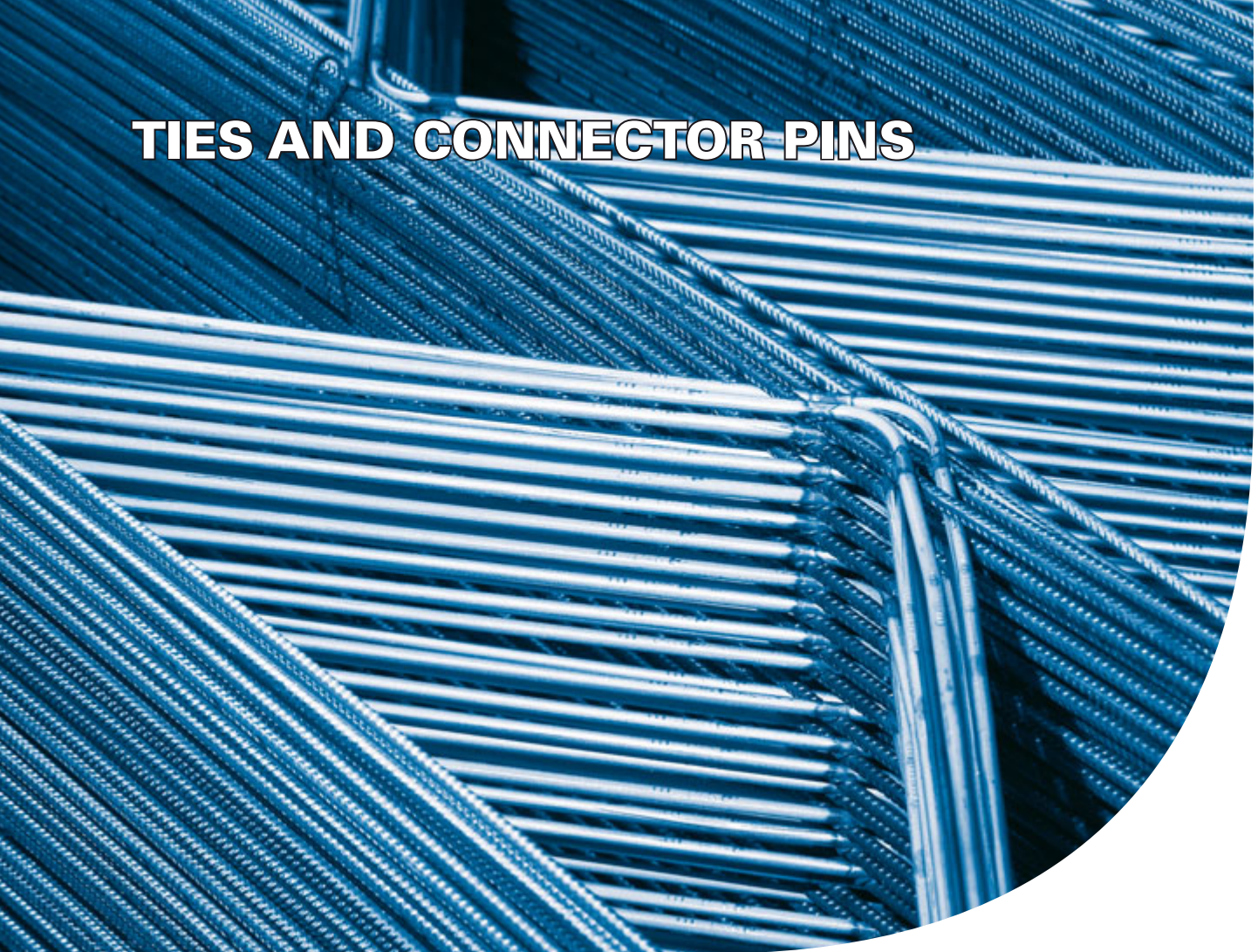


TIES AND CONNECTOR PINS



Version: Peikko Group 9/2010

TIES AND CONNECTOR PINS



Benefits of Ties and Connector Pins

- Covers all insulation thicknesses for the future – energy saving constructions!
- Reliable and well-known connector for sandwich element panels with over 45 years of use experience.
- Easy to install between insulation pieces.
- Stainless material inside insulation layer.
- Sizes according to insulation thicknesses.
- Beam tie for low elements and openings.
- Prefabricated products guarantee stable and high quality and accurate deliveries.
- Provides effective workflow for the customer.



Peikko benefits

- Reliable: passed demanding test program
- Competitive price and delivery time
- Economical and easy to use in designing, manufacturing and installation of the elements

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TIES AND CONNECTOR PINS

1. DESCRIPTION OF THE SYSTEM

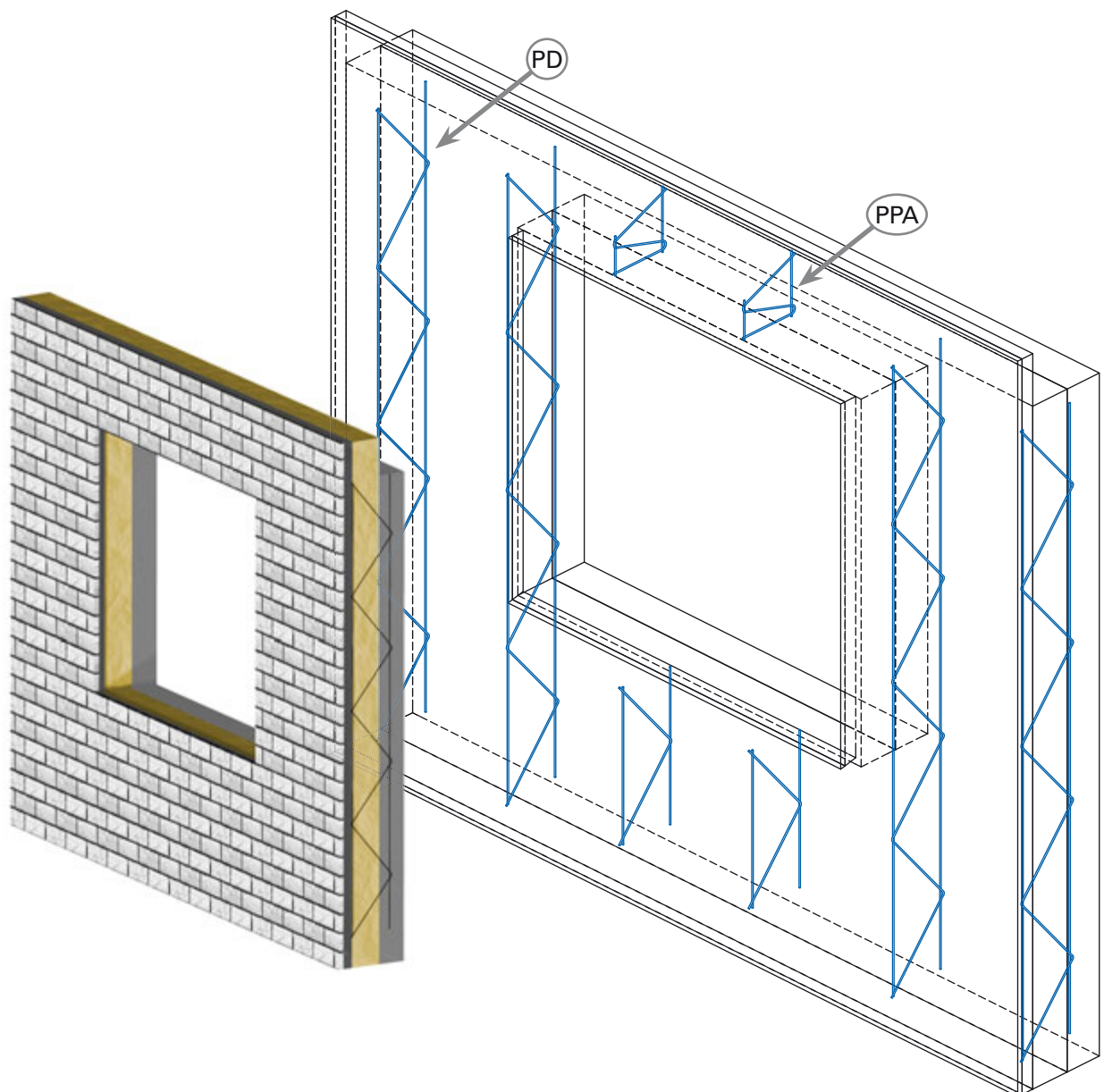
Ties are connecting reinforcement which allows the joining of sandwich wall concrete panels together. Sandwich wall's design is based on logic that outer panel's self weight is hung with ties and connectors into inner panel.

PD diagonal ties are designed to join sandwich panel's concrete layers together from full height of the panel.

PPA beam ties can be used in low structures e.g. door and window beams and also in low socle elements.

PPI and PDQ connector pins are used to connect the concrete panels of the sandwich wall together. The connector pins can be used for example in polyurethane or EPS insulated sandwich panels, panels where footing or foundation carries the outer concrete panel and in edges of the panels as an additional tie.

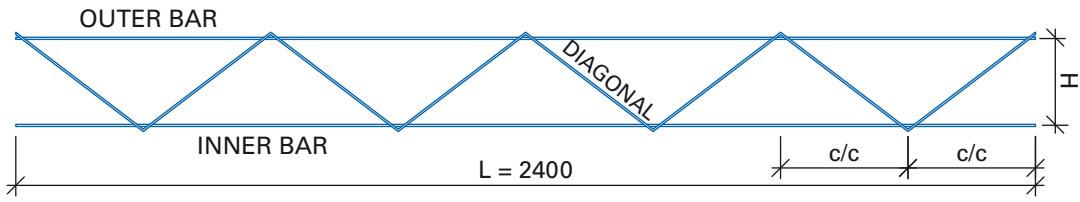
Figure 1. PD diagonal ties and PPA beam ties in wall element.



2. DIMENSIONS AND MATERIALS

2.1 PD diagonal ties

Table 1. Dimensions of the PD diagonal ties [mm].

				
Tie model	H (bars' c/c)	Spacing c/c*	Recommended insulation thickness	Length L
PD / PDM / PDR 100	100	300	40	2400
PD / PDM / PDR 120	120	300	60	
PD / PDM / PDR 140	140	300	80	
PD / PDM / PDR 150	150	300	90	
PD / PDM / PDR 180	180	300	120	
PD / PDM / PDR 200	200	300	140	
PD / PDM / PDR 210	210	300	150	
PD / PDM / PDR 220	220	300	160	
PD / PDM / PDR 240	240	300	180	
PD / PDM / PDR 260	260	300	200	
PD / PDM / PDR 280	280	300	220	
PD / PDM / PDR 300	300	300	240	
PD / PDM / PDR 320	320	300	260	
PD / PDM / PDR 340	340	300	280	
PD / PDM / PDR 360	360	300	300	
PD / PDM / PDR 380	380	300	320	
PD / PDM / PDR 400	400	300	340	
PD / PDM / PDR 420	420	300	360	
PD / PDM / PDR 440	440	300	380	
PD / PDM / PDR 450	450	300	390	

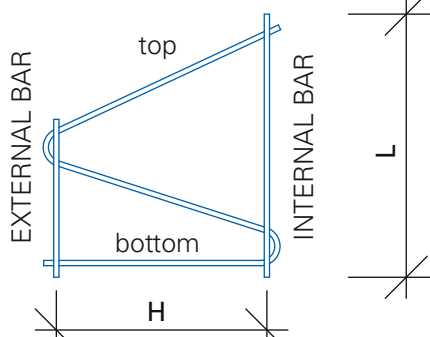
PD tie's standard length L is 2400 mm. PD ties can be manufactured in multiples of 300 mm. Tie's H_{min} is 100 mm and H_{max} is 450 mm.

* c/c spacing can be other than 300 mm when the ties are ordered as a special product

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2.2 PPA beam ties

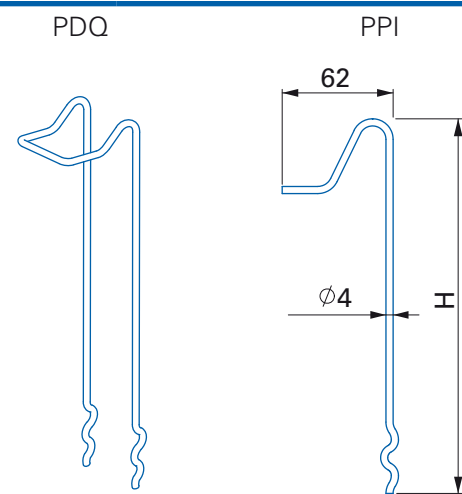
Table 2. Dimensions of the beam ties [mm].

			
PPA beam tie	H	L	Recomm. insulation thickness
PPA 150	150	250	90
PPA 180	180	250	120
PPA 200	200	250	140
PPA 210	210	250	150
PPA 220	220	250	160
PPA 240	240	250	180
PPA 260	260	250	200
PPA 280	280	250	220
PPA 300	300	250	240
PPA 320	320	300	260
PPA 340	340	300	280
PPA 360	360	350	300
PPA 380	380	350	320
PPA 400	400	350	340
PPA 420	420	400	360
PPA 440	440	400	380
PPA 450	450	400	390

Note! All product sizes are not available directly from the stock. Please check the stock availability from valid price list or product catalogue (PPA, PPI and PDQ).

2.3 PPI and PDQ connector pins

Table 3. Dimensions of PPI and PDQ connector pins and advisable insulation thicknesses [mm].

			
Connector pin model	H	Recommended insulation thickness	
		when installed	
		straight (PPI & PDQ)	in 45° angle (PPI only)
PPI/PDQ 170	170	80	-
PPI/PDQ 190	190	100	-
PPI/PDQ 210	210	120	-
PPI/PDQ 230	230	140	80
PPI/PDQ 250	250	160	100
PPI/PDQ 280	280	190	120
PPI/PDQ 300	300	210	140
PPI/PDQ 320	320	230	160
PPI/PDQ 340	340	250	170
PPI/PDQ 360	360	270	190
PPI/PDQ 380	380	290	200
PPI/PDQ 400	400	310	210
PPI/PDQ 420	420	330	230
PPI/PDQ 440	440	350	240
PPI/PDQ 450	450	360	250

The minimum length of connector pin is insulation thickness +90 mm.

2.4 Materials

Table 4. Materials and material strengths.

	Material	Strength (cold formed)
①	Black reinforcement steel	$f_{yk} \geq 500 \text{ N/mm}^2$
②	Stainless reinforcement steel	$\sigma_{0,2} \geq 600 \text{ N/mm}^2$
③	Stainless steel	$\sigma_{0,2} \geq 500 \text{ N/mm}^2$

Table 5. Material options.

Tie	Internal bar	External bar	Diagonal
PDM	① Ø 5 mm	① Ø 5 mm	③ Ø 5 mm
PD	① Ø 5 mm	② Ø 5 mm	③ Ø 5 mm
PDR	② Ø 5 mm	② Ø 5 mm	③ Ø 5 mm
PPA	② Ø 5 mm	② Ø 5 mm	② Ø 5 mm

The material of PPI connector pin is ② Ø 4 mm.

3. MANUFACTURING

3.1 Manufacturing method and markings

Ties are produced by using automatic resistance welding and are cut mechanically to length.

The connector pins are cut and bent mechanically.

Each package of ties is marked with the mark of Inspecta Certification, the emblem of Peikko Group, the type and quantity of the product and manufacturing date.

Stainless outer bar of PD tie is marked with yellow paint marks at both ends of the bar.

Figure 2. Stainless rebar of PD tie is marked with yellow.



Connector pin packages are marked with type of the pin and the emblem of Peikko Group. Package size 500 pcs.

3.2 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

3.3 Quality control

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

The welding joint is tested according to EN 10080 and EN 15630-2.

Figure 3. Ties being tested.



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4. RESISTANCES

4.1 Welding joints

Table 6. The welding joint between diagonal and bar [kN].

Characteristic tensile resistance N_{Rsk}	7,0
Resistance value N_{Rsd}	5,6

4.2 Anchoring the cross joint

Table 7. Resistance of the cross joint anchoring [kN].

Concrete strength	$\geq C12/15$	
The anchor depth of bars	15 mm (+5)	25 mm (± 5)
Characteristic tensile resistance N_{Rck}	4,7	7,0
Resistance value N_{Rcd}	3,8	5,6

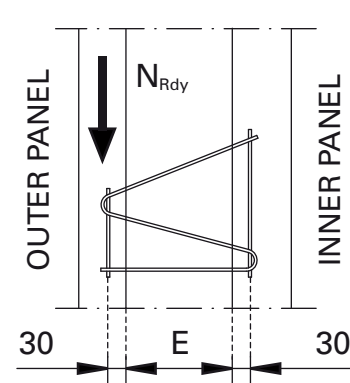
4.3 Resistances of PPI and PDQ connector pins

Table 8. Resistances of PPI and PDQ connector pins [kN].

Concrete strength	$\geq C25/30$
Characteristic tensile resistance N_{Rck}	7,0
Resistance value N_{Rcd}	3,5

4.4 Resistances of PPA beam tie

Table 9. The vertical resistance of PPA beam tie [kN].

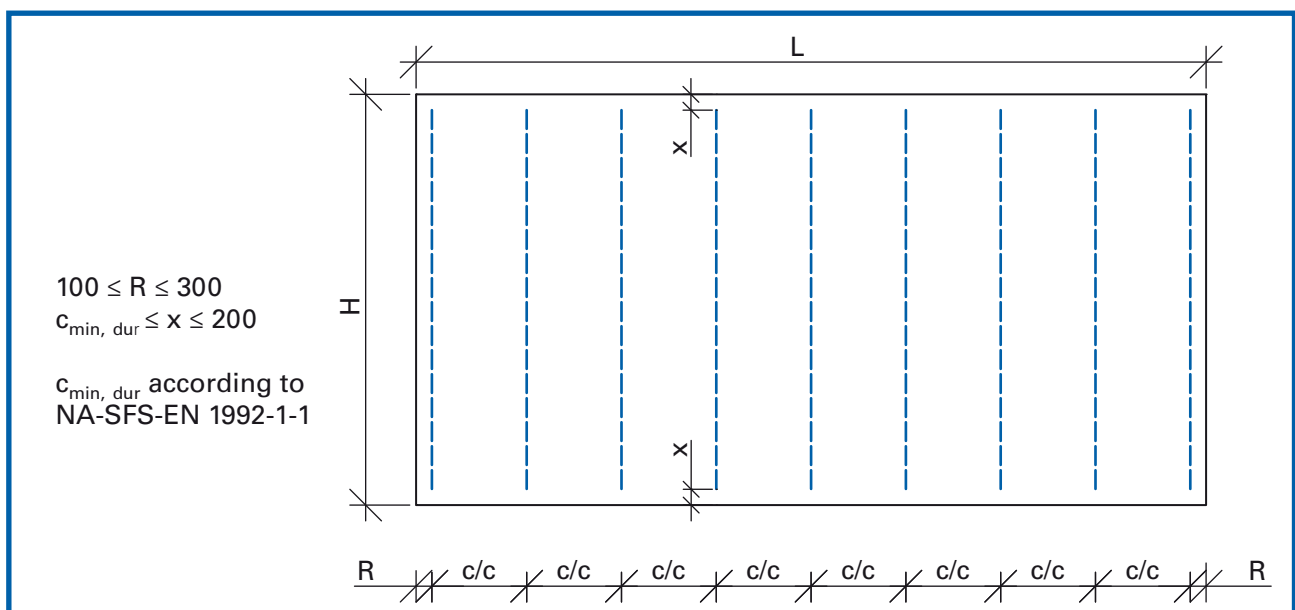
<p>Concrete $C \geq 12/15$</p> 	
Concrete	C12/15
Vertical characteristic resistance N_{Rky}	1,5
Vertical design resistance N_{Rdy}	1,1

5. DESIGN

5.1 Design principles

In load bearing wall elements the inner panel is the load bearing structure. Because the inner panel is thin therefore its stability limits its resistance.

Figure 4. Positioning of the ties in element.



$c_{min, dur}$ = Minimum concrete cover due to exposure conditions

Design is based on the concept that outer panel weight is hung into inner panel.

When designing element all the different situations (production, lifting, transport, erection) have to be taken into account.

The element is lifted up from both panels, for example with Peikko® PNLF lifting hooks, which have anchoring legs for both panels.

If the element is lifted only from the inner panel, then the element designer has to take this into account in element design.

5.1.1 Selecting the type of tie

The height (H dimension) of the tie's bars is selected according to insulation thickness and required anchoring depth. Recommended height for the tie is insulation thickness +60 mm, which means that the anchoring depth of the bar is 27 mm.

5.1.2 Positioning of the ties

If the outer panel is hung, the c/c spacing of the ties is typically the same as the insulation width.

Attention has to be paid to the effect that are caused by openings. In narrow spaces (300 – 600 mm) two ties are used.

The outermost tie's distance R (see figure) from the element's edge has to be between 100 – 300 mm. Tie's edge distance x (see figure) from upper and bottom edge has to be ≤ 200 mm. Placing the ties near the element edge will reduce element edges from warping. The smallest c/c of the ties is 100 mm.

5.1.3 Requirements for concrete and reinforcement

The concrete strength of the element has to be at least C12/15 before lifting, handling or removing the element from the mould. Otherwise the concrete has to correspond to local building codes concerning wall elements.

Distances between diagonals in PD are designed for c/c 150 meshes. This way the ties never change the position of the mesh.

The designer has to take care of the concrete cover thickness. The thickness of concrete cover must be adequate according to environmental exposure class, fire resistance class and intended operating life. Required edge and central distances have to be followed and taken into account.

5.1.4 Dimensioning principle

Outer panel weight is hung into the inner panel, see Figure 5.

Tension resistance of a single diagonal (anchoring depth ≥ 25 mm into concrete panels) (see tables 6 and 7):

$$N_{Rd} = \frac{N_{Rk}}{\gamma_{Mw}} = \frac{7,00}{1,25} = 5,60 \text{ kN}$$

Vertical tension resistance N_{Rdy} :

$$N_{Rdy} = N_{Rd} \times \cos 45^\circ = 5,60 \times \cos 45^\circ = 3,96 \text{ kN}$$

Requirement: $N_{Rdy} \geq G_d$

G_d = design value of outer panel weight

$G_d = \gamma_G \times G_k$

G_k = characteristic value of outer panel weight

γ_G = partial factor for permanent action

Required pieces of tensile diagonals n_{req} :

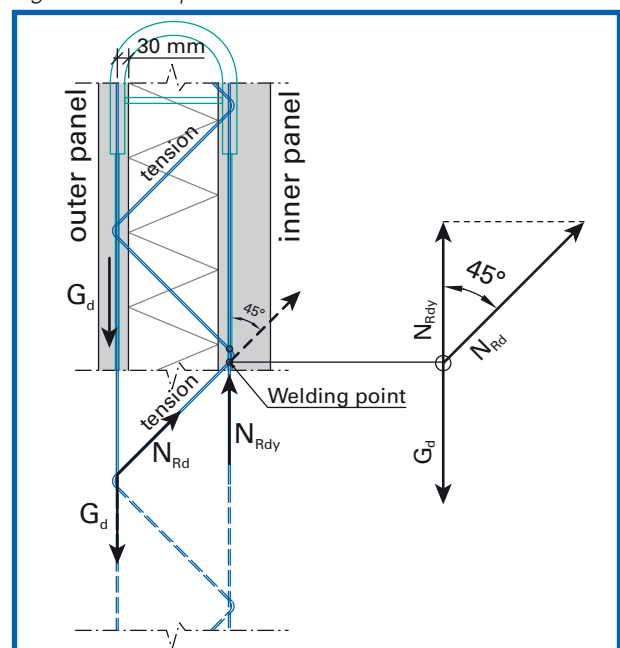
$$n_{req} \geq \frac{\gamma_G \times G_k}{N_{Rdy}}$$

$$\text{if } \gamma_G = 1,35 \rightarrow n_{req} \geq \frac{1,35 \times G_k}{3,96} \geq 0,34 \times G_k$$

Requirements:

- Concrete strength \geq C12/15 before lifting
- Anchoring depth ≥ 25 mm
- Lifting parts are anchored into both outer and inner panels

Figure 5. Concept of load transfer.



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5.2 Connector pin design

5.2.1 Limitations for application

Connector pin requires 50 mm anchoring depth. Anchoring depth is ensured by installing the pin through insulation up to the bended limiter in the pin.

5.2.2 Design rules information

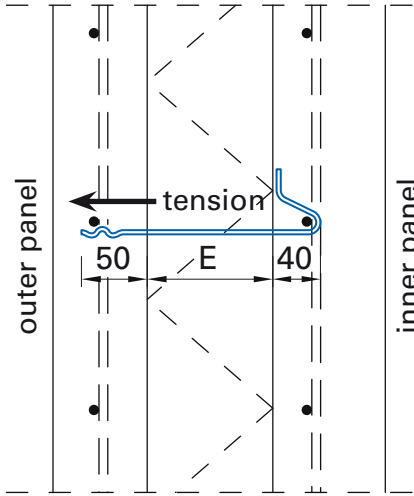
Connector pins are installed to the whole sandwich wall with maximum distance of 500 mm.

To prevent the warping of the outer concrete panel the row of first pins must be located less than 150 mm from the edge of the panel. One pin is located and installed at every corner.

If connector pin is installed perpendicular to the face of the panel it cannot support the weight of the panel. This way installed it connects panels together against tension along the pin.

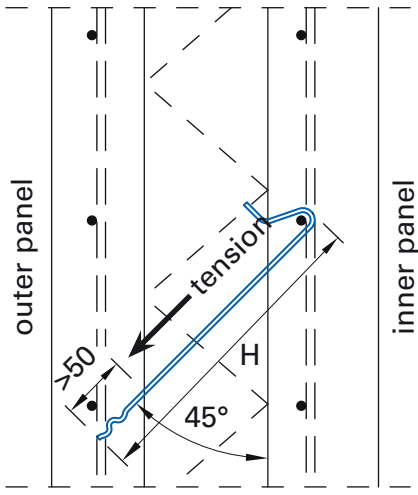
Connector pin can also be used in inclined diagonal direction. Inclined diagonal use requires special length pin and installing jig so that sufficient anchoring length can be achieved. Diagonal pin can be replaced with PPA beam tie.

Table 10. Measurements of the pin in perpendicular use.

		
Insulation [mm]	Connector pin	
80	PPI 170	PDQ 170
100	PPI 190	PDQ 190
120	PPI 210	PDQ 210
140	PPI 230	PDQ 230
160	PPI 250	PDQ 250
190	PPI 280	PDQ 280
210	PPI 300	PDQ 300
230	PPI 320	PDQ 320
250	PPI 340	PDQ 340
270	PPI 360	PDQ 360
290	PPI 380	PDQ 380
310	PPI 400	PDQ 400
330	PPI 420	PDQ 420
350	PPI 440	PDQ 440
360	PPI 450	PDQ 450

Note! All product sizes are not available directly from the stock. Please check the stock availability from valid price list or product catalogue.

Table 11. Installation of the connector pin in inclined position with installing jig.

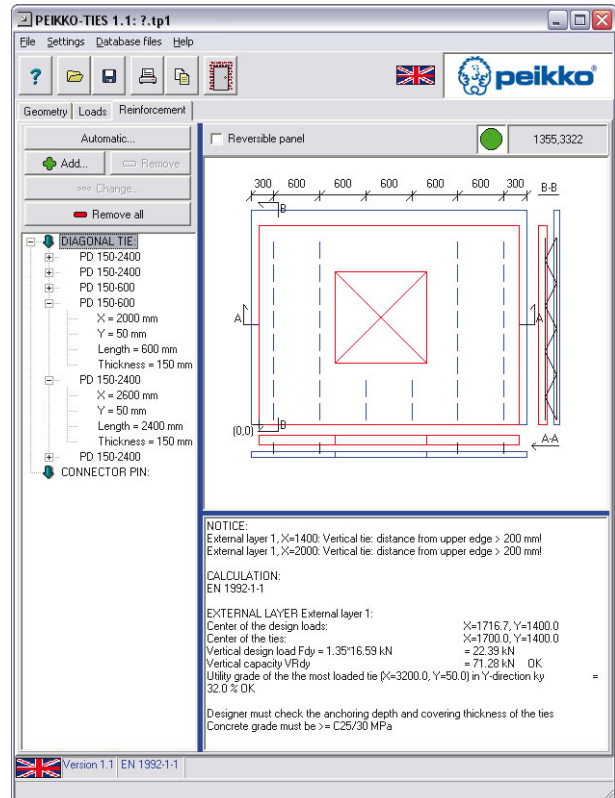


Insulation [mm]	Connector pin
80	PPI 230
100	PPI 250
120	PPI 280
140	PPI 300
160	PPI 320
170	PPI 340
190	PPI 360
200	PPI 380
210	PPI 400
230	PPI 420
240	PPI 440
250	PPI 450

5.3 Design software

Peikko dimensioning program *Peikko-Ties* is available from www.peikko.com.

Figure 6. *Peikko-Ties* dimensioning program.



6. INSTALLATION

6.1 Installation of ties

The ties are installed into fresh concrete in turns with insulation panels. This way it can be ensured that the proper and required anchoring of the tie occurs in the lower concrete panel. Ties are not allowed to be inserted through the insulation. Designed anchoring depth (usually 30 mm) of the tie has to stay above the insulation. The insulation panel is installed tightly against the tie so that there is no gap around the tie.

Stainless steel bar marked with yellow paint at the end of the bar is meant for the outer panel of the sandwich wall.

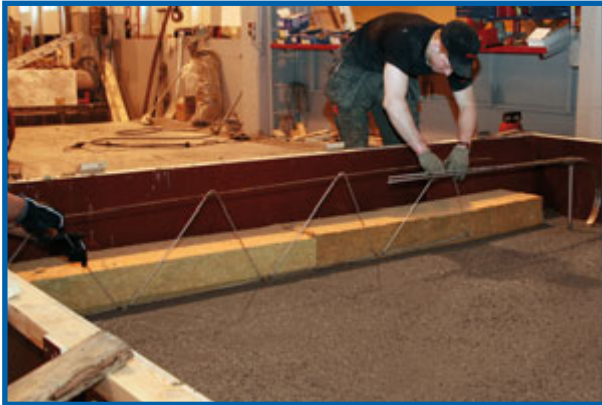
The erection, lifting and handling of elements has to be done according to designs.

If hard insulation materials are being used it may be advisable to leave a 15 mm gap between the insulation panels for the ties. The gap has to be filled with e.g. PU-foam before the top concrete layer is

TIES AND CONNECTOR PINS

cast. The used fill material can not be expanding type.

Figure 7. Tie installation in precast plant.



6.2 Installation of connector pins

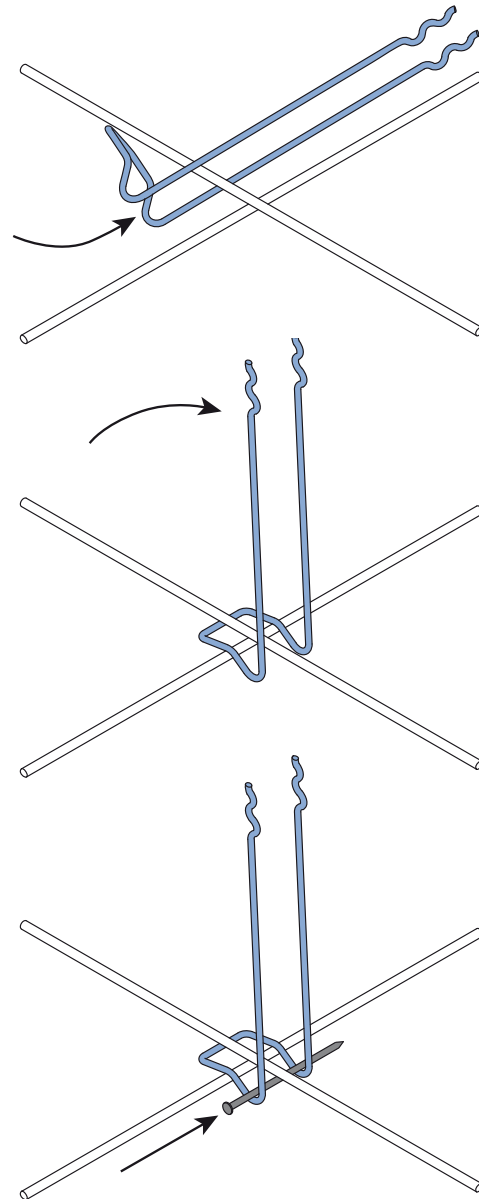
Connector pin's waved end is pushed straight through the insulation to the right level. During installation the pin is moved back and forth so that concrete will compact around the pin. The hooked loop of the pin is installed so that one mesh reinforcement bar will be in pin's loop.

Pin in inclined direction is installed with installing jig which ensures the right installation angle.

If hard insulation material and bigger thicknesses will make the installing of the pins difficult, pre drilling of small holes for pins is recommended.

6.2.1 Installation of PDQ pins

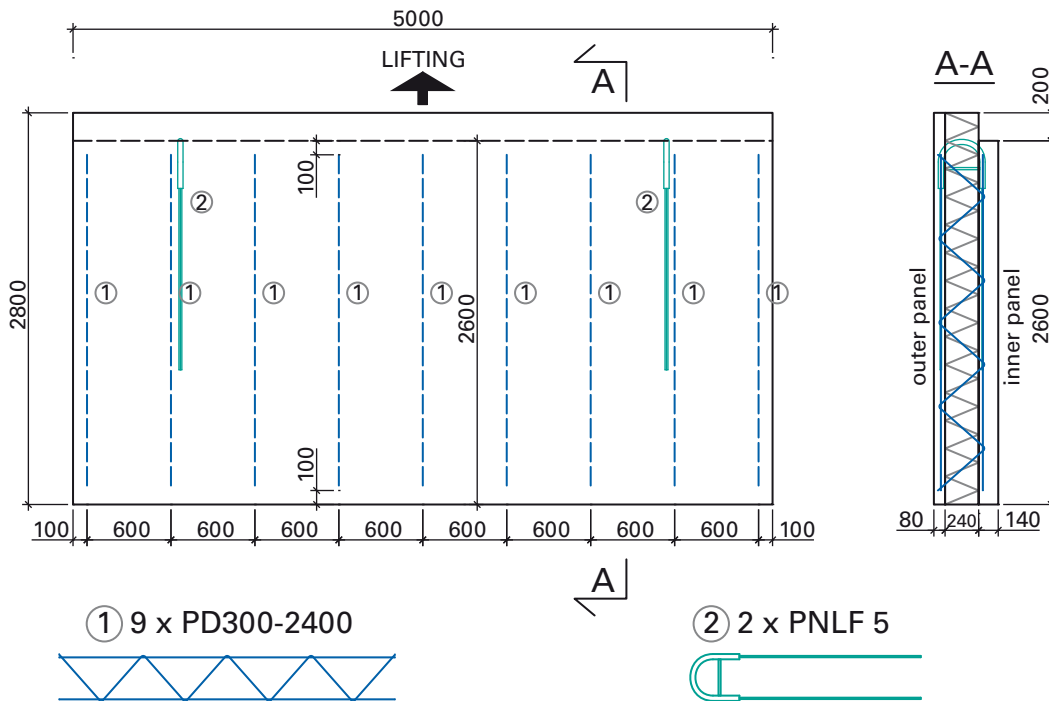
Figure 8. PDQ tie installation.



7. EXAMPLES OF DESIGN

The required ties for the sandwich panels are calculated by following method. Outer panel is hung from the load bearing inner panel. Ties can be measured also with Peikko-Ties dimensioning program. The free program is available to download from www.peikko.com.

Example 1

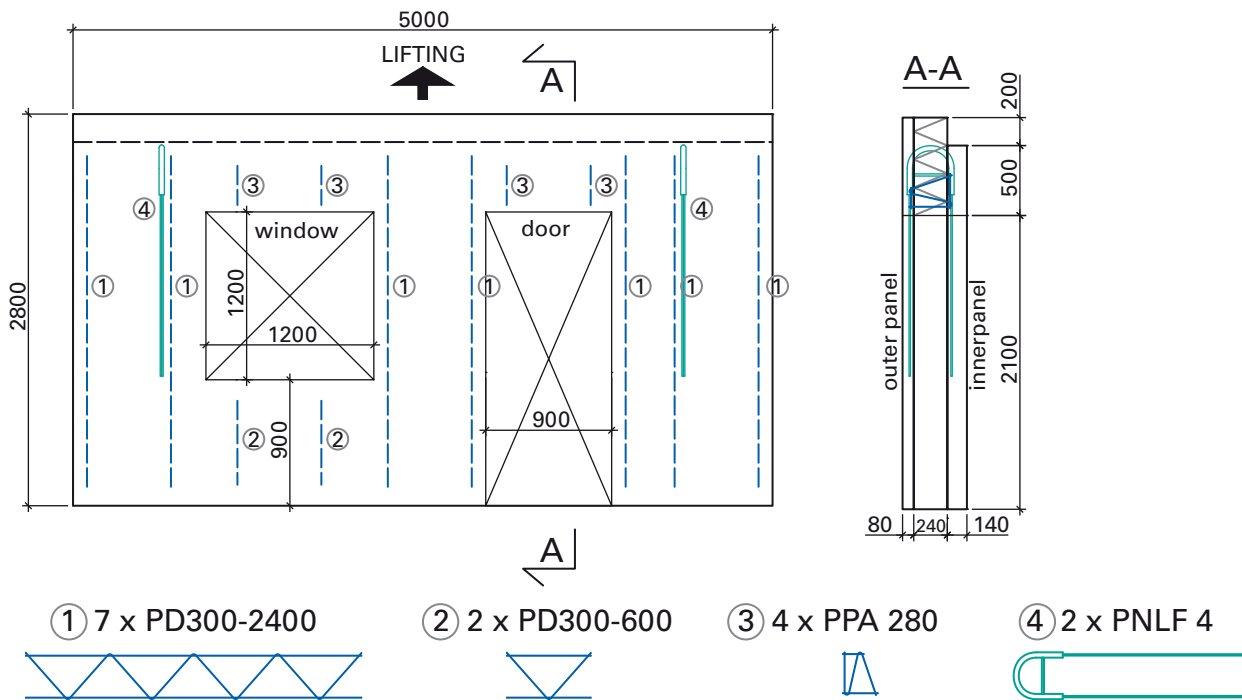


Lifting:

- Outer and inner panels are connected together with PNLF lifting hook.
- Lifting in vertical direction
- Weight of sandwich wall element:
 $G_{k, \text{tot}} = 74,9 \text{ kN}$
 Lifting spread angle $\beta \leq 60^\circ$
 \rightarrow Selected PNLF 5 ($G_{\text{max}} \leq 83,1 \text{ kN}$)
- Outer panel weight G_k
 $G_k = 5,00 \times 2,80 \times 0,08 \times 25$
 $G_k = 28,0 \text{ kN}$
- Required tensile diagonals
 $n_{\text{req}} \geq 0,34 \times 28,0$
 $n_{\text{req}} \geq 9,5 \rightarrow 10 \text{ pcs}$
 Selected $4 \times 9 = 36 > 10 \text{ OK}$
- Required height H of ties:
 $H_{\text{req}} \geq E + 60$
 $H_{\text{req}} \geq 240 + 60$
 $H_{\text{req}} \geq 300 \text{ mm}$
 \rightarrow Selected PD 300-2400

TIES AND CONNECTOR PINS

Example 2



Like Example 1 but window and door openings added.

$$G_{k, \text{tot}} = 56,2 \text{ kN}$$

$$\beta \leq 60^\circ \rightarrow \text{PNLF 4 selected (} G_{\text{max}} \leq 56,6 \text{ kN)}$$

Outer panel weight:

$$G_k = 21,3 \text{ kN}$$

$$\rightarrow n_{\text{req}} \geq 0,34 \times 21,3$$

$$n_{\text{req}} \geq 7,3 \rightarrow 8 \text{ pcs}$$

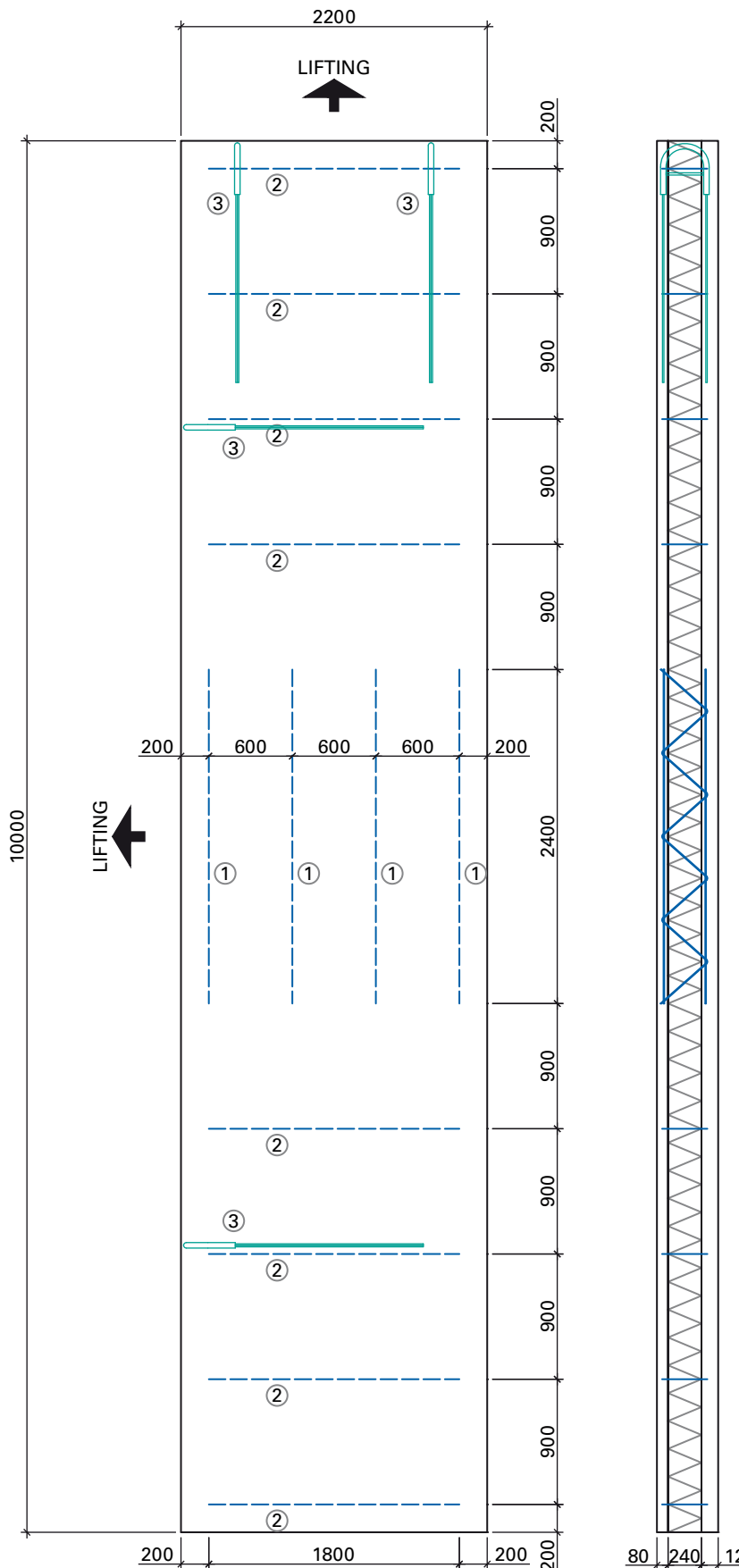
Selected:

$$n = (4 \times 7) + 2$$

$$n = 30 > 8 \text{ OK}$$

Note! The additional resistance resulted from the PPA beam ties is not taken into account in the example.

Example 3



① 4 x PD300-2400



② 8 x PD300-1800



③ 4 x PNLF 6



Weight of SW-wall element:

$$G_{k, \text{tot}} = 112,2 \text{ kN}$$

$$\beta \leq 60^\circ \rightarrow \text{PNLF 6 selected}$$

$$(G_{\text{max}} \leq 124,1 \text{ kN})$$

Lifting in vertical and horizontal directions → PD-ties must bear outer panel weight in two directions. Outer and inner panels are connected together for lifting with PNLF hooks.

Outer panel weight:

$$G_k = 44,0 \text{ kN}$$

Required number of tensile diagonal pieces:

$$n_{\text{req}} \geq 0,34 \times 44,00$$

$$n_{\text{req}} \geq 14,96 \rightarrow 15 \text{ pcs}$$

Vertical:

Selected pos ①

$$n = 4 \times 4 = 16 > 15 \text{ OK}$$

Horizontal:

Selected pos ②

$$n = 3 \times 8 = 24 > 15 \text{ OK}$$

Note! Warping and thermal expansion of the outer panel has not been taken into account in the example.



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