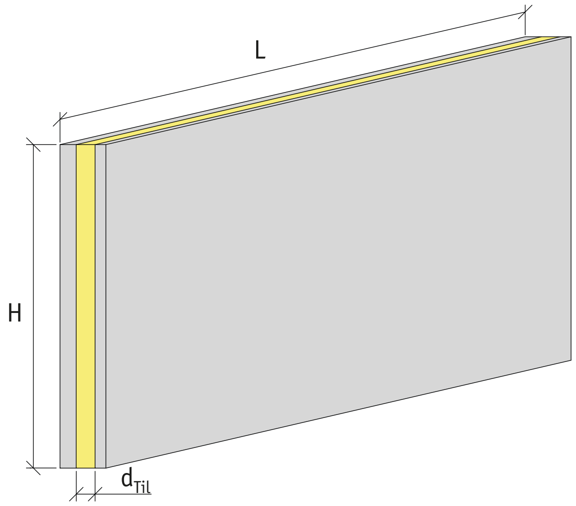
-30°C

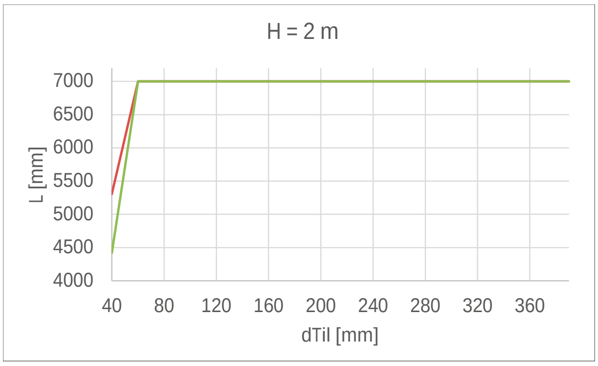
-40°C

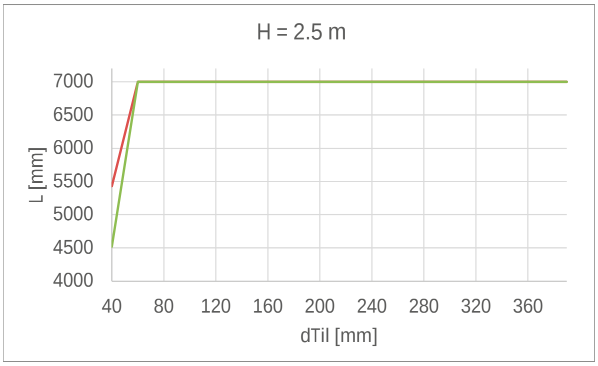
L - Length of the panel

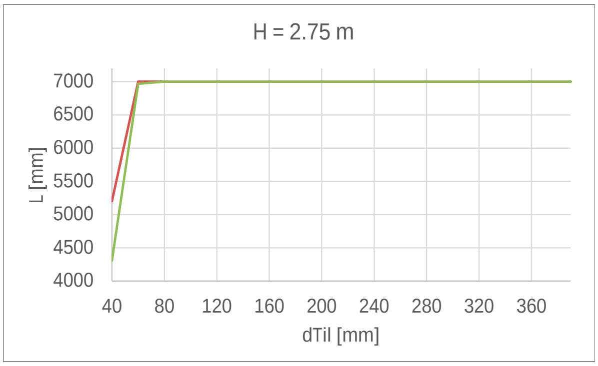
H - Height of the panel

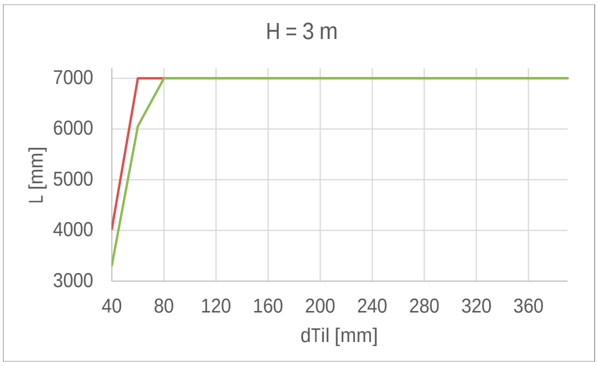
d_{Til} - Thickness of thermal insulation

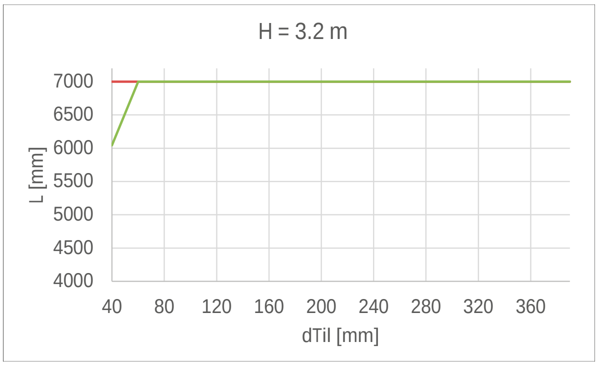












Design boundaries:

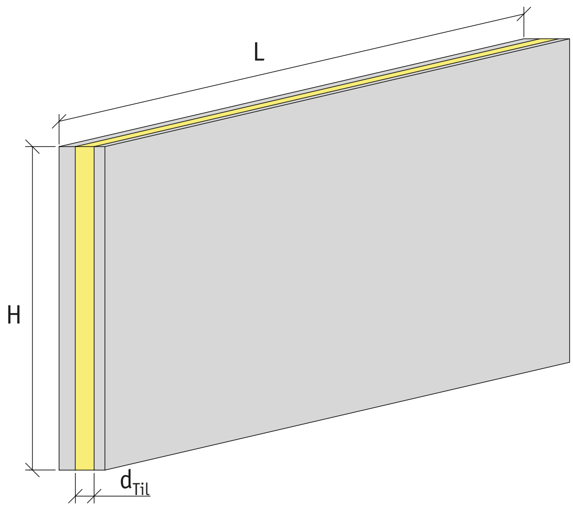
Concrete grade:	C30/37
Thickness of outer layer:	80 mm
Spacing of Diagonal Ties:	600 mm
Maximal surface temperature:	82°C
Temperature gradient:	ΔT= ±5°C
Wind suction:	-0.8kN/m²
Adhesion of formwork:	2kN/m²
Dynamic factor:	2.5

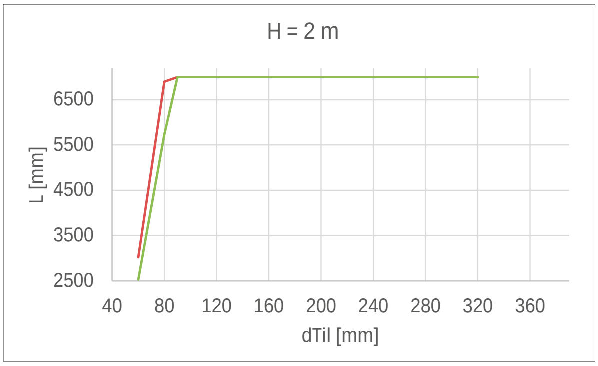
Minimum surface temperature of outer concrete layer:

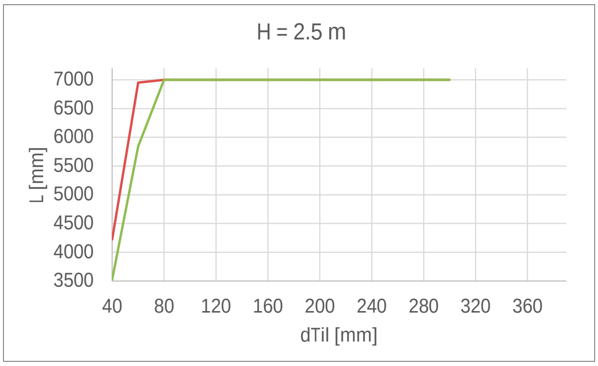
-30°C

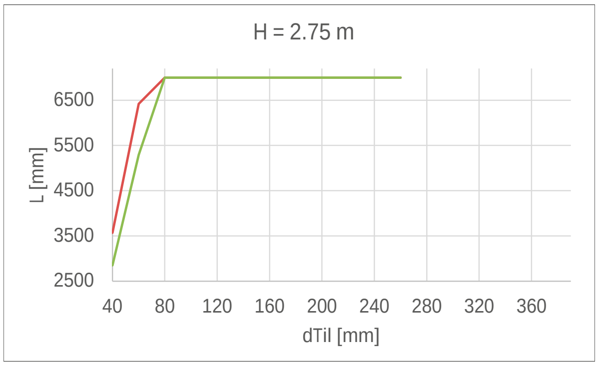
-40°C

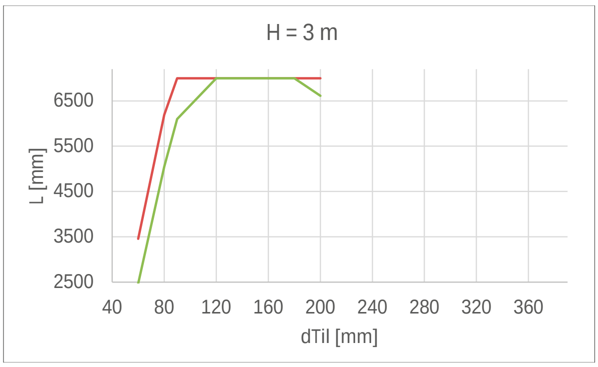
L - Length of the panel
H - Height of the panel
d_{Til} - Thickness of thermal insulation

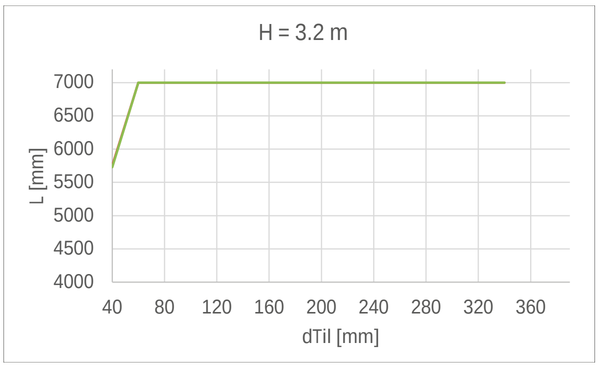












For panels outside of the scope of application defined in part 1.2 of the technical manual, a customized design may be made by Peikko's Customer engineering service.

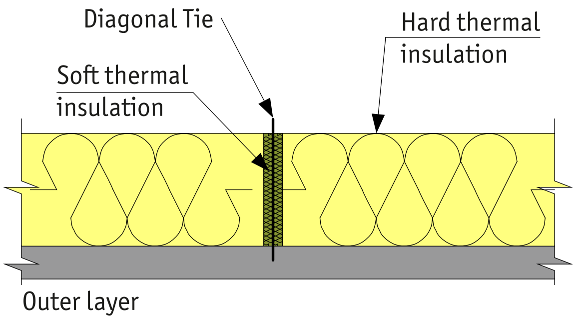
Ties

The Ties are installed into fresh concrete in turns with insulation panels. This ensures that the correct required anchoring of the tie occurs in the lower concrete panel. Ties must not be inserted through the insulation. The designed anchoring depth (see Table 1) of the Ties must stay above the insulation. The insulation panel is installed tightly against the tie so that there is no gap around the tie. If hard insulation materials are being used, diagonals create a gap between the insulation panels. The gap must be filled with a material such as PU foam before the top concrete layer is cast (see *Figure 21*). The fill material cannot be of an expanding type. Thin plates of soft thermal insulation (20 mm) could be placed between hard insulation plates and ties instead of PU foam (see *Figure 22*). The standard length of Diagonal Ties is 2400 mm. Multiple Diagonal Ties may be placed in one row without splicing (see *Figure 20*).

Figure 20. Installation of Diagonal Ties.

Figure 21. Filling the gaps of hard insulation.

Figure 22. Soft thermal insulation between hard thermal insulation



Connector Pins

The waved end of PPI Connector Pins is pushed straight through the insulation into the fresh concrete layer. During installation, the pin is moved back and forth to cause the concrete to compact around the pin. The hooked loop of the pin is installed so that the mesh reinforcement bar will be in the pin's loop.

The PDQ Connector Pin is hung on the reinforcing mesh of the outer layer (see *Figure 24*). During installation of the thermal insulation, it is advisable to cut insulation at the position of the pins. The waved end is anchored to the inner layer by the minimum anchorage length (see Table 1).

Figure 23. Concrete cover of Diagonal Ties in the inner layer.

The Pin is installed in the inclined direction with an installing jig (wooden block with 45° angle cut) to ensure the correct installation angle (see *Figure 25*).

If hard insulation material and greater thicknesses make it difficult to install the Pins, pre-drilling small holes for the Pins is recommended.

Figure 24. Installing of PDQ Connector Pin.

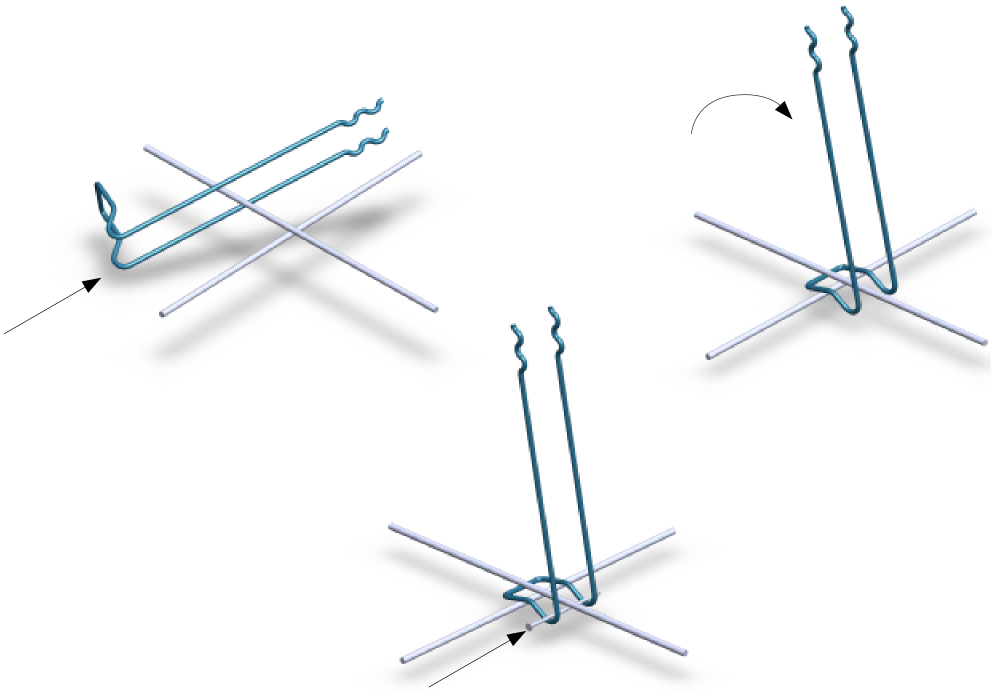
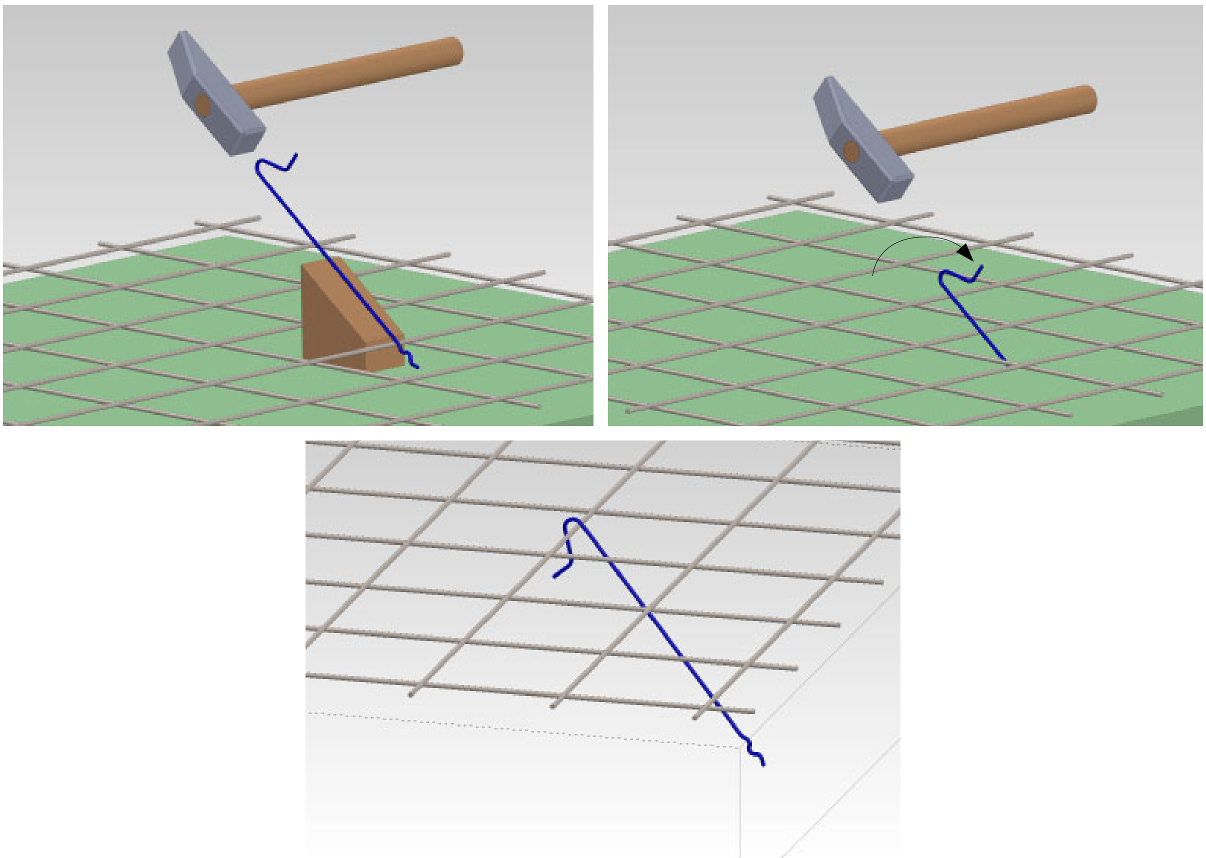


Figure 25. Installation of incline Connector Pin.



PEIKKO GROUP CORPORATION

Peikko Group Corporation is a leading global supplier of concrete connections and composite structures. Peikko's innovative solutions make the customers' building process faster, easier and more reliable. Peikko has subsidiaries in over 30 countries in Asia-Pacific, Europe, the Middle East, and North America, with manufacturing operations in 9 countries. Our aim is to serve our customers locally with leading solutions in the field in terms of quality, safety, and innovation.

Peikko is a family-owned and run company with over 1200 professionals. Peikko was founded in 1965 and is headquartered in Lahti, Finland.