PHILIPPGROUP

Power Duo System

Installation Instruction

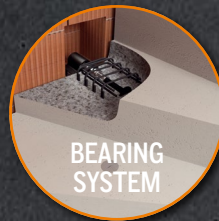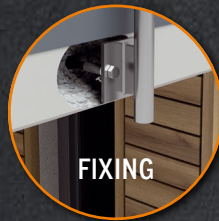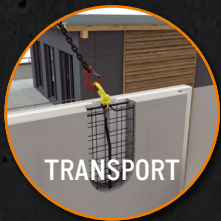## Our products from the division
BUILDING SOLUTIONS

SERVICES

» On-site tests -> we ensure that your requirements are properly covered by our planning.

» Test reports -> for your safety and documentation.

» Trainings -> the knowledge of your employees from planning and production is enhanced by our experts on site, online or via webinar.

» Planning support -> latest design software, planning documents, CAD data and much more can be downloaded any time from www.philipp-group.de.

HIGH DEMANDS ON PRODUCT SAFETY AND PRACTICALITY

» Close cooperation with notified bodies and - if necessary - approval of our solutions.

TECHNICAL DEPARTMENT

» Our expert-team will support you at any time during your planning phase with detailed advice.
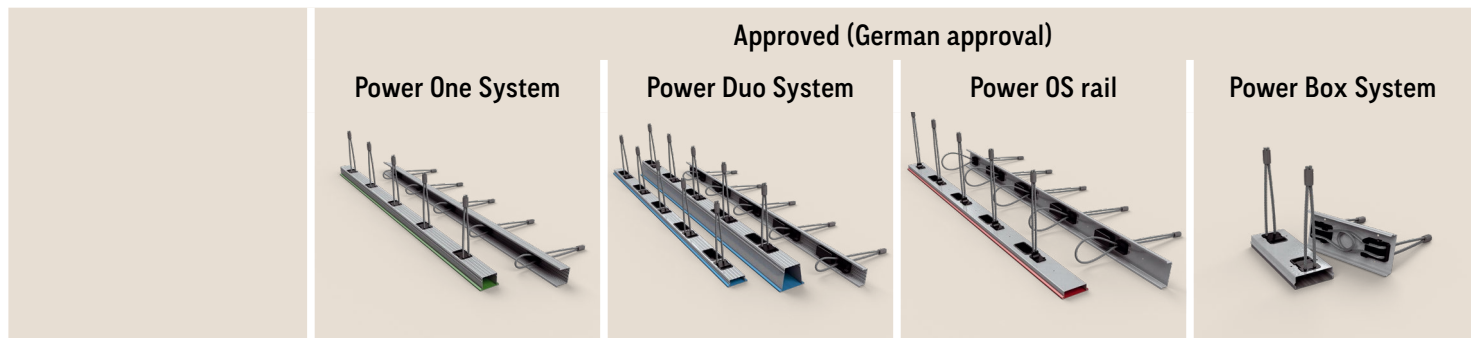
TRANSPORT   CONNECTION   FACADE   FIXING   BEARING SYSTEM   EARTHING

CONTENT

PRODUCT CHARACTERISTICS - OVERVIEW

	Approved (German approval)			
	Power One System	Power Duo System	Power OS rail	Power Box System
LOAD DIRECTIONS / MAX. DESIGN RESISTANCES				
$v_{Rd,\parallel}$ (kN/m)	60.0	90.0	80.0	105.0
$v_{Rd,\perp}$ (kN/m)	37.5	37.5	35.7	28.6
Z_{Rd} (kN/loop)	10.0	10.0	10.0	–
AREA OF APPLICATION (RECOMMENDED)				
Precast building	✓	✓	✓	✓
In-situ concrete constructions	–	–	✓	–
Wall / wall	✓	✓	✓	✓
Wall / wall (T-connection)	–	✓	✓	✓
Wall / column	–	✓	✓	–
Minimum wall thickness (cm)	10	12 / 14 ①	14	14
Concrete strength precast unit	C30/37	C25/30 ② / C30/37	C25/30	C30/37
TECHNICAL INFORMATION				
Technical basis	National technical approval (abZ)	National technical approval (abZ)	National technical approval (abZ)	National technical approval (abZ)
Max. fire resistance	F 180	Firewall (REI 90-M) and also F 180	F 180	F 180
Mortar grouting	Grouting mortar	Thixo- or grouting mortar	Normal weight concrete	Grouting mortar
Manufacturer of mortar	BETEC	BETEC / P&T	–	P&T

① with P&T / ② with BETEC

Constructive

	Connecting rails	Connecting loop
	-	-
	-	-
	-	-
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	-	-
	-	-
	-	-
	F 180	F 180
	Mortar or normal weight concrete	Mortar or normal weight concrete
	-	-
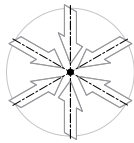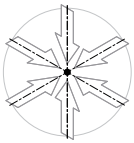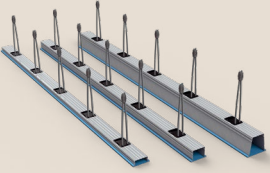
Accessories

for Connecting rails and loop systems

Magnetic fastener
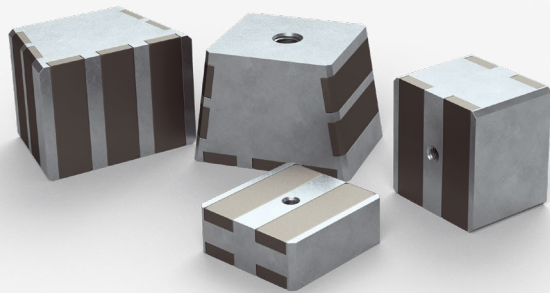
Mortar

BETEC Grouting

BETEC Thixo

EuroGrout Varix

EuroGrout Universalfüller

EuroGrout 04

POWER DUO SYSTEM WITH GERMAN APPROVAL

YOUR BENEFITS AT A GLANCE:

» Approved system of rails and mortar

» Power Duo system can be combined with grouting or thixo mortar from two suppliers

» Large tolerance range for installation and corresponding design values available.

» Forces in all directions transferable
  › Tensile forces, shear forces parallel and right-angled to the joint

» Most economical application using thixo mortar
  › saves sealing of the joint and grouting in sections
  › saves time and reduces costs

» Reduction of planning effort by simple and quick webbased design

» Suitable for all fire protection requirements (from fire retardant to firewall)

Our design software you will find at
www.philipp-software.de

Approved for all fire resistance classes
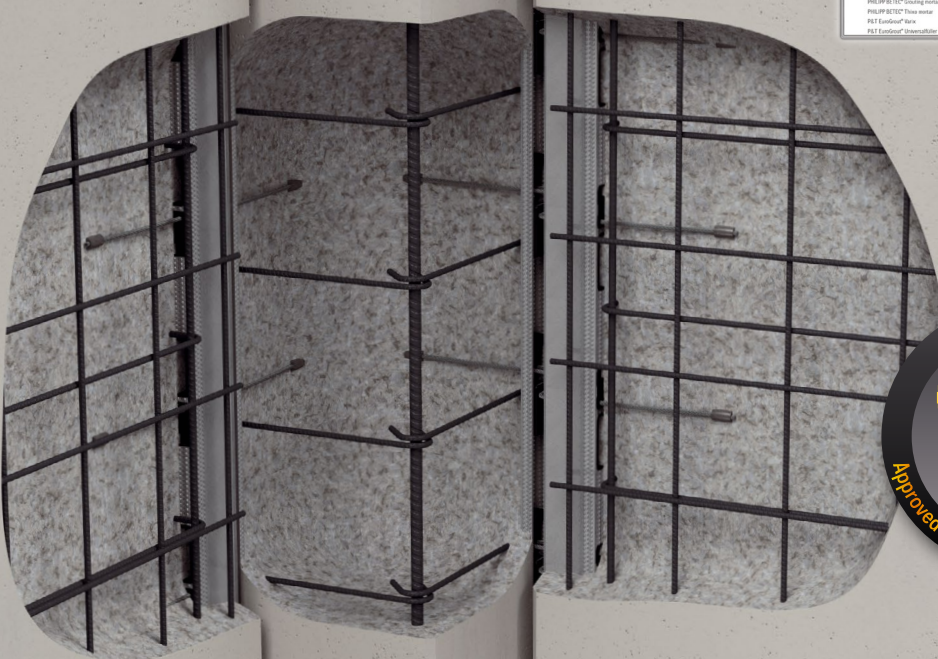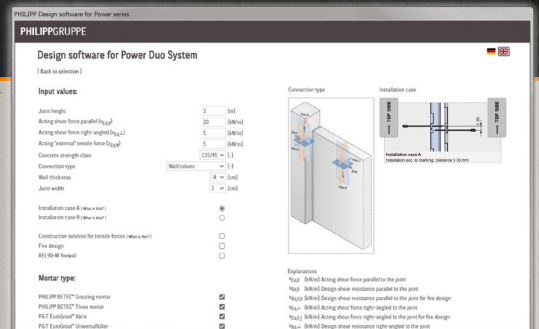
SYSTEM COMPONENTS

SYSTEM COMPONENTS AND DIMENSIONS

The Power Duo System is used to connect precast concrete units where high static forces have to be transferred and proofed. It is able to transfer shear and tensile forces plane to the wall (stiffening, support reactions) as well as shear forces right-angled to the wall (wind pressure, earth pressure). A simple installation and the joint geometry pre-defined by the rail guarantee an easy application.

All components of the Power Duo System are optimally coordinated, it consists of two differently deep, profiled and galvanized channels.
Both channels are equipped with plastic recess formers and galvanised steel wire loops each with a distance of 250 mm. During concreting the plastic recess formers are filled and in combination with the profiled channel incl. the wire loops the system enables an excellent load bearing capacity.
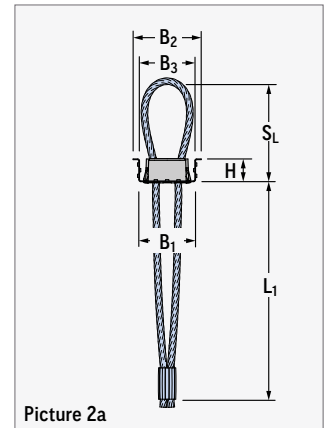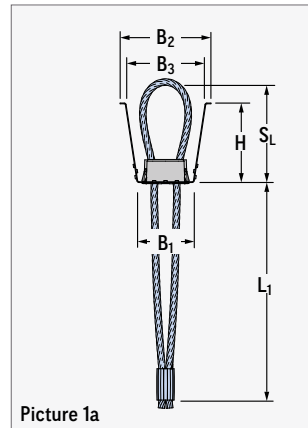Two rails are installed surface-flush on the opposite side of each particular concrete unit.

After demoulding, the plastic cover is removed and the loops are folded down to a right-angled position to the rail.
Due to the possibility to install wall elements directly between columns already positioned (e.g. with skeleton construction) the outcome of this is a significant reduction of time. Finally, the joints are filled with a belonging thixo mortar (page 24) or grouting mortar (page 26) to generate a force and form-fit connection.

The national approved
PHILIPP Power Duo System
Power Duo rails
(Z-21.8-2028 / Z-21.8-2066)

BETEC®
(Z-21.8-2028)
Thixo mortar / grouting mortar

EuroGrout®
(Z-21.8-2066)
Thixo mortar / grouting mortar
(Universalfüller / Varix)

⚠ **NOTE THE APPROVAL!**

This Installation Instruction provides necessary technical information. In all cases, the requirements of the national German approval must be considered!

Picture 1a
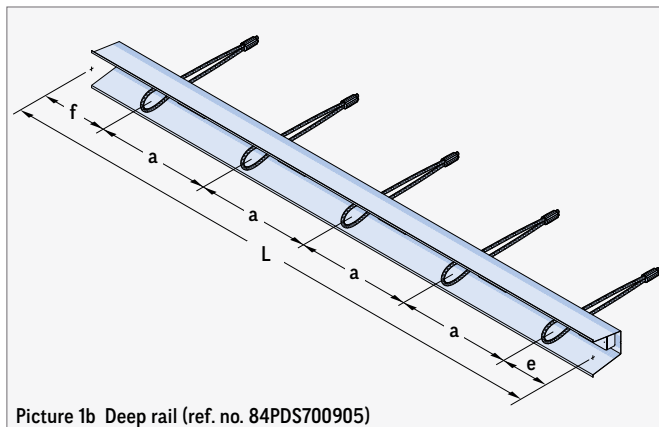
Picture 2a

Picture 1b Deep rail (ref. no. 84PDS700905)
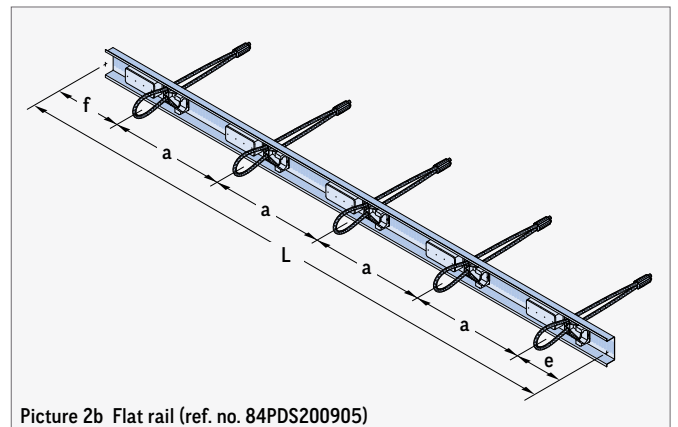
Picture 2b Flat rail (ref. no. 84PDS200905)

TABLE 1: DIMENSIONS

Ref. no.	Dimensions (mm)										Weight per rail (kg)
	B_1	B_2	B_3	H	L	L_1	S_L	e	f	a	
84PDS700905	50	80	70	70	1250	190	90	107	143	250	1.99
84PDS200905	50	60	50	20							1.34

APPLICATION

DIMENSIONS OF CONCRETE UNIT

Due to the required concrete cover of 20 mm for the Power Duo rails the min. resulting wall thickness is 120 mm (picture 3). In the following pictures only the required reinforcement for the Power Duo system is shown!

WALL THICKNESSES / REINFORCEMENT

① () Data in brackets: wall thickness < 140 mm only permissible with mortar EuroGrout Universalfüller / Varix.

② () Data in brackets: only for normal weight concrete C25/30
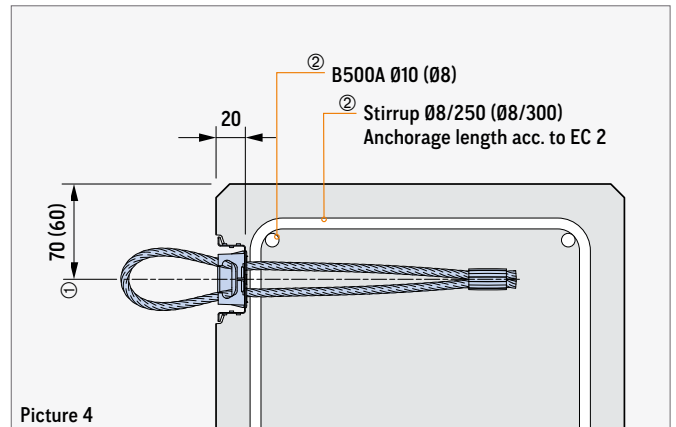
Picture 3

Picture 4

RAIL LENGTH

The minimum length of a rail must be 50 cm for the Power Duo system (picture 5, minimum 2 loops are required so that a strut-and-tie-model can work).

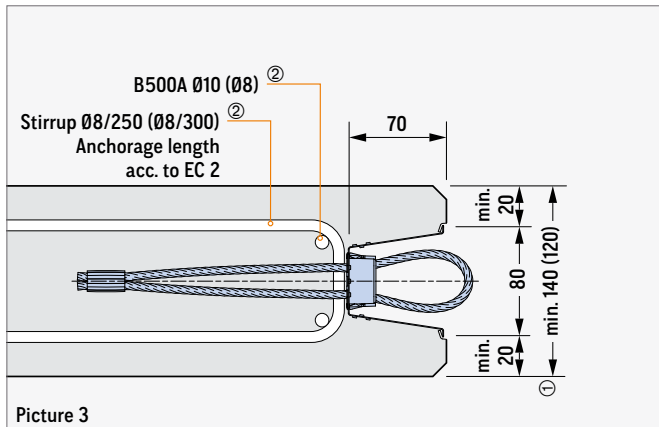For an installation with increased tolerances (picture 6), the minimum length of the rail is 75 cm. So, it is possible to install the Power Duo rails in shorter parts (page 18).

INSTALLATION OF THE RAILS

In general, the Power Duo rails shall be installed with care for the direction (see marking on the rails). Nevertheless, load-bearing capacities are also available in case of a deviating installation with larger tolerances (see also pictures 14 and 15). Picture 5 shows the recommended installation of the Power Duo, the wire loops have a small tolerance in vertical direction.

Picture 5 Recommended installation
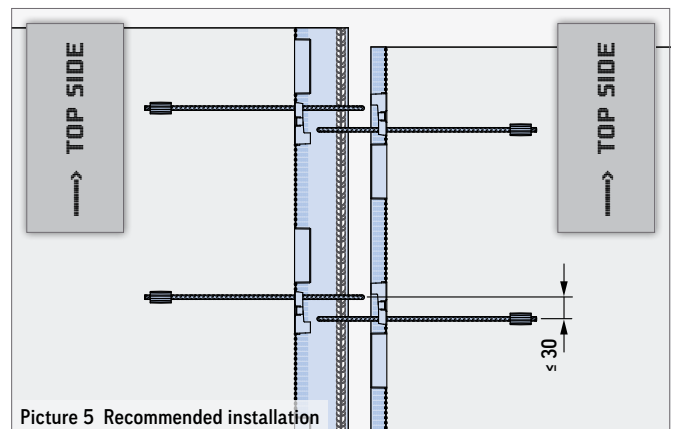
In contrast, picture 6 shows an example of an installation of Power Duo rails with a maximum tolerance of 125 mm (half a wire loop distance) up to which a design value is available.

Picture 6 Installation with max. tolerance
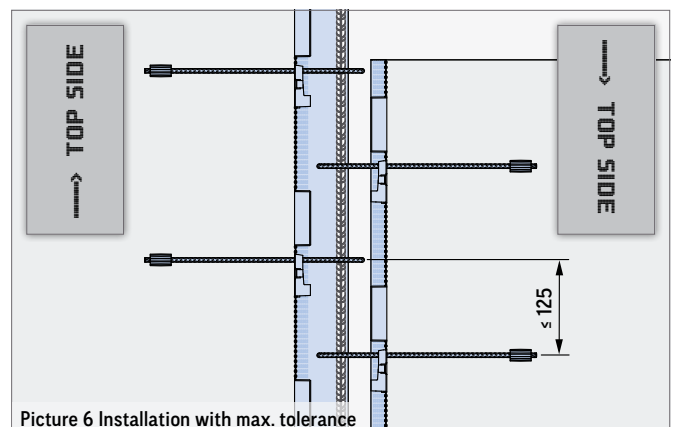
APPLICATION

RANGE OF APPLICATIONS

The Power Duo system can be used for various connections of reinforced concrete elements. It transfers primarily static shear forces parallel and right-angled to the wall as well as tensile forces from predominantly static loads. Only in case of direct weathering on the connection between reinforced concrete elements it must be ensured for the application that the crack width in the joint is limited to w ≤ 0.3 mm.
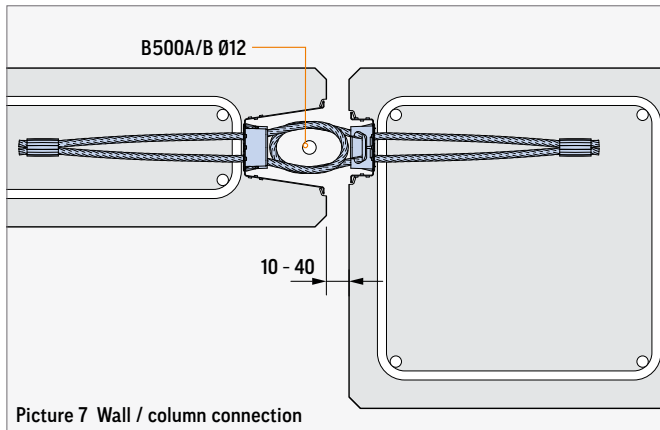
Picture 7 Wall / column connection
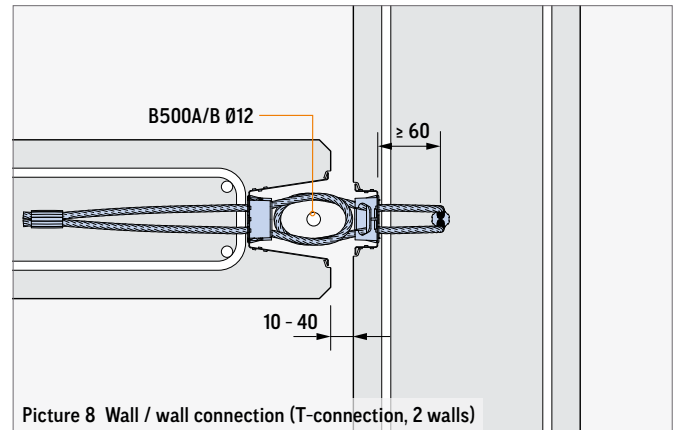
Picture 8 Wall / wall connection (T-connection, 2 walls)
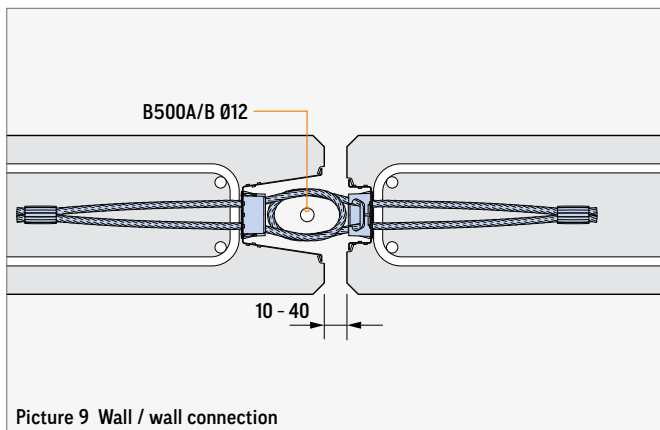
Picture 9 Wall / wall connection
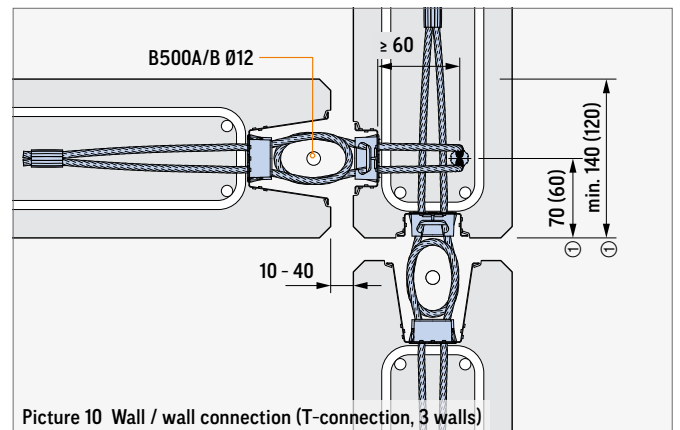
Picture 10 Wall / wall connection (T-connection, 3 walls)
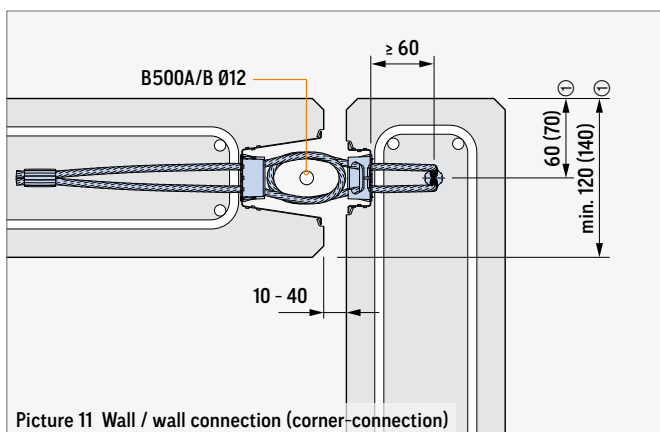
Picture 11 Wall / wall connection (corner-connection)

WALL THICKNESSES

① () Data in brackets: wall thicknesses < 140 mm only permissible with mortar EuroGrout® Universalfüller / Varix.

APPLICATION IN CASE OF FIRE

The Power Duo system can be used to meet all the requirements for fire resistance.

CONSTRUCTION

In addition to the range of application, the precast reinforced concrete connections using the Power Duo System may be considered as equivalent to the connections regulated in the German standard DIN 4102-4:2016-05, para. 5.12.5 to 5.12.7.

TABLE 2: FIRE RESISTANCE CLASS

Requirement	acc. to Eurocodes or EN 13501	acc. to DIN 4102
Fire-retardant	R 30	F 30
	REI 30	
	EI 30	
Highly fire-retardant	R 60	F 60
	REI 60	
	EI 60	
Fire-resistant	R 90	F 90
	REI 90	
	EI 90	
Firewall (min. C30/37)	REI 90-M	Firewall
	EI 90-M	

FIRE RESISTANT WALLS

For the design of a requirement listed in table 3, the temperature at the wire loops must be known first. This can be determined from the temperature profile acc. to EN 1992-1-2:2012, picture A.2.

With this temperature the reduction factor (picture 12) and the final load capacity of the wire loops (table 3) are resulting.

TABLE 3: DESIGN FOR FIRE RESISTANT WALLS

| Requirement	Fire resistance class		Shear force		Tensile force
			parallel to the joint	right-angled to the joint	
	acc. to Eurocodes or EN 13501	acc. to DIN 4102	$v_{Rd.ll}$ (kN/m)	$v_{Rd\perp}$ (kN/m)	z_{Rd} (kN/m)
Fire-retardant	R 30	F 30			
	REI 30				
	EI 30		$v_{Rd.fi.ll} = \alpha_{fi} \times v_{Rd.ll}$	$v_{Rd.fi\perp} = 2.5$	$z_{Rd.fi} = \alpha_{fi} \times z_{Rd.ll}$
Highly fire-retardant	R 60	F 60			
	REI 60				
	EI 60				
Fire-resistant	R 90	F 90			
	REI 90				
	EI 90				

α_{fi} : reduction factor depending on the wire loop temperature, see diagram in picture 12.
$v_{Rd.ll}$: Design value of the shear force bearing capacity parallel to the joint according to table 6
z_{Rd} : Design value of the tensile force bearing capacity according to table 8 (4 loops per metre)

PROOFS:

SHEAR FORCE PARALLEL TO THE JOINT:

$$v_{Rd.fi.ll} \geq v_{Ed.ll}$$

SHEAR FORCE RIGHT-ANGLED TO THE JOINT:

$$v_{Rd.fi\perp} \geq v_{Ed\perp}$$

TOTAL TENSILE FORCE:

$$z_{Rd.fi} \geq z_{Ed.N}$$

For a design example of a fire-resistant wall please refer to page 16.
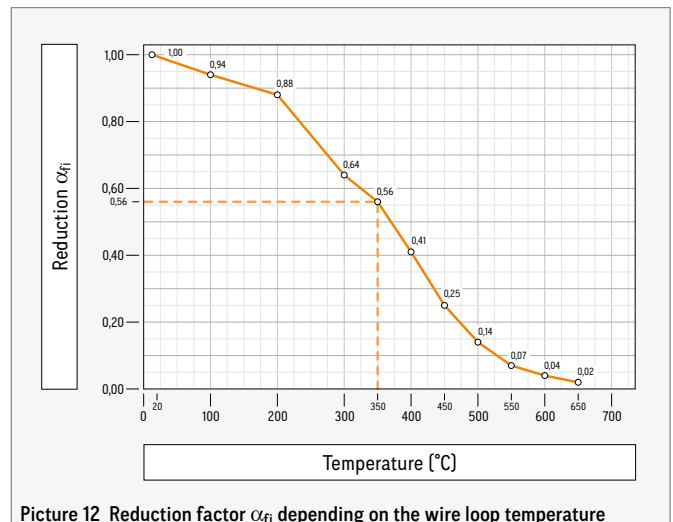
Picture 12 Reduction factor α_{fi} depending on the wire loop temperature

APPLICATION IN CASE OF FIRE

FIREWALL

TABLE 4: DESIGN FOR FIREWALLS

Requirement	Fire resistance class		Shear force		Tensile force
			parallel to the joint	right-angled to the joint	
	acc. to Eurocodes or EN 13501	acc. to DIN 4102	$v_{Rd.ll}$ (kN/m)	$v_{Rd\perp}$ (kN/m)	z_{Rd} (kN/m)
Firewall (min. C30/37)	REI 90-M	Firewall	$v_{Rd.ll}$	$v_{Rd.fi\perp} = 2.5$	$z_{Rd.fi} = 2.5$
	EI 90-M				

$v_{Rd.ll}$: Design value of the shear force bearing capacity parallel to the joint according to table 6

PROOF:

SHEAR FORCE PARALLEL TO THE JOINT:

$$v_{Rd.fi.ll} \geq v_{Ed.ll}$$

SHEAR FORCE RIGHT-ANGLED TO THE JOINT:

$$v_{Rd.fi\perp} \geq v_{Ed\perp}$$

TOTAL TENSILE FORCE:

$$z_{Rd.fi} \geq z_{Ed.N}$$

For a design example of a firewall please refer to page 17.

TABLE 5: SUITABLE MORTARS FOR THE CASE OF FIRE

Requirement	Fire resistance class		Mortar type			
			Grouting mortar		Thixotropic mortar	
	acc. to Eurocodes or EN 13501	acc. to DIN 4102	EuroGrout® Varix	BETEC® Grouting mortar	EuroGrout® Universalfüller	BETEC® Thixo-Mörtel
Fire-retardant	R 30	F 30	✓	✓	✓	✓
	REI 30					
	EI 30					
Highly fire-retardant	R 60	F 60	✓	✓	✓	✓
	REI 60					
	EI 60					
Fire-resistant	R 90	F 90	✓	✓	✓	✓
	REI 90					
	EI 90					
Firewall (min. C30/37)	REI 90-M	Firewall	✓	✓	✓	✓
	EI 90-M					

DESIGN AND CONSTRUCTION

The precast concrete units to be connected must be designed according to EC 2. They have to be made of normal weight concrete with a strength class of at least C25/30 acc. to EN 206.

It is part of the structural engineer to design the units and prove the joint connections according to the national German approval. When designing the bearing capacities of the concrete element connection with the Power Duo system, the type of the mortar used must be considered in advance.

In the approvals grouting mortars as well as thixotropic mortars are specified. In table 6 shear loads parallel to the joint ($v_{Rd.II}$) and in table 7 shear loads right-angled to the joint ($v_{Rd.\perp}$) are listed acc. to the approvals.

If shear loads parallel and right-angled to the joint appear at the same time, the load bearing capacities have to be reduced according to picture 16 and 17.

Acting tensile forces shall be considered differently depending on the planned construction.

With the help of examples (from page 14), the design for different applications is easy to understand:

Example 1+2: Differences in tensile force transfer

Wall panel incl. load transfer of tensile forces with our without constructive solutions

Example 3+4: Fire requirements

Design for a fire-resistant wall or firewall
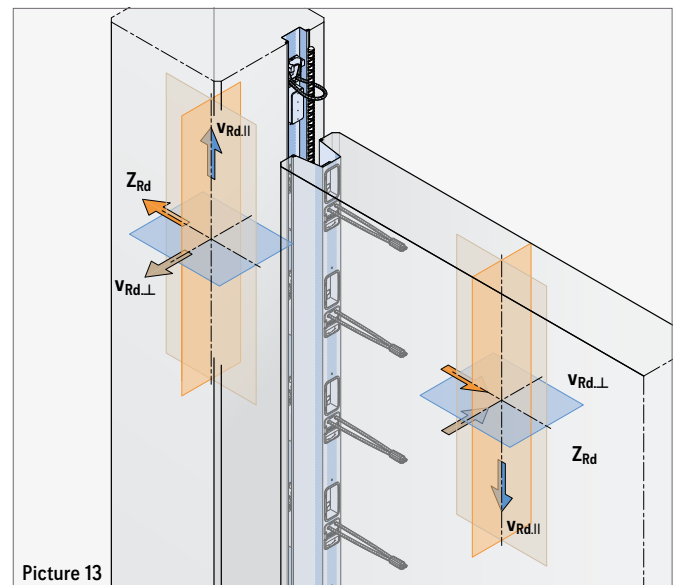
WALL THICKNESSES

For the design of the approved systems (in Germany), an easy-to-use and customer-oriented software is available on our website.

Picture 13

DESIGN VALUES FOR THE SHEAR FORCE BEARING CAPACITY $V_{RD.II}$ AND TENSILE FORCE BEARING CAPACITY Z_{RD}

Design values W1
Installation acc. to marking; tolerance ≤ 30 mm

Design values W2
Installation acc. to marking; tolerance > 30 mm and ≤ 125 mm

Picture 14

Design values W2
Installation contrary to marking; tolerance ≤ 125 mm
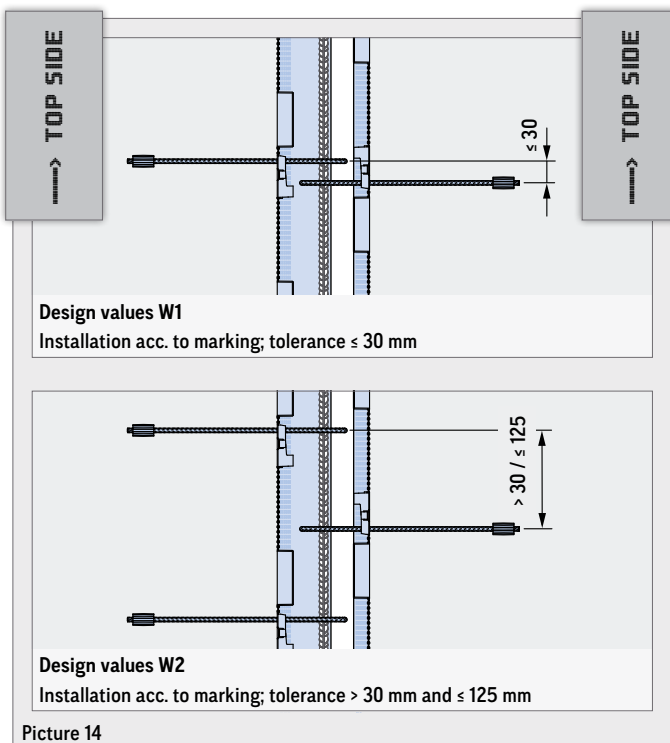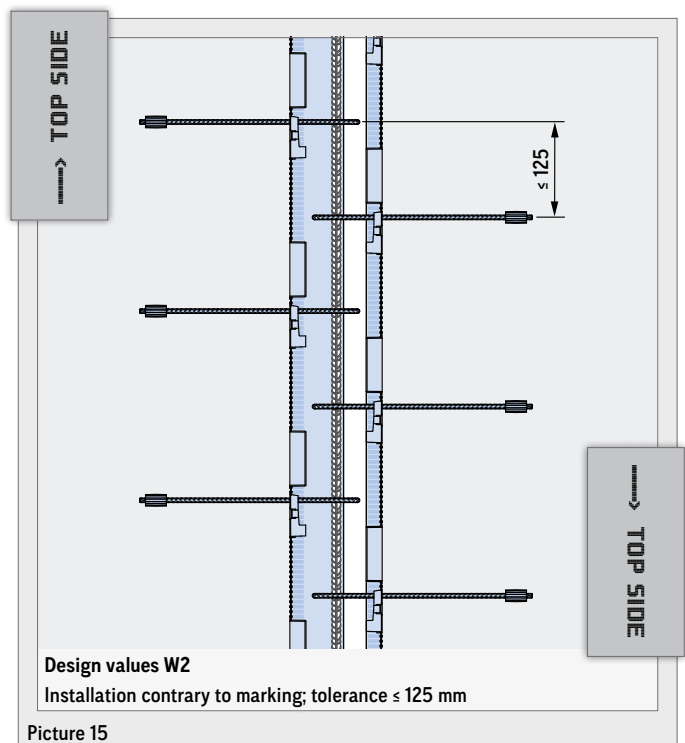
Picture 15

DESIGN AND CONSTRUCTION

TABLE 6: DESIGN VALUES OF THE SHEAR FORCE BEARING CAPACITY PARALLEL TO THE JOINT

Wall thickness h (cm)	Design value of the shear force bearing capacity $v_{Rd.II}$ (kN/m)			
	Design values W1		Design values W2	
	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar
12 ≤ h < 14 ①	60.0	60.0	–	–
h ≥ 14	90.0 (60.0 with C25/30)	70.0	65.0	50.0

TABLE 7: DESIGN VALUES OF THE SHEAR FORCE BEARING CAPACITY RIGHT-ANGLED TO THE JOINT

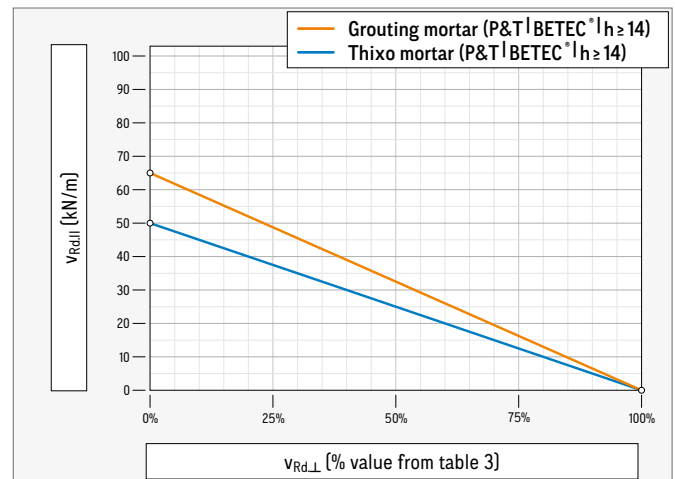| Wall thickness h (cm)	Design value of the shear force bearing capacity $v_{Rd\perp}$ (kN/m)									
	Concrete strength C25/30		Concrete strength C30/37		Concrete strength C35/45		Concrete strength C40/50		Concrete strength C45/55	
	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar
12 ①	–	–	7.0	7.0	8.0	8.0	8.6	8.6	9.1	9.1
13 ①	–	–	8.3	8.3	9.5	9.5	10.2	10.2	10.8	10.8
14	8.4	–	9.7	9.7	11.1	11.1	11.9	11.9	12.6	12.6
15	9.7	–	11.2	11.2	12.7	12.7	13.7	13.7	14.5	14.5
16	11.0	–	12.7	12.7	14.4	14.4	15.5	15.5	16.5	16.5
17	12.4	–	14.2	14.2	16.2	16.2	17.4	17.4	18.6	18.6
18	13.8	–	15.9	15.9	18.1	18.1	19.4	19.4	20.7	20.7
19	15.3	–	17.5	17.5	20.0	20.0	21.4	21.4	22.8	22.8
20	16.7	–	19.3	19.3	21.9	21.9	23.5	23.5	25.1	25.1
21	18.3	–	21.0	21.0	24.0	24.0	25.7	25.7	27.4	27.4
22	19.9	–	22.8	22.8	26.0	26.0	27.9	27.9	29.7	29.7
23	21.5	–	24.7	24.7	28.1	28.1	30.2	30.2	32.2	32.2
24	23.1	–	26.6	26.6	30.3	30.3	32.5	32.5	34.6	34.6
25	24.8	–	28.5	28.5	32.5	32.5	34.9	34.9	37.2	37.2
26	26.5	–	30.5	30.5	34.8	34.8	37.3	37.3	37.5	37.5
27	28.3	–	32.5	32.5	37.1	37.1	37.5	37.5	37.5	37.5
28	30.1	–	34.6	34.6	37.5	37.5	37.5	37.5	37.5	37.5
29	31.9	–	36.7	36.7	37.5	37.5	37.5	37.5	37.5	37.5
≥ 30	33.8	–	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5

② C25/30 only permissible when using BETEC® grouting mortar
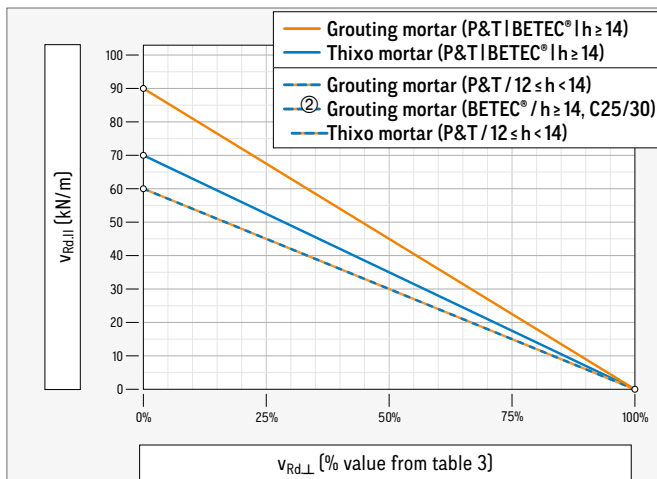
Picture 16 Design values W1
Interaction diagram of the shear forces parallel and right-angled to the joint

Picture 17 Design values W2 (larger tolerance range)
Interaction diagram of the shear forces parallel and right-angled to the joint

TABLE 8: DESIGN VALUE OF THE TENSILE FORCE BEARING CAPACITY PER WIRE LOOP

Wall thickness h (cm)	Design value of the tensile force bearing capacity $Z_{Rd.N}$ (kN/loop)			
	Design values W1		Design values W2	
	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar
12 ≤ h < 14 ①	6.5	6.5	–	–
h ≥ 14	10.0	7.5	7.2	5.4

① Wall thicknesses only possible with mortar EuroGrout® Universalfüller or EuroGrout® Varix

EXAMPLE 1/2 STIFFENING WALL WITH / WITHOUT TENSILE FORCES

Picture18 **Example 1** stiffening wall <u>with</u> tensile forces

Picture 19 **Example 2** stiffening wall <u>without</u> tensile forces
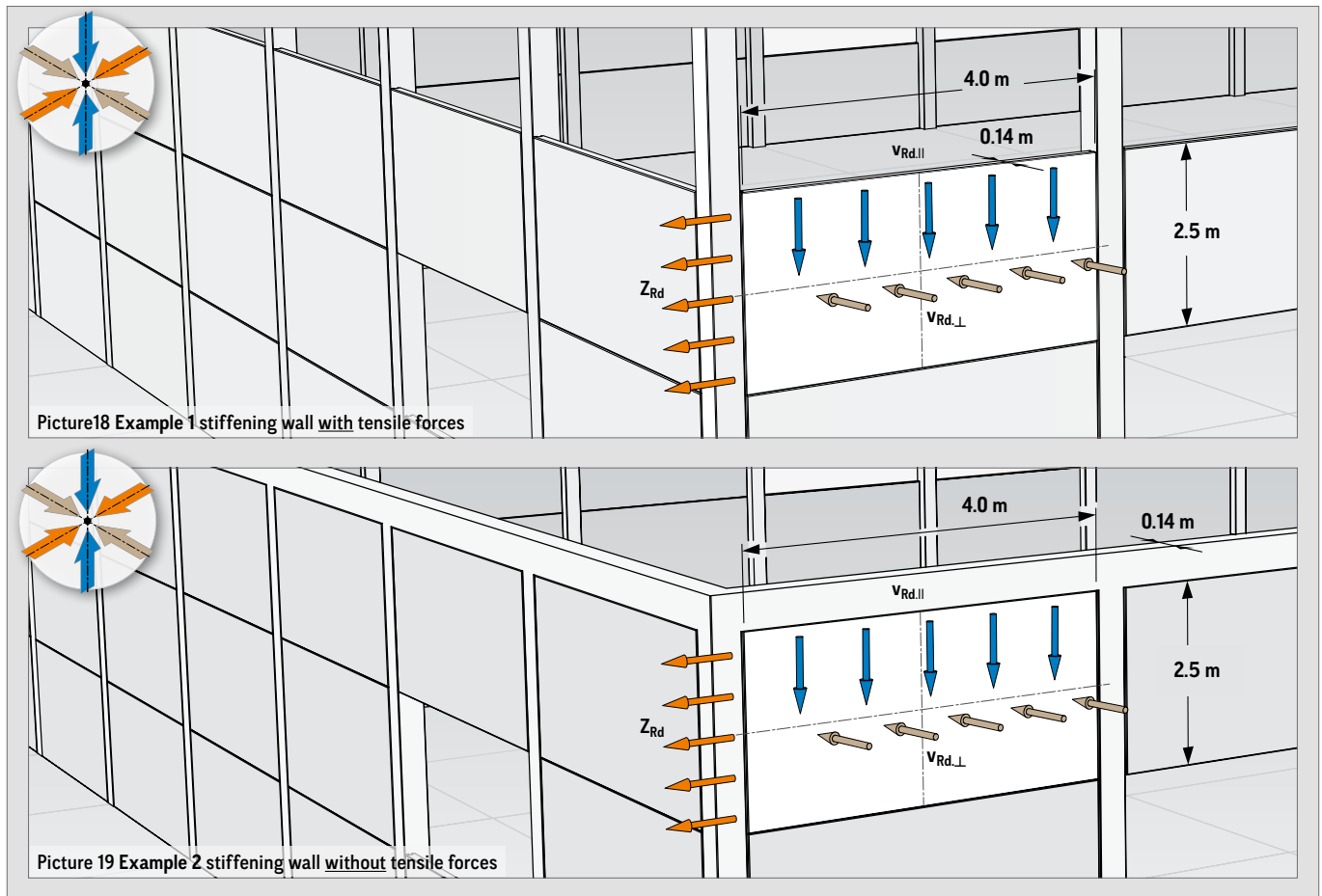
The examples show a wall, which shall be installed as a stiffening member. The resulting shear forces parallel to the joint are taken by the Power Duo System with thixo mortar and added with shear forces right-angled to the joint caused by wind.

Example 1 shows a design without constructive solutions, in example 2 the tensile force component from the shear force parallel is taken by a constructive solution.

ACTIONS / BOUNDARY CONDITIONS:

» From wind
  › Building height ≤ 10 m, wind zone 3, terrain category II/III, according to EC 1
  › $W_D = 1.5 \times (0.8 \text{ kN/m}^2 \times 1.0) = 1.2 \text{ kN/m}^2$
» Loads caused by the shear wall: 10.68 kN/m
» Wall thickness 14 cm
» Concrete strength class C30/37
» Tensile force: $z_{Ed.N} = 10$ kN/m
» Wall dimensions L = 4.0 m; H = 2.5 m
» Installation of the rails according to marking, vertical tolerance ≤ 30 mm
» Design resistances for thixo mortar:
  › $v_{Rd.II} = 70$ kN/m (value from table 6, design value W1)
  › $v_{Rd.\perp} = 9.7$ kN/m (value from table 7)

TABLE 9: COMPONENT OF TENSILE FORCE

Load from	Shear force parallel $v_{Ed.II}$	Shear force right-angled $v_{Ed.\perp}$	External tensile force
Component of tensile force	$z_{Ed.VII} = 0.5 \times v_{Ed.II}$	$z_{Ed.V.\perp} = 0.25 \times v_{Ed.\perp}$	$z_{Ed.N}$

EXAMPLE 1/2 STIFFENING WALL WITH / WITHOUT TENSILE FORCES

VERIFICATION OF SHEAR FORCES

$v_{Ed.II}$ = 10.68 kN/m × 4.0 m / 2 / 2.5 m = 8.54 kN/m ≤ $v_{Rd.II}$ = 70 kN/m

$v_{Ed.\perp}$ = (1.2 kN/m² × 2.50 m × 4.0 m) / 2 / 2.5 m = 2.4 kN/m per joint

If both forces occur at the same time, the interaction (picture 16) must be considered:

Percentage of shear force parallel:

$v_{Ed.II}$ / $v_{Rd.II}$ = 8.54 kN/m / 70 kN/m = 12 %

The linear interaction results in a permissible shear force right-angled to the joint: 100 % – 12 % = 88 %

The reduced shear force right-angled to the wall can be set to 88 %:

red. $v_{Rd.\perp}$ = 0.88 × 9.7 kN/m = 8.5 kN/m ≥ $v_{Ed.\perp}$ = 2.4 kN/m

It is shown that the interaction of both shear forces can be absorbed.

VERIFICATION OF TENSILE FORCES

Design example 1: no load transfer of tensile forces by constructive solutions

The two shear forces result in individual tensile force components that act in the direction of the wire loops. The sum of these individual components (total tensile force) is compared to the tensile force resistance Z_{Rd} of the loops according to table 8.

Verification of the total force: n × Z_{Rd} ≥ $z_{Ed.VII}$ + $z_{Ed.V.\perp}$ + $z_{Ed.N}$

n   (1/m)   : numbers of wire loops per metre of joint, n = 4 loops/metre

Z_{Rd} (kN)   : design value of tensile force bearing capacity per metre acc. to table 8

$z_{Ed.N}$ (kN/m) : acting „external" tensile force per metre of joint

$z_{Ed.VII}$ (kN/m) : expansion force resulting from shear force parallel per metre of joint

$z_{Ed.V.\perp}$ (kN/m) : expansion force resulting from shear force right-angled per metre of joint

VERIFICATION OF TOTAL TENSILE FORCE:

n × Z_{Rd} ≥ $z_{Ed.VII}$ + $z_{Ed.V.\perp}$ + $z_{Ed.N}$ (n = 4 loops per metre)

Z_{Rd} = 7.5 kN/loop (table 8)

$z_{Ed.N}$ = 10 kN/m

$z_{Ed.VII}$ = 0.5 × 8.54 kN/m = 4.27 kN/m

$z_{Ed.V.\perp}$ = 0.25 × 2.4 kN/m = 0.6 kN/m

30 kN/m ≥ 4.27 kN/m + 0.6 kN/m + 10 kN/m = 14.87 kN/m

Design example 2: Load transfer of the tensile forces by constructive solutions e.g. ring beam

Verification of total tensile force:

$z_{Ed.ges}$ = $z_{Ed.V.\perp}$ + $z_{Ed.N}$

$z_{Ed.ges}$ (kN/m) : total tensile force per metre of joint

$z_{Ed.N}$ (kN/m) : acting „external" tensile force per metre of joint

$z_{Ed.V.\perp}$ (kN/m) : expansion force resulting from shear force right-angled per metre of joint

Verification of total tensile force:

$z_{Ed.ges}$ = $z_{Ed.V.\perp}$ + $z_{Ed.N}$ (kN/m)

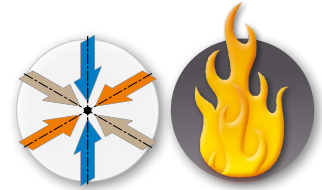$z_{Ed.V.\perp}$ = 0.25 × 2.4 kN/m = 0.6 kN/m

$z_{Ed.N}$ = 10 kN/m

$z_{Ed.ges}$ = 0.6 kN/m + 10 kN/m = 10.6 kN/m

The calculated tensile force must be absorbed e.g. by a ring beam or other constructive solutions.

EXAMPLE 3 – FIRE-RESISTANT WALL

ACTIONS / BOUNDARY CONDITIONS:

» Wall thickness d = 14 cm
» Joint height h = 3.0 m
» Concrete strength class C30/37
» Mortar: grouting mortar (design values table 6 and 8)
» Outer shear force parallel to the joint $v_{Ed.II}$ = 40 kN/m (e.g. stiffening forces)
» Outer shear force right-angled: $v_{Ed\perp}$ = 2 kN/m
» Outer tensile force $z_{Ed.N}$ = 2 kN/m
» No load transfer of tensile forces by constructive solutions!
» Installation of the rails according to marking, vertical tolerance ≤ 30 mm
» Requirements of a fire-resistant wall, one-sided fire exposure

VERIFICATION OF TENSILE AND SHEAR FORCE IN CASE OF FIRE

For the verification of fire-stressed connections the load bearing capacities according to table 10 may be used. Depending on the temperature acting on the wire loop (see temperature profile EN 1992-1-2:2012-12, picture A.2) the design resistances shall be reduced by α_{fi} as shown in picture 21.

TABLE 10: LOAD BEARING CAPACITIES IN CASE OF FIRE

Load from	Shear force parallel $v_{Ed.II}$	Shear force right-angled $v_{Ed\perp}$	Total tensile force: $z_{Ed.VII} + z_{Ed.N}$
Design value of the load bearing capacity (kN/m)	$v_{Rd.fi.II} = \alpha_{fi} \times v_{Rd.II}$	$2.5 = v_{Rd.fi\perp}$	$z_{Rd.fi} = \alpha_{fi} \times z_{Rd}$

DETERMINATION OF THE TEMPERATURE AT THE WIRE ROPE:

Distance x from the fire-stressed surface (picture 20):
» Wall thickness d = 140 mm
» Width of the loop b = 50 mm

x = (d − b) / 2 = (140 − 50) / 2 = 45 mm

Reading the temperature at the wire rope θ (°C), according to diagram EN 1992-1-2, picture A.2

Determined temperature: θ (°C) = 350 °C → α_{fi} = 0.56 (picture 21)

ACTIONS

Tensile force component from shear force:
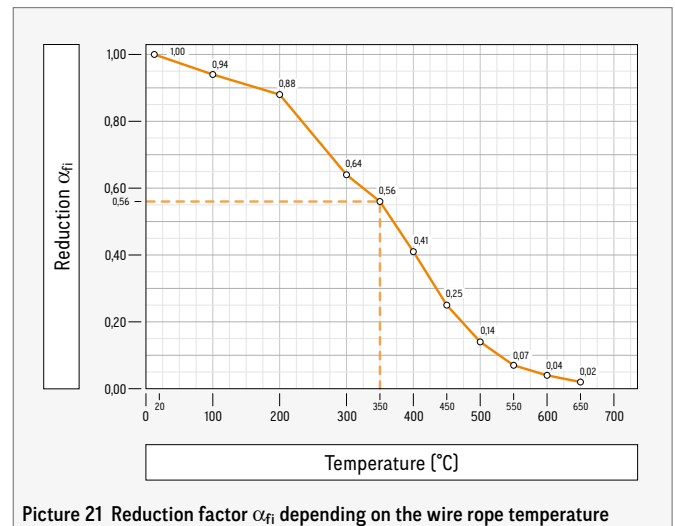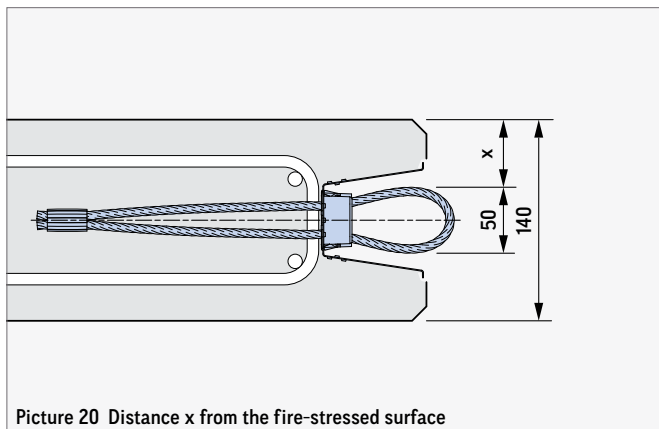$z_{Ed.VII}$ = 0.5 × $v_{Ed.II}$ = 0.5 × 40 kN/m = 20 kN/m

Total tensile force:
$z_{Ed.fi}$ = $z_{Ed.VII}$ + $z_{Ed.N}$ = 20 + 2 = 22 kN/m

REDUCED LOAD CAPACITIES IN CASE OF FIRE

$v_{Rd.fi.II}$ = α_{fi} × $v_{Rd.II}$ = 90 kN/m × 0.56 = 50.4 kN/m
$z_{Rd.fi}$ = α_{fi} × z_{Rd} = 40 kN/m × 0.56 = 22.4 kN/m

Picture 20 Distance x from the fire-stressed surface

Picture 21 Reduction factor α_{fi} depending on the wire rope temperature

VERIFICATIONS:

SHEAR FORCE PARALLEL TO THE JOINT:

$v_{Rd.fi.II}$ = 50.4 kN/m ≥ 40 kN/m = $v_{Ed.II}$

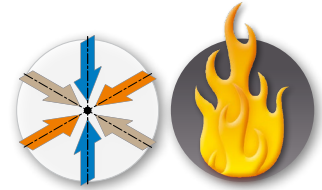**SHEAR FORCE RIGHT-ANGLED TO THE JOINT:**

$v_{Rd\perp}$ = 2.5 kN/m > 2 kN/m = $v_{Ed\perp}$

TOTAL TENSILE FORCE:

$z_{Rd.fi}$ = 22.4 kN/m ≥ 22 kN/m = z_{Ed}

EXAMPLE 4 - FIREWALL

ACTIONS / BOUNDARY CONDITIONS:

» Wall thickness d = 14 cm
» Joint height h = 10 m
» Concrete strength min. C30/37
» Mortar: thixo mortar ($v_{Rd.ll}$ = 70 kN/m, table 6)
» Outer shear force parallel to the joint $v_{Ed.ll}$ = 60 kN/m
» Outer shear force right-angled: $v_{Ed.\perp}$ = 2 kN/m
» Outer tensile force $z_{Ed.N}$ = 2 kN/m
» No load transfer of tensile forces by constructive solutions!
» Installation of the rails according to marking, vertical tolerance ≤ 30 mm
» Requirements for firewall, one-sided exposure

VERIFICATION OF THE TENSILE AND SHEAR FORCE IN CASE OF FIRE

For the verification of load bearing, fire-stressed connections the load bearing capacities according to table 11 may be used. Please note that both the shear force right-angled to the joint and the total tensile force in the system are limited to a maximum of 2.5 kN/m each.

TABLE 11: LOAD BEARING CAPACITIES FOR FIREWALLS

Load from	Shear force parallel $v_{Ed.ll}$	Shear force right-angled $v_{Ed.\perp}$	Tensile force z_{Ed}
Design value of the load bearing capacity (kN/m)	$v_{Rd.ll}$	2.5 = $v_{Rd.fi.\perp}$	2.5 = $z_{Rd.fi}$

VERIFICATION:

SHEAR FORCE PARALLEL TO THE JOINT:

$v_{Rd.ll}$ = 70 kN/m ≥ 60 kN/m = $v_{Ed.ll}$

SHEAR FORCE RIGHT-ANGLED TO THE JOINT:

$v_{Rd.fi.\perp}$ = 2.5 kN/m ≥ 2 kN/m = $v_{Ed.\perp}$

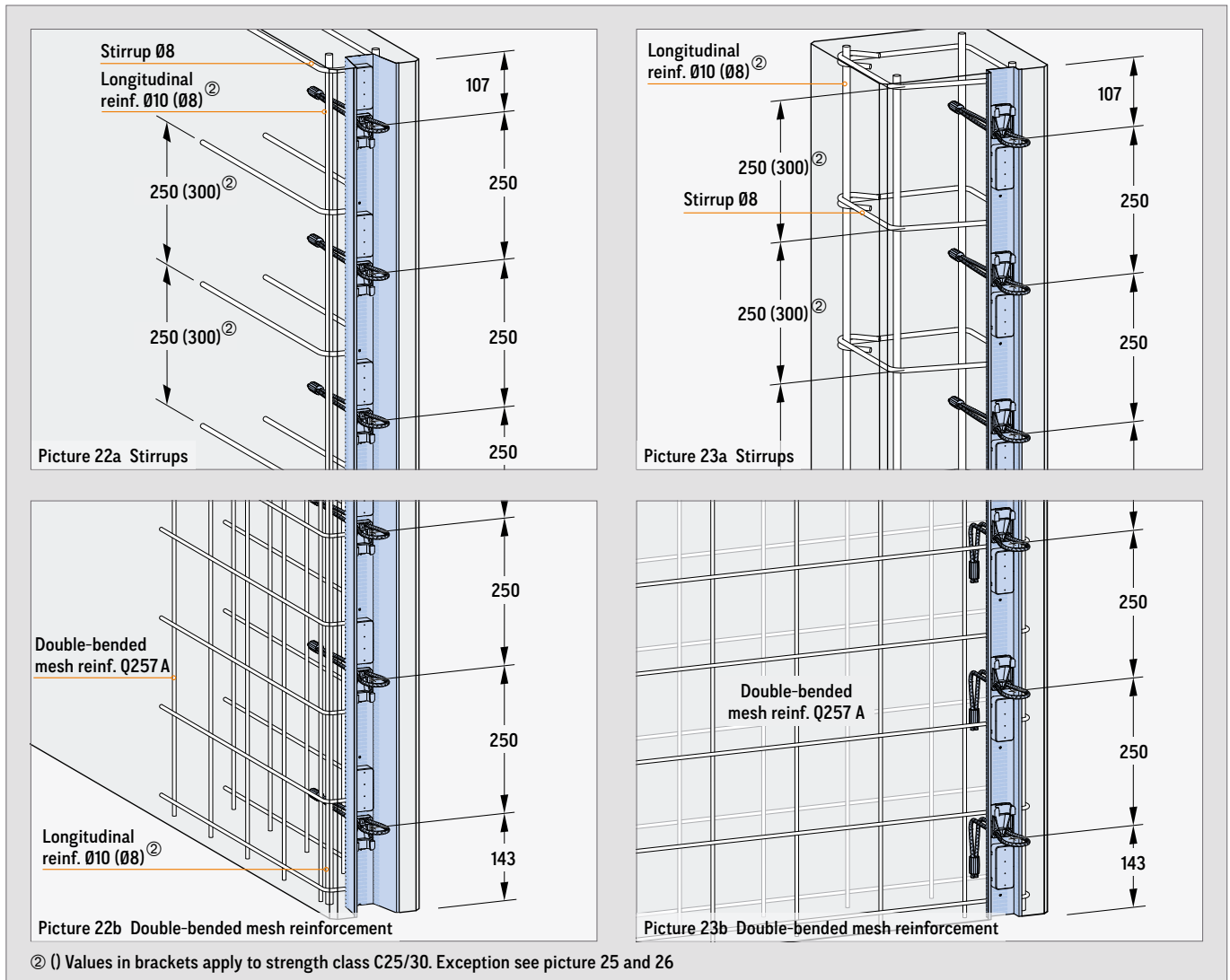**TOTAL TENSILE FORCE:**

$z_{Rd.fi}$ = 2.5 kN/m ≥ 2 kN/m = z_{Ed}

REINFORCEMENT

If the Power Duo rails are installed flush and according to the recommended marking all requirements of the German approval for the edge distances are met (picture 22a, 22b, 23a, 23b). In the range of the Power Duo rails the precast elements must be provided with a minimum reinforcement. This reinforcement shall be stirrups Ø8/25 / longitudinal reinforcement 2Ø10 (Ø8/30 / 2Ø8 with C25/30) as per picture 22a, 23a.

Stirrup Ø8
Longitudinal reinf. Ø10 (Ø8) ②
250 (300) ②
250 (300) ②
107
250
250
250

Picture 22a Stirrups

Longitudinal reinf. Ø10 (Ø8) ②
250 (300) ②
Stirrup Ø8
250 (300) ②
107
250
250

Picture 23a Stirrups

Double-bended mesh reinf. Q257 A
Longitudinal reinf. Ø10 (Ø8) ②
250
250
143

Picture 22b Double-bended mesh reinforcement

Double-bended mesh reinf. Q257 A
250
250
143

Picture 23b Double-bended mesh reinforcement

② ( ) Values in brackets apply to strength class C25/30. Exception see picture 25 and 26

REINFORCEMENT

! Alternatively, the stirrups can be replaced by a comparable mesh reinforcement (picture 22b and 23b).

END ANCHORAGE OF THE WIRE ROPE

✖ A bending of the end anchorage by the reinforcement is not permissible.
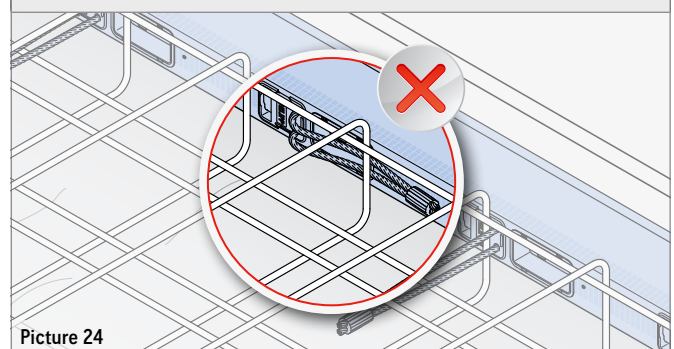
This requirement is fulfilled by a mesh reinforcement e.g. type Q257 A (equal 2.57 cm²/m). Existing reinforcement can be taken into account.
The anchorage of the connecting loops in the precast element must be aligned in an angle of 90° to the Power Duo rails. With a vertical installation in the mould the stability of the rope ends in the precast unit shall be ensured by tying them to the reinforcement with wire.
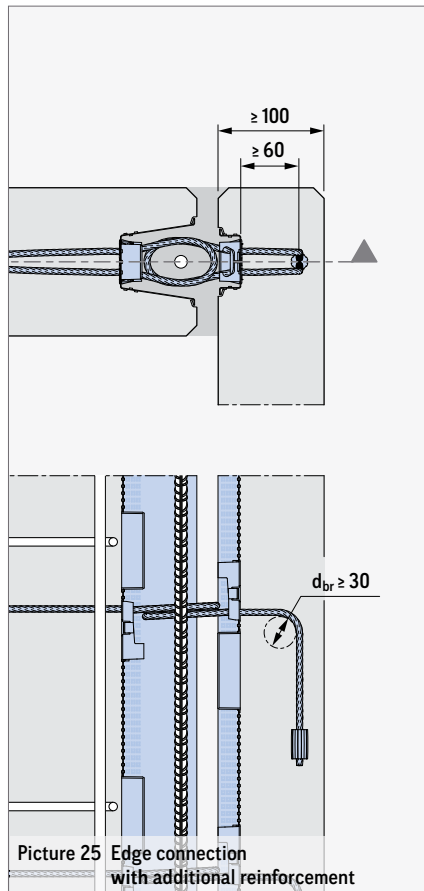

Picture 24

REINFORCEMENT

BENDING OF THE END ANCHORAGE

If the anchorage of the wire loop is bent, attention must be paid that the horizontal anchorage part is ≥ 60 mm (picture 25 and 26). Depending on the planning situation, additional reinforcement may be provided as shown in picture 26.
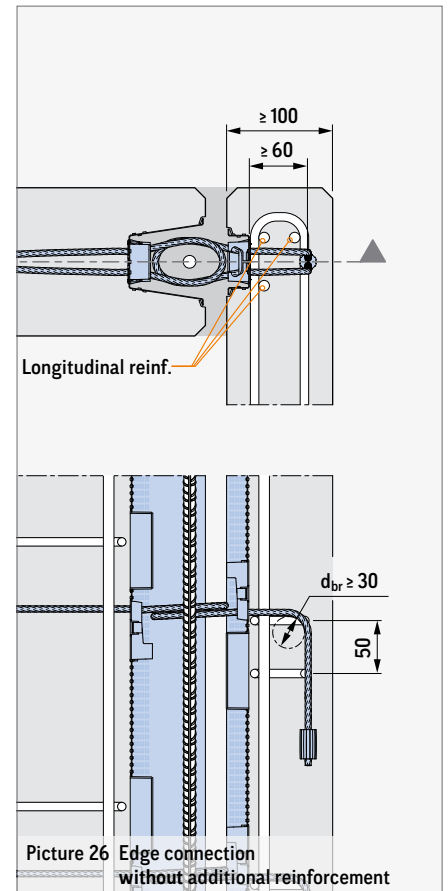
⚠️ **ADDITIONAL REINFORCEMENT (C25/30)**

For T- and edge connections with a bended end anchorage **no** reduced reinforcement, stirrups ø8/300, is possible with concrete strength C25/30 (see picture 22a). The longitudinal bars shown can be selected for C25/30 with Ø8 instead of Ø10 mm.

≥ 100
≥ 60

$d_{br} \geq 30$

Picture 25 Edge connection with additional reinforcement

≥ 100
≥ 60

Longitudinal reinf.

$d_{br} \geq 30$

50

**Picture 26** Edge connection without additional reinforcement

⚠️ **REDUCTION OF LOAD-BEARING CAPACITY**

If a corner connection is made without additional reinforcement (picture 25) for the bent end anchorage, the design values for the shear force parallel to the joint $v_{Rd,II}$ and the tensile force $Z_{Rd,N}$ shall be reduced to 70 % (page 13).

TABELLE 12: REINFORCEMENT (B500A/B)

Ød_s (mm)	Ød_{br} (mm)
Ø8	Ø32

Ød_{br}

Ød_s
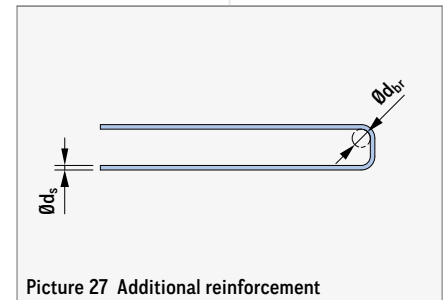
Picture 27 Additional reinforcement

PHILIPP Power Duo System
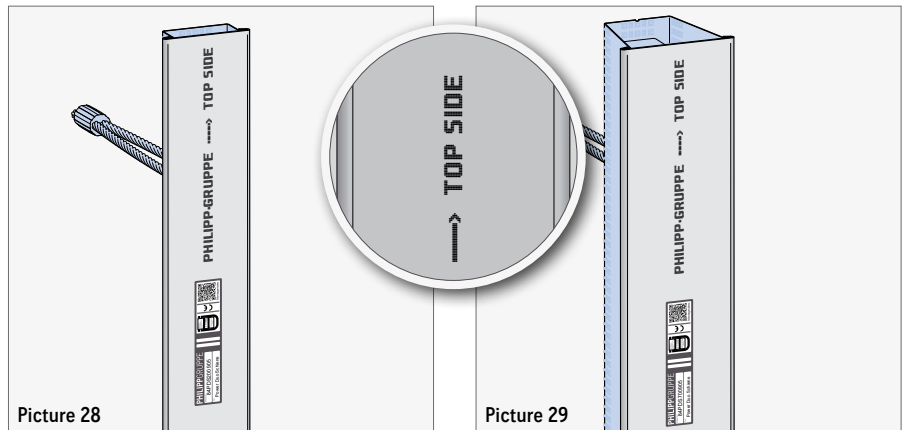
INSTALLATION

INSTALLATION OF THE POWER DUO RAILS

The Power Duo System consists of a flat and a deep rail. An identification for the installation direction is visible on the plastic covering.
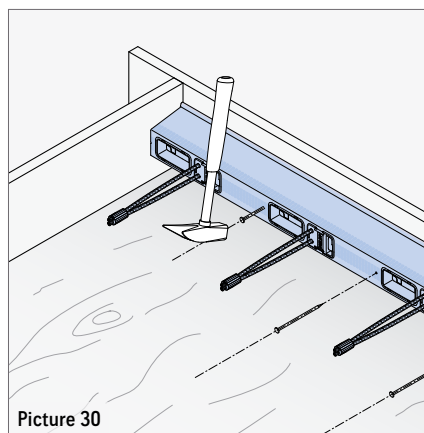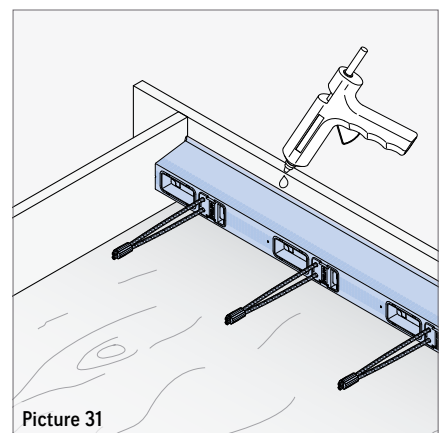Both rails are labelled with manufacturer, product name and CE mark.

Picture 28

Picture 29

The Power Duo rails can be fixed to the formwork by nailing as well as hot bonding (picture 30 and 31).
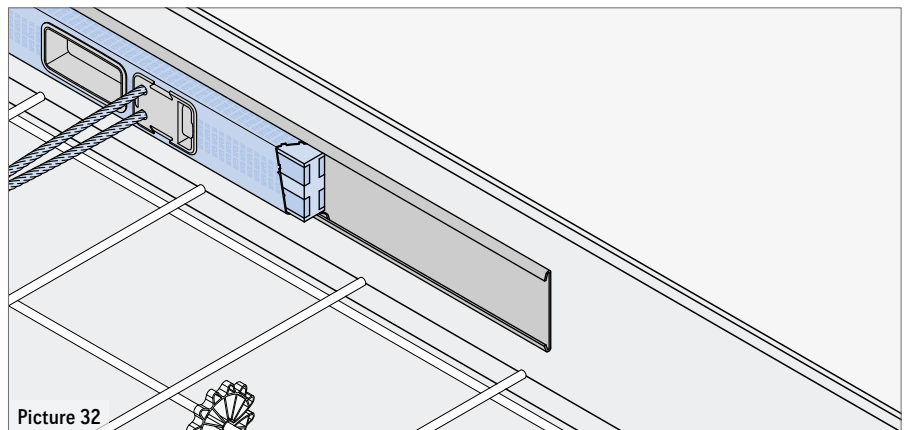

Picture 30

Picture 31

By using the magnetic fixations the PHILIPP Power Duo rails can be fixed to steel formworks fast and easily.

MAGNETIC FASTENER

For more information about the Magnetic fastener please refer to the corresponding Application Instruction.
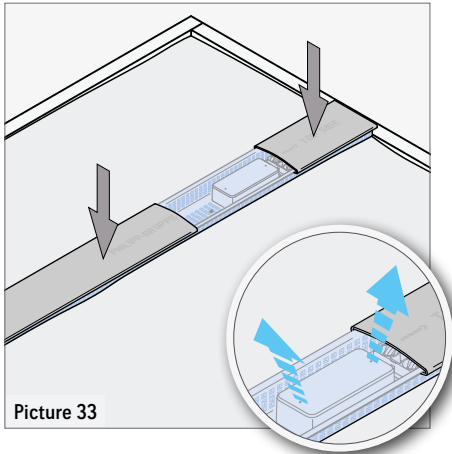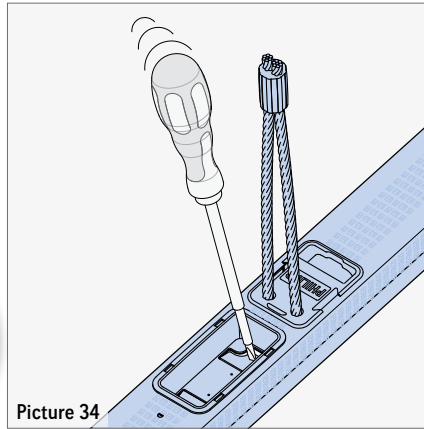

Picture 32

CONCRETING HEIGHT

If Power Duo rails are installed for an upright production of wall-like elements (e. g. battery moulds) depending on the concreting height resulting high loads on the rails due to the concrete pressure are to be expected. To prevent deformations of the profile and/or concrete penetration additional measures should be taken.
For further information please contact our technical hotline (e-mail: technik@philipp-gruppe.de, phone: +49 6021 4027-318).
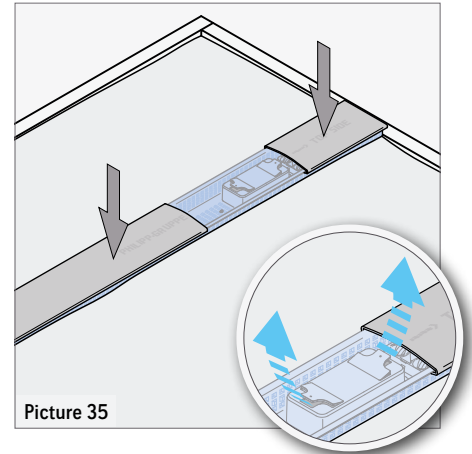
INSTALLATION

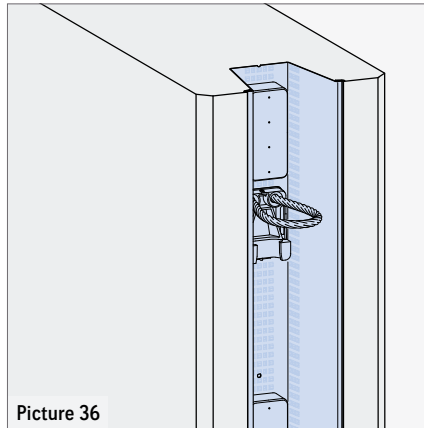Picture 33

Picture 34

Picture 35

⚠ **CONCRETING**

During concreting of elements attention must be paid to the ventilation of all plastic recesses to guarantee a complete filling with concrete.

In order to ventilate a plastic recess box, e.g. when the Power Duo rails are installed on the concrete surface (plastic cover on the top, picture 33), it has four little holes on the top the air can pass off.

If necessary, the plastic recesses can be opened at the predetermined breaking point by using a spiky tool (e.g. screw driver – picture 34).
Hence, a complete filling of the concrete into the recesses is guaranteed.

For elements with the same height it is recommended to start the installation at the upper elements edge (picture 36). So it is possible to concrete the rail-free part at the bottom of the element (picture 37).

Picture 36
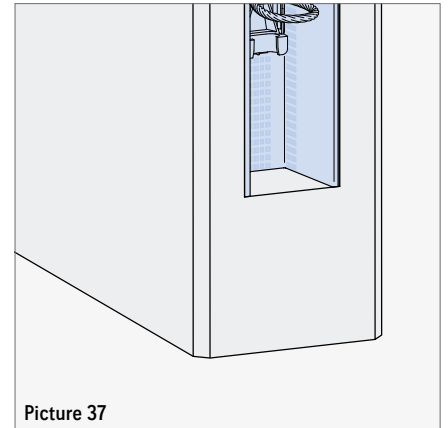
Picture 37

In order to get a continuous poured joint it is also possible to arrange the Power Duo in parts. However, these rail parts should be divided only in steps of 25 cm length. Thus, joints with Power Duo rails are only possible in steps of 25 cm length.

If the joint length cannot be divided by 25 cm the rail-free part can be completed with a loop-free rail (ref. no. 84VS20 and 84VS70) or timber (picture 40) to create a recess.

Part length can be divided by 25 cm
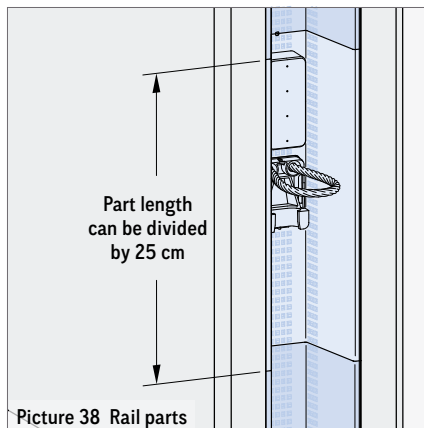
Picture 38 Rail parts

For the design non relevant area
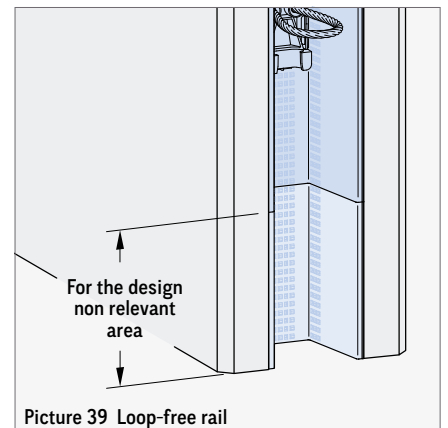
Picture 39 Loop-free rail

PREPARATION FOR MOUNTING

The plastic cover of the installed rail must be released at one end. Then, it can be removed easily from the rail (picture 41).
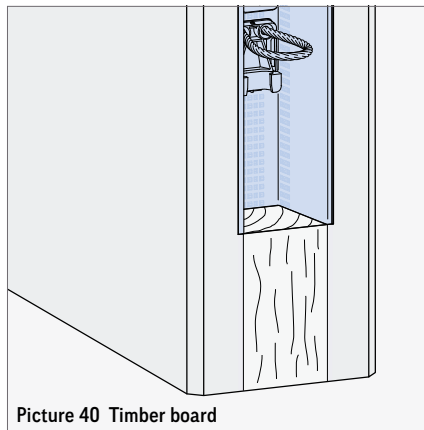
Picture 40 Timber board
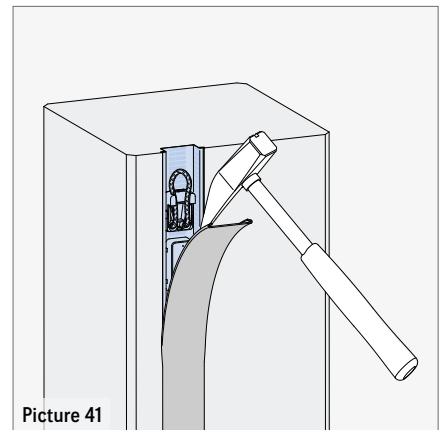
Picture 41

Now, the wire loops of the flat and the deep rail have to be folded out right-angled to the rail (picture 42).
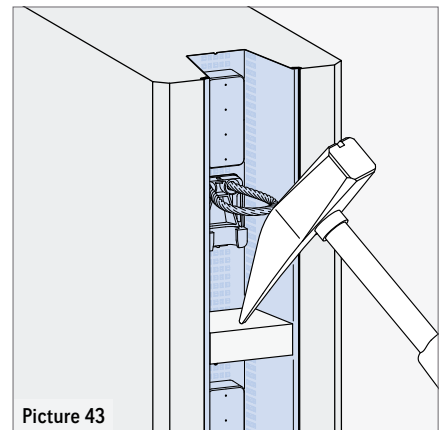
⚠ POLYSTYRENE SPACERS

From the deep Power Duo rail the polystyrene spacers have to be re-moved (picture 43).

Picture 42

Picture 43

MOUNTING

MOUNTING OF THE PRECAST ELEMENTS

If the Power Duo rails are installed correctly the loops overlap horizontally with the nominal dimension of 70 mm as shown in picture 44 and lie on top of each other in vertical direction.

Nevertheless, the Power Duo system approval already considers horizontal and vertical mounting tolerances. The maximum permissible horizontal deviations are shown in picture 45 and 46.
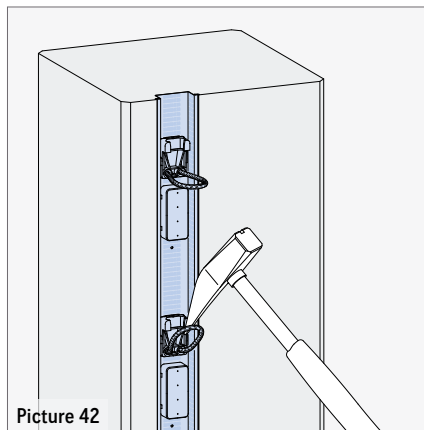
Prior the filling of the joint a reinforcing bar (Ø12 mm) shall be positioned along the entire joint length through the overlapping loops. It is not necessary to overlap the reinforcing bars. The correct installation is to be checked visually.
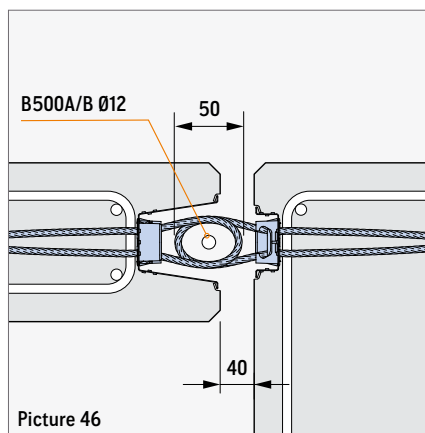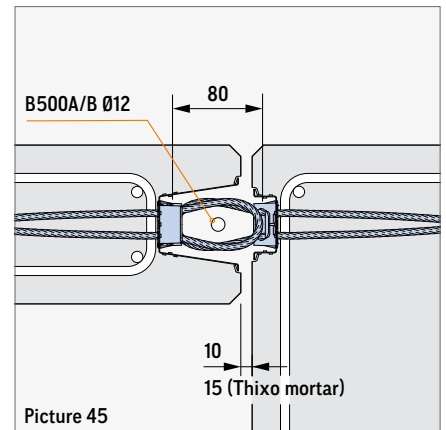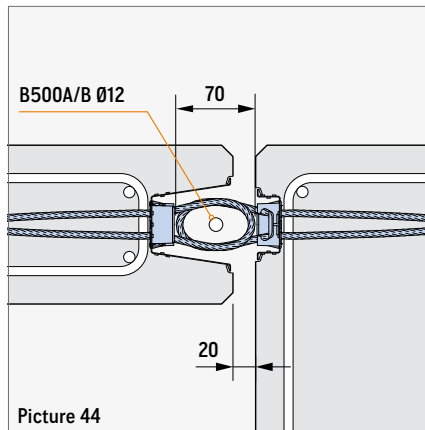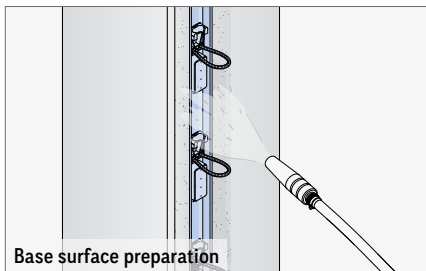
B500A/B Ø12   70   20

Picture 44

B500A/B Ø12   80   10   15 (Thixo mortar)

Picture 45

B500A/B Ø12   50   40

Picture 46

PHILIPP-BETEC® THIXO MORTAR

Base surface preparation

min. 15 mm
max. 40 mm

Mounting conditions

approx. 3.0-4.2 litre

2 to 4 minutes

Mixing

a   b

Consistency check

①
②

Mortar grouting

Aftertreatment of the joint surface

GROUTING WITH PHILIPP-BETEC® THIXO MORTAR OR BETEC® THIXO MORTAR

The system-approved, high-quality, stiff-plastic and thixotropically adjusted PHILIPP-BETEC® mortar is ready for use and consists of approved raw material components. More details can be found in the approval (no. Z-21.8-2028).

BASE SURFACE PREPARATION

Pre-wet the surface well in order to improve the adhesion. If necessary, adhesion-reducing parts in the joints have to be removed, the flanks must be free from dirt, cement slurry and grease.

MOUNTING CONDITIONS
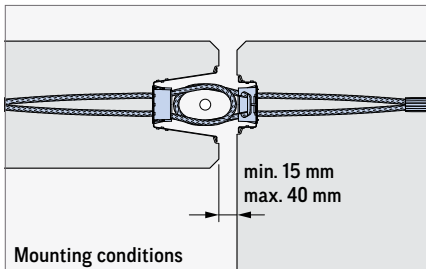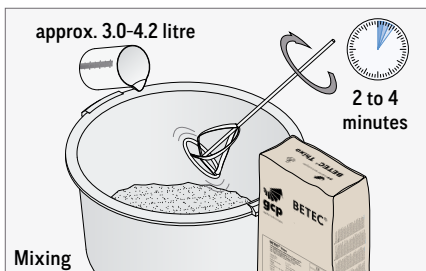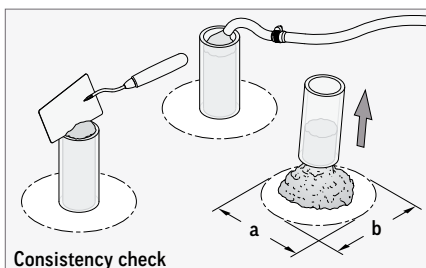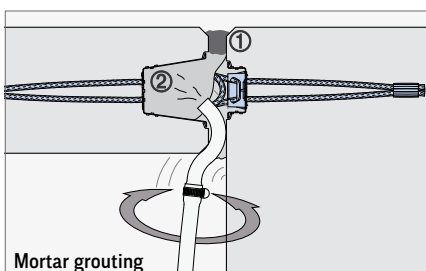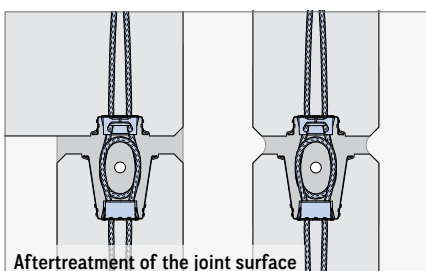
The distance of 15 - 40 mm between the concrete elements must be taken attention to. Both the temperature of the concrete elements and the processing temperature is set between +5° and +30 °C. With lower temperatures specific measures in wintertime must be started.

MIXING PROCESS

The PHILIPP-BETEC® materials are stirred in a suitable mixing machine (e.g. compulsory mixer). Depending on the mixer the mixing time is different, as a rule between 2-4 minutes. A homogeneous, lump-free mixture is to be produced. Normally, 4/5 of the required amount of water is filled in, the powder component is added, the mixture is mixed for approx. 2 minutes and then the remaining water is added. Finally, the mixture is mixed for 1-2 minutes again. Then, the grouting starts immediately.

CONSISTENCY CHECK

The flow diameter (a + b) / 2 for the stiff-plastic PHILIPP-BETEC® Thixo mortar shall be greater than 15 cm and less than 19 cm. Corresponding consistency is dependent on the amount of water added, the mixing intensity and powder temperature. At high temperatures the mortar hardens faster. According to EN 1015-3 the flow diameter is determined with a defined funnel.

MORTAR GROUTING

Grouting starts immediately after the mixing process is finished. For this suitable, electrically operated screw pumps are used. First, one of the two joint flanks is closed resp. sealed. Usually, a sealing cord resp. sealing hose or the Thixo mortar itself can be used here ①. The grouting is then done slowly and continuously from the bottom to the top ②. A hose end suitable for the grouting (e. g. bent or curved tube) has to be turned during grouting from the left to the right (alternating) in order to ensure a filling without any voids.

AFTERTREATMENT OF THE JOINT SURFACE

After grouting the joint must be trowelled. This has to be done as long as the mortar is still fresh and not hardened.

P&T EUROGROUT® UNIVERSALFÜLLER (THIXO MORTAR)

Base surface preparation

min. 15 mm
max. 40 mm
Mounting conditions

3.5 – 3.75 litre
2 to 3 minutes
Mixing

Tube Ø70 mm
Height 100 mm
a   b
Consistency check

①
②
Mortar grouting

Aftertreatment of the joint surface
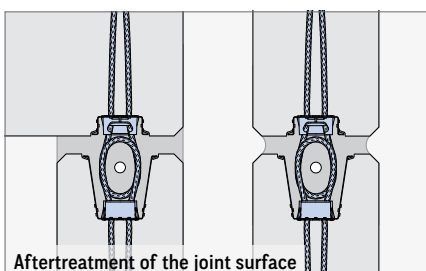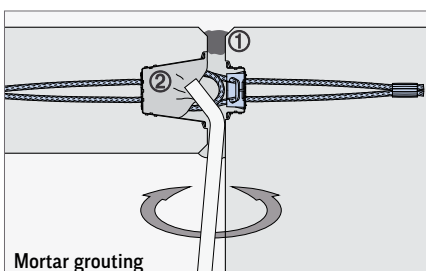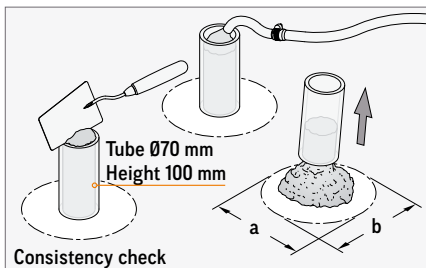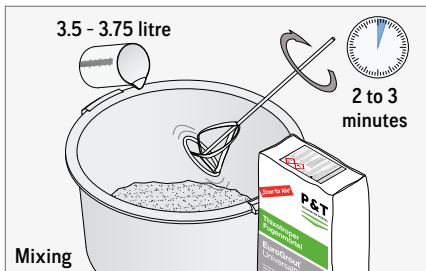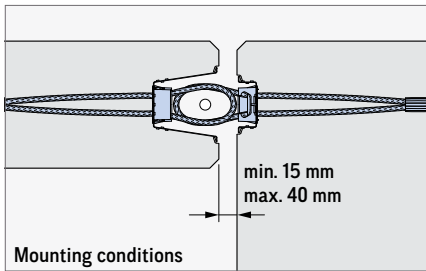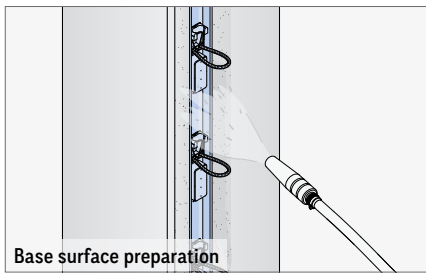
GROUTING WITH EUROGROUT® UNIVERSALFÜLLER

The EuroGrout® Universalfüller is a mortar approved for the Power Duo System. Its dry mix can be mixed quickly and easily and is filled in the joint by using a mixing pump afterwards. As a sealing of the joint is not necessary the effort and therefore the time spent is reduced significantly.

BASE SURFACE PREPARATION

Pre-wet the surface well in order to improve the adhesion. If necessary, adhesion-reducing parts in the joints have to be removed, the flanks must be free from dirt, cement slurry and grease.

MOUNTING CONDITIONS

The distance of 15 – 40 mm between the concrete elements must be taken attention to. The unit and processing temperature of the Universalfüller must comply with the latest corresponding DAfStb regulation.

MIXING PROCESS

The Universalfüller is designed for a machine processing with mixing pumps. A machining with small, handy mixing pumps allows long draws without changing the position of the pump frequently.
For a manual processing, the Universalfüller must be mixed in a compulsory mixer or with a slow-running stirrer. Here, 4/5 of the water amount is filled in the mixer, then the powder is added and after a short time of mixing the remaining water.

CONSISTENCY CHECK

The flow diameter (a + b) / 2 must be between 11 and 15 cm and must be determined according to the latest DAfStb regulation for cement based grouting concrete and mortar, appendix C. Instead of an ebonite ring a plastic tube (prepared with separating agent) with an inner diameter of d = 70 mm and a height of h = 100 mm can be used. The grouting of the plastic tube must be done by using the equipment mentioned below in "Mortar grouting".

MORTAR GROUTING

Equipment used for the grouting is either a screw pump or a continuous mixer. First, one joint flank is closed completely. Usually, a sealing cord resp. sealing hose or the Thixo mortar itself can be used here ①. Then, the remaining space of the joint is filled from the opposite side and from the bottom to the top using a bent tube (according to the Technical Data Sheet EuroGrout® Universalfüller) ②. The tube has to be turned during grouting from the left to the right (alternating) in order to ensure a filling without any voids.

AFTERTREATMENT OF THE JOINT SURFACE

After grouting the joint must be trowelled. Waste material has to be removed for optical reasons before hardening.

PHILIPP-BETEC® GROUTING MORTAR

Base surface preparation

min. 10 mm
max. 40 mm
Mounting conditions

approx. 2.6 litre
4 to 5 minutes
Mixing

- max. 3.75 m joint height
- grouting layerwise
Mortar grouting

! **GROUTING**

Bear in mind when grouting air must be able to leak. A careful vibration can avoid entrapped air. The processing time is about 30 minutes at 20 °C.
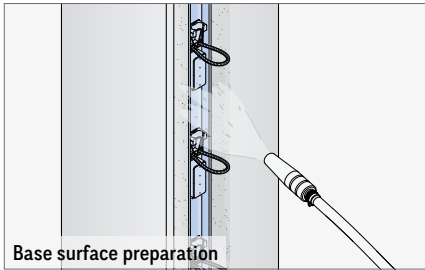
GROUTING WITH PHILIPP-BETEC® GROUTING MORTAR OR BETEC® GROUTING MORTAR

The PHILIPP-BETEC® system-approved, high-quality grouting mortar is a ready-to-use mortar. It consists of approved raw material components.

BASE SURFACE PREPARATION

The concrete surface has to be cleaned from dirt, grease and adhesion-reducing parts and layers until the core concrete is exposed. A pre-watering of the concrete surface must be done until the water saturation is reached. At the time of the joint filling the concrete surface shall only look pale damp, stagnant water must be removed.
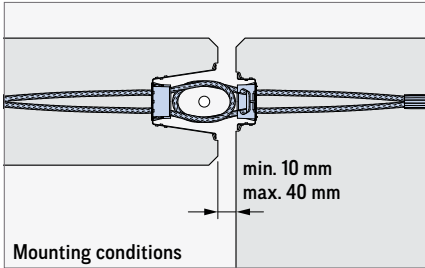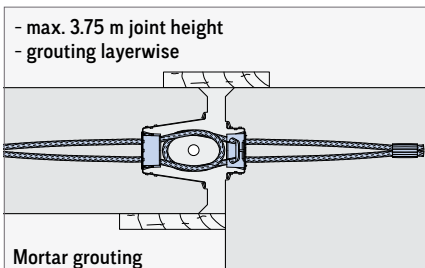
PROPERTIES

The grouting mortar is free of chlorides. Because of the controlled swelling the mortar is shrink-free and thus guarantees a force-fit connection. It has a good adhesion to steel and concrete and shows no signs of segregation. Furthermore, it has a good pumpability as well as resistance to frost and de-icing salt. The grouting mortar is produced always in constant quality and is easy to process. Due to its flowable consistency the mortar is self-levelling and fills all accessible ventilated voids.
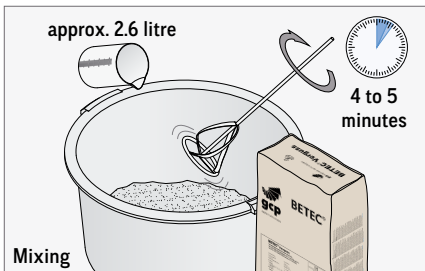
MIXING

Mixing can be done:

» by a separated mixing in a compulsory mixer first and following pumping of the mixture with a suitable screw pump. A mixing time of approximately 4 - 5 minutes is to be aimed. First 4/5 of the water amount has to be given, the powder added and after 2 - 3 minutes the balance of the water added until the requested consistency is reached and a homogeneous matrix of mortar satisfies.

» or by using a suitable continuous mixer. Hereby it must be proved that no reduction of the strength can arise.

MORTAR GROUTING

Both sides of the joint are sealed before the grouting mortar is filled into. Here, the use of a grouting hose with a hopper eases the process considerably. To reduce the concreting pressure it is recommended to fill in the grouting mortar in sections. (When using a joint tape be careful that it does not impede the grouting section or reduces the required concrete cover for the Power Duo System.)

PROCESSING TEMPERATURE

The processing temperature of the grouting mortar is at least +5 °C and maximum +30 °C. With lower temperatures specific measures in wintertime must be started.

AFTERTREATMENT

It shall be prevented that the grouting mortar dries up too fast for at least three days after application. Appropriate measures are covering with plastic sheets, wet tissues or watering.

P&T EUROGROUT® VARIX (GROUTING MORTAR)

Base surface preparation

min. 10 mm
max. 40 mm
Mounting conditions

approx. 3.0 litre
4 to 6 minutes
Mixing

- max. 3.75 m joint height
- grouting layerwise
Mortar grouting

⚠ **GROUTING**

Bear in mind when grouting air must be able to leak. The processing time is approximately 60 minutes at 20 °C.

GROUTING WITH EUROGROUT® VARIX

The EuroGrout® Varix grouting mortar is a mortar approved for the Power Duo System. It consists of a ready-to-use dry mixture based on cement and is used to grout precast concrete elements. It is shrink-free, has a high early strength and a good flowability.

BASE SURFACE PREPARATION

The surface must be free from dirt, oils, greases etc. and cement slurry rests on the surface shall be removed. A board formwork or other equipment should be used to seal the joint. To improve the adhesion, the joint surface should be pre-wetted thoroughly.

PROPERTIES

The grouting mortar is free of chlorides. It has a good adhesion to steel and concrete and shows no signs of segregation. Furthermore, it has a good pumpability and resistance to frost and de-icing salt. The grouting mortar is produced in consistently high quality and is easy to process. Due to its flowable consistency the mortar is self-levelling and fills out all accessible venting hollow spaces.

MIXING

Approximately 4/5 of the mixing water is put into the mixer, then the grouting mortar is stirred completely. Afterwards the remaining water is used to adjust the consistency. The mixing time is 4 – 6 minutes depending on the type of mixing.

MORTAR GROUTING

Both sides of the joint are sealed before the grouting mortar is filled into. Here, the use of a grouting hose with a hopper eases the process considerably. To reduce the concreting pressure it is recommended to fill in the grouting mortar in sections. (When using a joint tape be careful that it does not impede the grouting section or reduces the required concrete cover for the Power Duo System.)

PROCESSING TEMPERATURE

The processing temperature of the grouting mortar is at least +5 °C and maximum +30 °C. With lower temperatures specific measures in wintertime must be started.
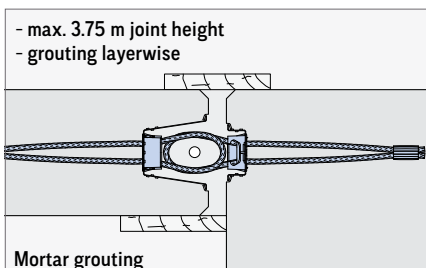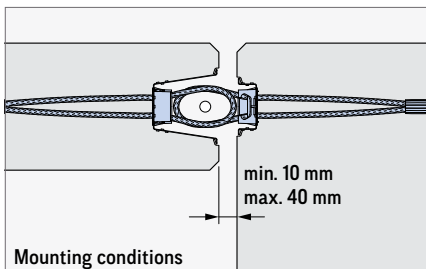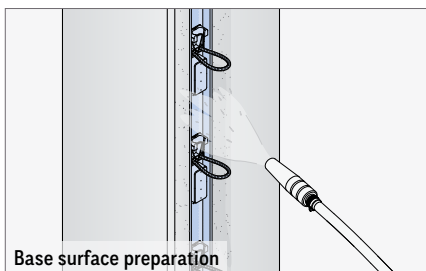
AFTERTREATMENT

It shall be prevented that the grouting mortar dries up too for three to five days after application. Appropriate measures are covering with plastic sheets, wet tissues or watering.
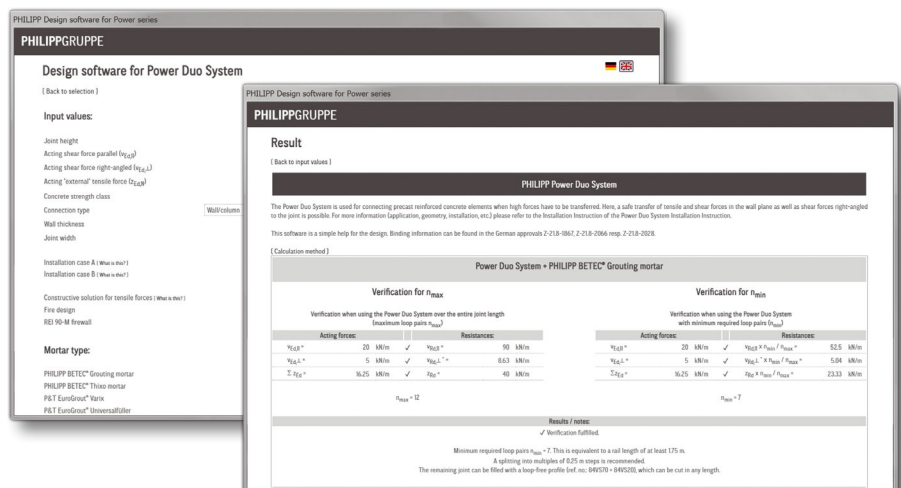
SOFTWARE / CAD

DESIGN

In order to design connections with the PHILIPP Power Duo System you can find an online design tool on our website (www.philipp-software.de), easy-to-use, understandable and without registration.


TEKLA STRUCTURES FROM COMPANY TRIMBLE SOLUTIONS GERMANY

Also for the CAD software Tekla Structures from Trimble a library of the Power Duo System is available. This includes 3-D models of the deep and the flat rail as well as rails without any loops, all in different lengths.

3-D MOUNTING PARTS

Time-saving during the planning process and support for the Building Information Modelling (BIM) method are becoming more and more important. This is the reason why the universal PHILIPP CAD library helps to work efficient on these matters.

» More than 1,200 PHILIPP products are available as 3-D model
» Universal CAD library with many export formats compatible for all CAD systems (e. g. IFC, DWG)
» Free offer for all people involved in precast building
» Time-saving in the design process because of ready-made models and views
» Simply structured catalogue
» More product details are provided
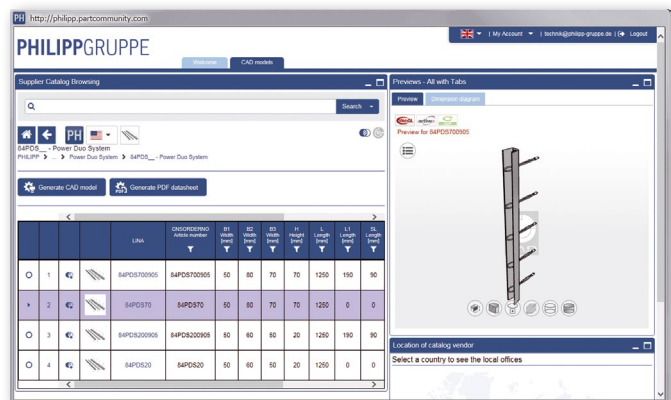
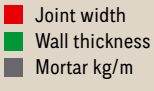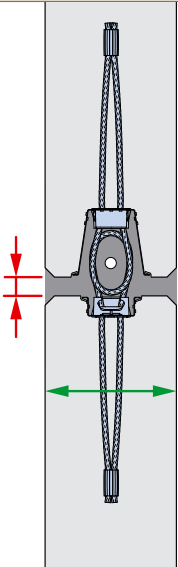» Standard PartCommunity:
  philipp.partcommunity.com
» BIM specific PartCommunity:
  3dfindit.com

GENERAL NOTES

TABLE 13: SITE CHECK LIST

Step	What	Comment	Thixo mortar	Grouting mortar
1	Open the rail	Remove cover	✓	✓
2	Check of joint	Pay attention to a clean surface, when necessary clean again	✓	✓
3	Fold-out the connecting loops	Pay attention to the 90° position	✓	✓
4	Align concrete units	Pay attention to admissible tolerances	✓	✓
5	Install joint reinforcement	Along the entire length of the joint	✓	✓
6	Pre-wetting of joints	Improvement of adhesion	✓	✓
7	Sealing on both sides	Use formwork, timber boards or joint tapes	–	✓
8	Mortar grouting	Pay attention to the required ambient temperature, compacting as well as processing time and instructions	✓	✓
9	Filling the joint	Screw pump or continuous mixer	✓	–
10	Demoulding	After hardening of the mortar	–	✓
11	Aftertreatment of joint	Protection against too fast drying	✓	✓
12	Aftertreatment of the joint before mortar is hardened	Joint has to be trowelled	✓	–

TABLE 14: MORTAR CONSUMPTION PER 1 M OF JOINT (KG/M)

Wall thickness (cm)	BETEC® Grouting mortar Joint width (cm) 1.0	2.0	3.0	4.0	BETEC® Thixo mortar Joint width (cm) 1.0	2.0	3.0	4.0		Wall thickness (cm)	EuroGrout® Varix Joint width (cm) 1.0	2.0	3.0	4.0	EuroGrout® Universalfüller Joint width (cm) 1.0	2.0	3.0	4.0
12	–	–	–	–	–	–	–	–	■ Joint width	12	11.7	14.5	17.3	20.1	10.6	13.1	15.7	18.2
13	–	–	–	–	–	–	–	–	■ Wall thickness	13	11.9	14.7	17.5	20.3	10.8	13.3	15.9	18.4
14	11.6	14.3	17.0	19.7	11.6	14.3	17.0	19.7	■ Mortar kg/m	14	12.1	14.9	17.7	20.5	11.0	13.5	16.1	18.6
15	11.8	14.7	17.6	20.5	11.8	14.7	17.6	20.5		15	12.3	15.3	18.3	21.3	11.2	13.9	16.6	19.3
16	12.0	15.1	18.2	21.2	12.0	15.1	18.2	21.2		16	12.5	15.7	18.9	22.1	11.3	14.3	17.2	20.1
17	12.2	15.5	18.7	22.0	12.2	15.5	18.7	22.0		17	12.7	16.1	19.5	22.9	11.5	14.6	17.7	20.8
18	12.4	15.8	19.3	22.8	12.4	15.8	19.3	22.8		18	12.9	16.5	20.1	23.7	11.7	15.0	18.3	21.5
19	12.6	16.2	19.9	23.5	12.6	16.2	19.9	23.5		19	13.1	16.9	20.7	24.5	11.9	15.3	18.8	22.3
20	12.8	16.6	20.5	24.3	12.8	16.6	20.5	24.3		20	13.3	17.3	21.3	25.3	12.1	15.7	19.3	23.0
21	13.0	17.0	21.0	25.1	13.0	17.0	21.0	25.1		21	13.5	17.7	21.9	26.1	12.3	16.1	19.9	23.7
22	13.2	17.4	21.6	25.8	13.2	17.4	21.6	25.8		22	13.7	18.1	22.5	26.9	12.4	16.4	20.4	24.4
23	13.3	17.8	22.2	26.6	13.3	17.8	22.2	26.6		23	13.9	18.5	23.1	27.7	12.6	16.8	21.0	25.2
24	13.5	18.2	22.8	27.4	13.5	18.2	22.8	27.4		24	14.1	18.9	23.7	28.5	12.8	17.2	21.5	25.9
25	13.7	18.5	23.3	28.2	13.7	18.5	23.3	28.2		25	14.3	19.3	24.3	29.3	13.0	17.5	22.1	26.6
26	13.9	18.9	23.9	28.9	13.9	18.9	23.9	28.9		26	14.5	19.7	24.9	30.1	13.2	17.9	22.6	27.3
27	14.1	19.3	24.5	29.7	14.1	19.3	24.5	29.7		27	14.7	20.1	25.5	30.9	13.3	18.3	23.2	28.1
28	14.3	19.7	25.1	30.5	14.3	19.7	25.1	30.5		28	14.9	20.5	26.1	31.7	13.5	18.6	23.7	28.8
29	14.5	20.1	25.7	31.2	14.5	20.1	25.7	31.2		29	15.1	20.9	26.7	32.5	13.7	19.0	24.3	29.5
30	14.7	20.5	26.2	32.0	14.7	20.5	26.2	32.0		30	15.3	21.3	27.3	33.3	13.9	19.3	24.8	30.3

Given consumption data are only guide values.

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Please refer also to the approvals of the Power Duo system. You can find all at www.philipp-group.de or are available on request.

For further information about the mortars, please follow the links given:

⊟ BETEC Grouting
⊟ BETEC Thixo
⊟ EuroGrout Varix
⊟ EuroGrout Universalfüller

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