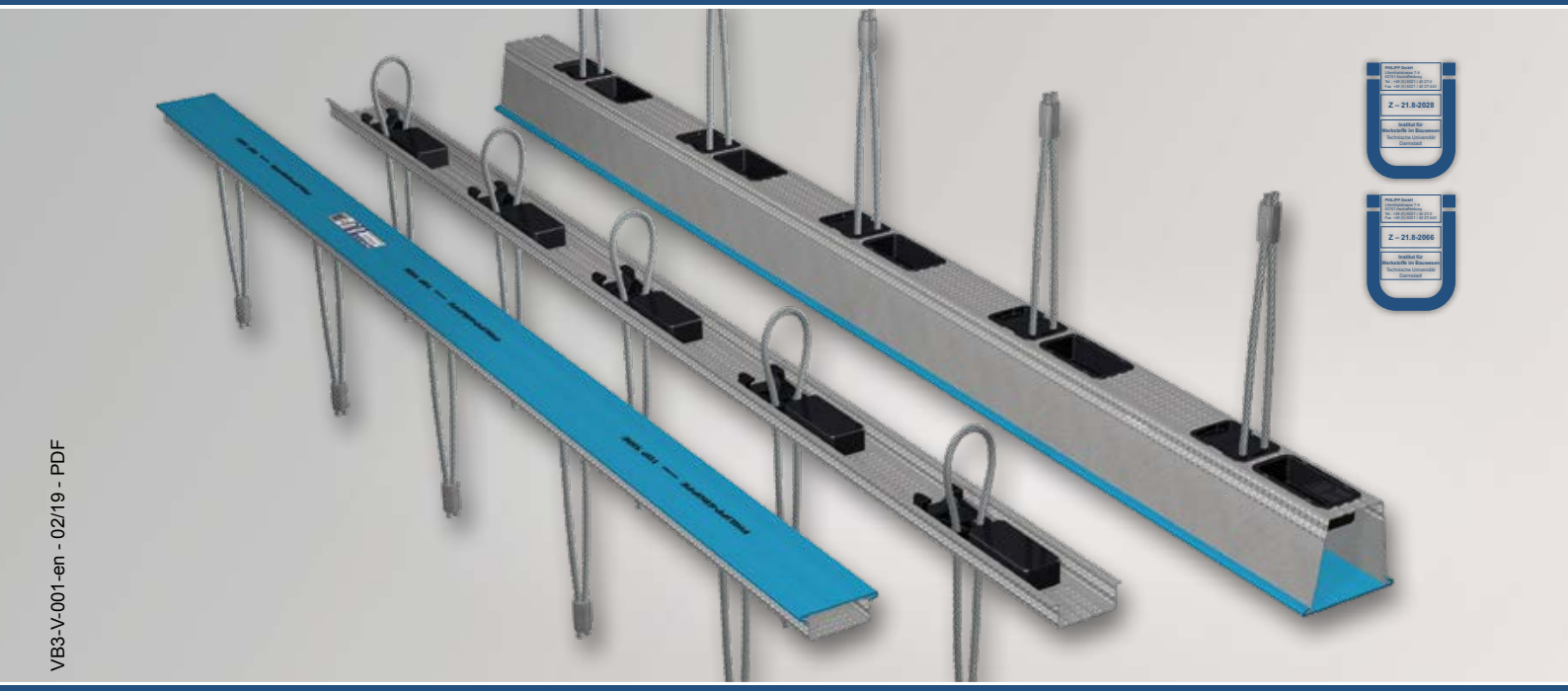
PHILIPPGROUP

PHILIPP Power Duo System



VB3-V-001-en - 02/19 - PDF

Installation Instruction

Transport and mounting systems for prefabricated building

Technical department

Our staff will be pleased to support your planning phase with suggestions for the installation and use of our transport and mounting systems for precast concrete construction.

Special designs

Customized to your particular needs.

Practical tests on site

We ensure that our concepts are tailored precisely to your requirements.

Inspection reports

For documentation purposes and your safety.

On-site service

Our engineers will be pleased to instruct your technicians and production personnel at your plant, to advise on the installation of precast concrete parts and to assist you in the optimisation of your production processes.

High safety level when using our products

Close cooperation with federal materials testing institutes (MTIs), and official approvals for the use of our products and solutions whenever necessary.

Software solutions

The latest design software, animated videos and CAD libraries can always be found under www.philipp-gruppe.de.

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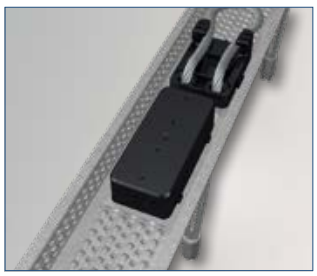
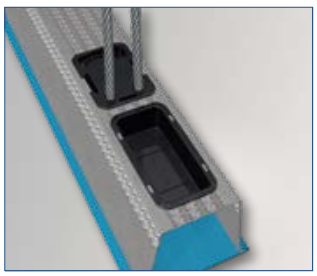
Content



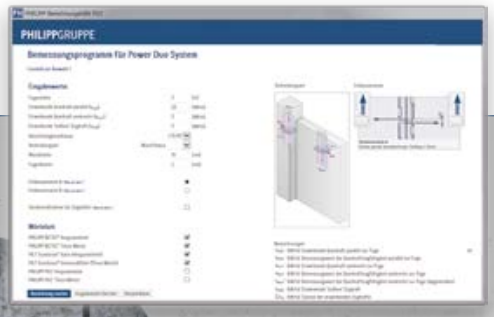


PHILIPP Power Duo System

Advantages at a glance:

- Power Duo rails are combinable with products of two mortar suppliers.
- More tolerant in case of faulty installation, e.g. false position of the loops.
- Forces in all directions transferable
  - tensile forces, shear forces parallel and right-angled to the joint.
- Approved application
  - with thixotropic mortar as well as grouting mortar.
- Most economical application using Thixo mortar
  - saves sealing of the joint and grouting in sections.
  - saves time and reduces costs.
- Reduced efforts for design and planning using our free online design software (on PHILIPP website).
- Use in loadbearing, fire-stressed walls (REI) and non-loadbearing fire walls (EI-M 90).

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

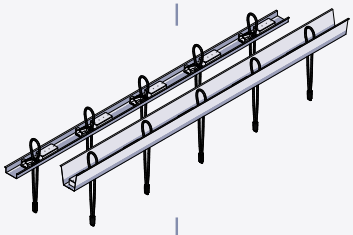


System components

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 galvanised channels.
Both channels are equipped with plastic recess formers and galvanised steel wire rope loops each with a distance of 250 mm. During concreting the plastic recess formers are filled and in combination with the profiled channel and the wire rope loops the system enables an excellent load bearing capacity.
The two rails are installed flush with the surface on the opposite side of each particular concrete unit.
After demoulding, the plastic cover is removed and the loops are folded down easily to the position needed. So, the concrete units are ready for transport and mounting at the job-site.
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-transmitting and form-fit connection.

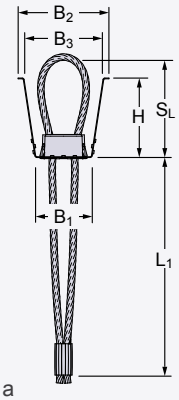
The German approved
PHILIPP Power Duo System
Power Duo rails
(Z-21.8-2028 / Z-21.8-2066)



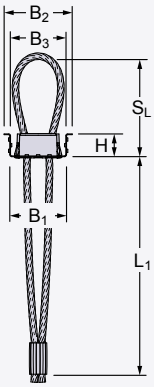
BETEC®
(Z-21.8-2028)
Thixo mortar / Grouting mortar

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

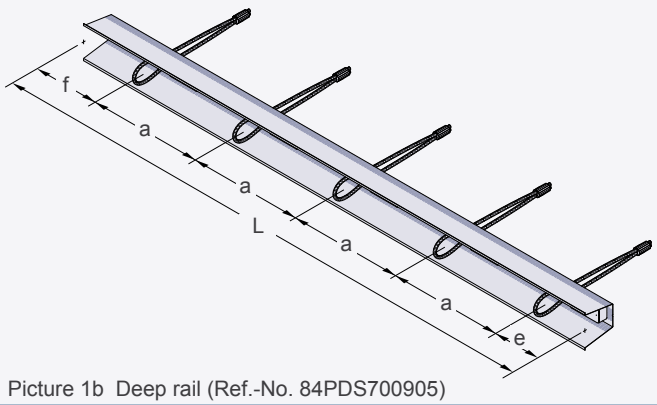
This Installation Instruction provides necessary technical information. In all cases, the requirements of the national German approval must be considered!



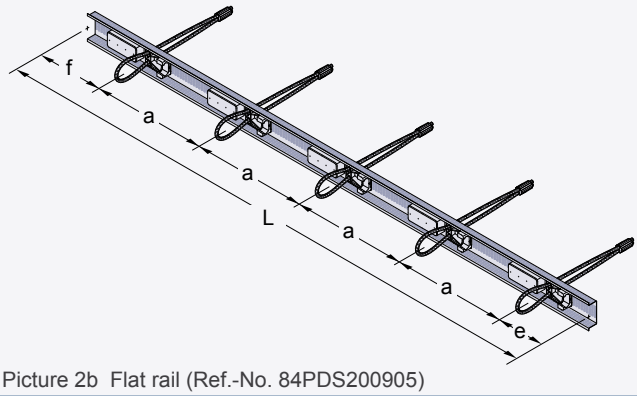
Picture 1a



Picture 2a



Picture 1b Deep rail (Ref.-No. 84PDS700905)



Picture 2b Flat rail (Ref.-No. 84PDS200905)

Table 1: Dimensions of the Power Duo rails

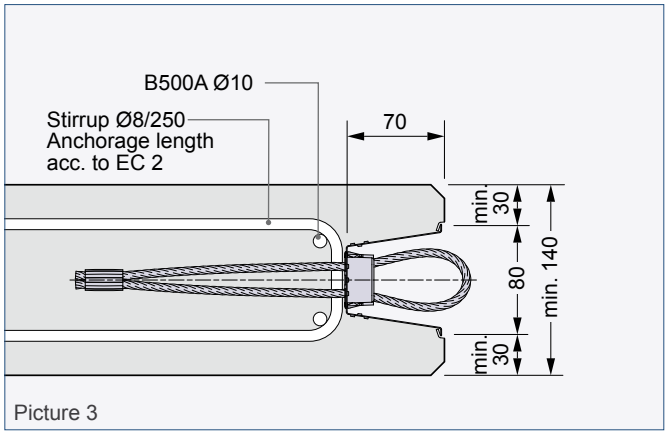
Ref.-No.	Dimensions [mm]										Weight per rail [kg]
	B_1	B_2	B_3	H	L	L_1	S_L	e	f	a	
84PDS700905	50	80	70	70	1250	190	90	107	143	250	1.99
84PDS200905	50	60	50	20							1.34

Application

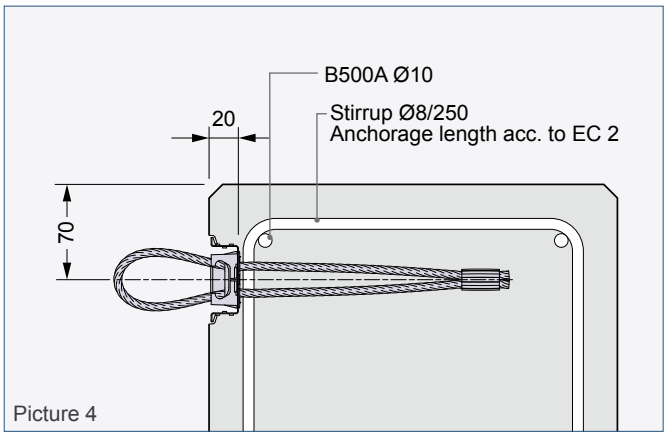
Dimensions of concrete units

Due to the required concrete cover of 30 mm for the Power Duo rails the min. resulting wall thickness is 140 mm (picture 3).

In the following pictures only the required reinforcement for the Power Duo system is shown!



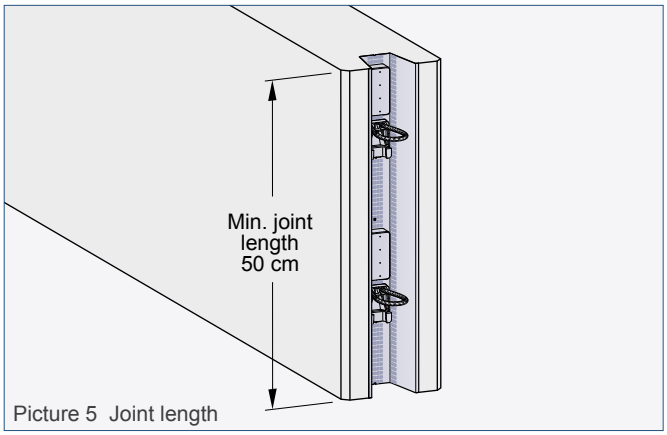
Picture 3



Picture 4

Length of joints

The minimum length of a joint must be 50 cm for the Power Duo system (minimum 2 loops are required so that a strut-and-tie-model can work). So, it is possible to install the Power Duo rails in shorter parts (page 22).

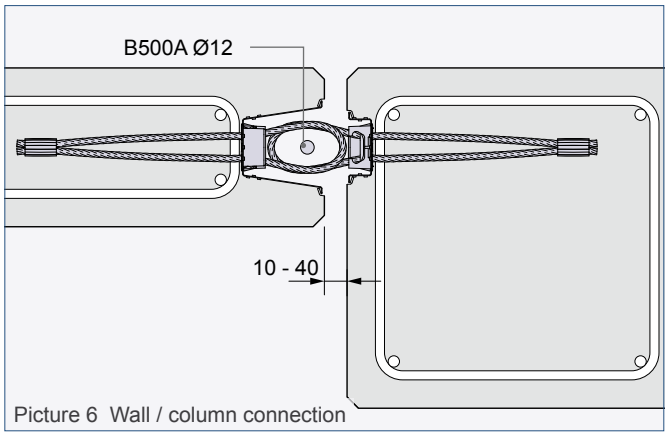


Picture 5 Joint length

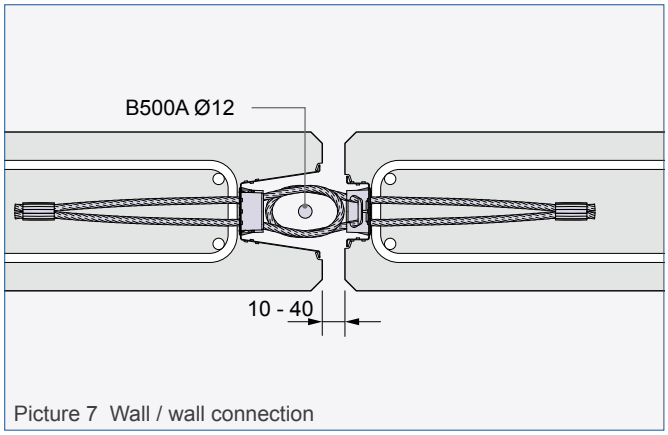
Application

Range of applications

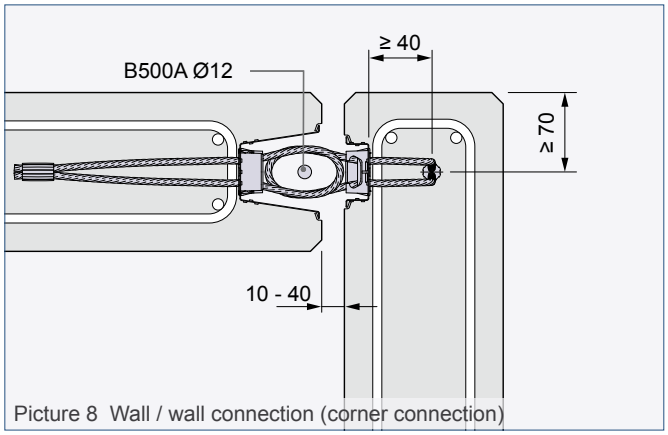
The Power Duo system can be used for various connections of reinforced concrete elements. It transfers primarily static shear forces parallel and right-angled to the wall as well as tensile forces from predominantly static loads. Only in case of direct weathering on the connection between reinforced concrete elements it must be ensured for the application that the crack width in the joint is limited to w ≤ 0.3 mm.



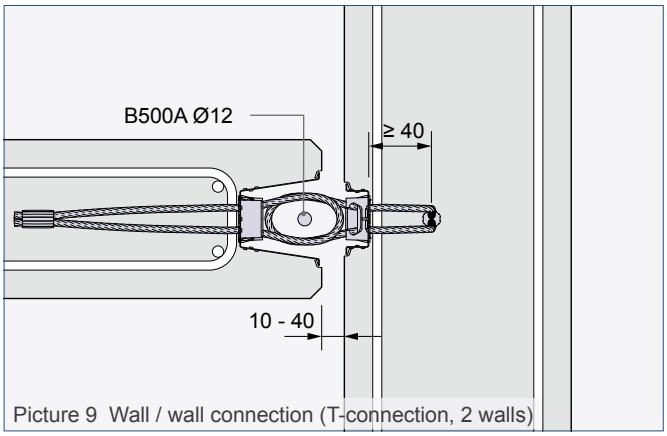
Picture 6 Wall / column connection



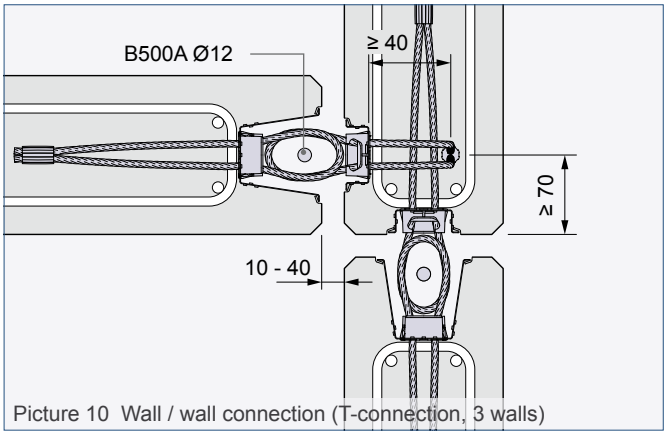
Picture 7 Wall / wall connection



Picture 8 Wall / wall connection (corner connection)



Picture 9 Wall / wall connection (T-connection, 2 walls)

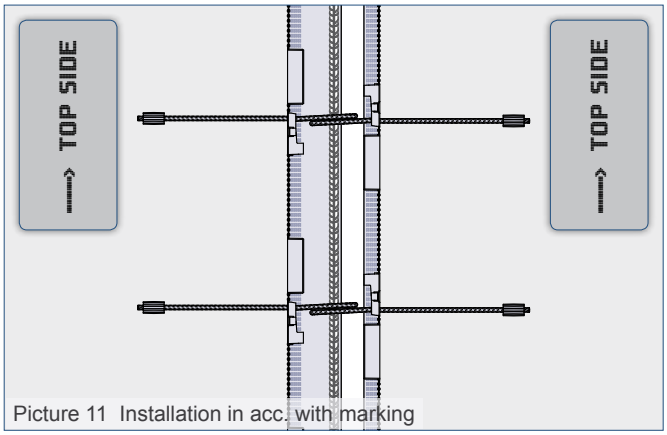


Picture 10 Wall / wall connection (T-connection, 3 walls)

Application

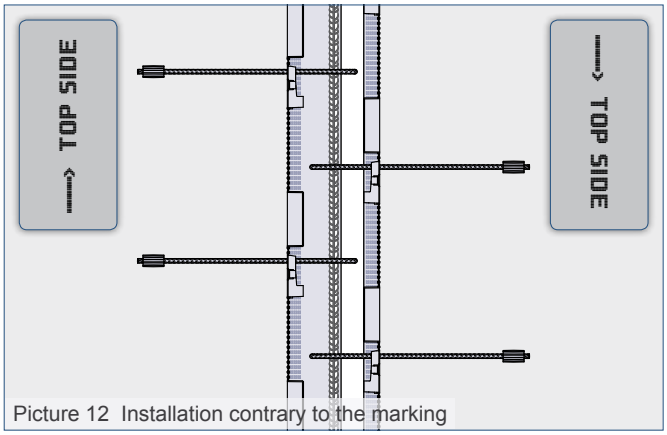
Installation of the rails

In general, the Power Duo rails shall be installed with care for the direction (see marking on the rails). If the installation is not done correctly there are still design values for bearing capacities available so that a verification is possible anyway (see also Picture 28 and 29).
Picture 9 shows the correct installation of the Power Duo rails. The opposite rails are arranged according to its marking. As a result, the wire rope loops do not have a false position in vertical direction.



Picture 11 Installation in acc. with marking

In contrast, picture 12 shows an incorrect installation of the Power Duo rails. Here, one of the opposite rails is arranged against the direction given by the marking. False positions in vertical direction up to the maximum of half a wire rope loop distance (= 125 mm) are covered by a design value.



Picture 12 Installation contrary to the marking

Application in case of fire

Loadbearing, fire-stressed wall (REI)

The Power Duo system is suitable for loadbearing, fire-stressed connections, if the bearing capacities are reduced according to the calculation example case 3 (Page 18).

Forces on loadbearing fire-stressed walls

permissible: Self-weight, additional loads, use as stiffening element

inadmissible: Stress right-angled to the joint (wind load), criterion M (DIN EN 1992-1-2:2010-12)

Non-loadbearing fire wall (EI 90-M)

The Power Duo system can be installed in most fire wall constructions as a connection solution. Based on the approvals the Power Duo system provides connections equivalent to the construction details mentioned in DIN 4102-4:2016-05 chap. 5.12.5 - 5.12.7.
These details primarily refer to connection possibilities of non-loadbearing, lying resp. standing walls. The term ″non-loadbearing wall” is defined (in DIN 4102-4:2016-05, chap. 5.1.1) approx. as follows:

Forces on non-loadbearing fire walls

permissible: Self-weight, stress right-angled to the joint (wind load), criterion M (DIN EN 1992-1-2:2010-12)

impermissible: Additional loads, use as stiffening element

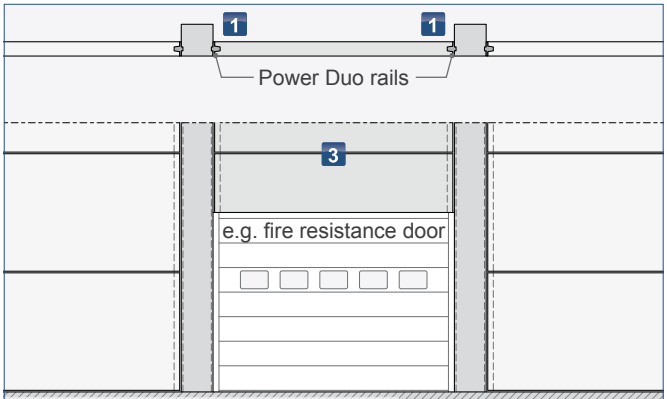
For the planning of non-loadbearing fire walls DIN EN 1992-1-2:2010-12 in combination with DIN EN 1992-1-2/NA:2010-12 and DIN 4102-4:2016-05 must be considered.

Non-loadbearing walls are pane-shaped elements which, even in the event of fire, are loaded only by their self-weight and also do not serve as a stiffening against buckling of loadbearing walls; but they must transfer wind loads acting on their surface to loadbearing components, e.g. shear walls.

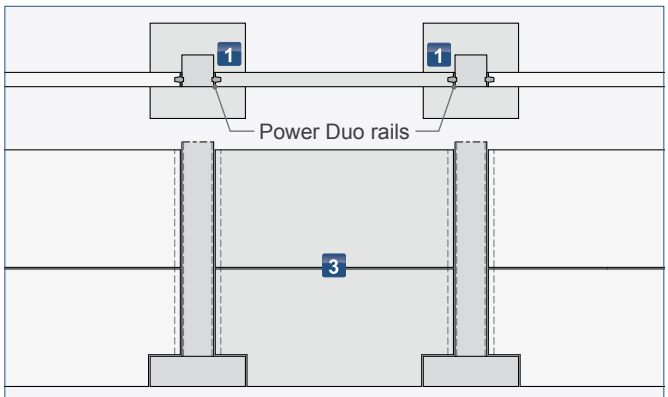
Lying, non-loadbearing walls

Following applications and construction details show connections of lying, non-loadbearing wall elements according to DIN 4102-04:2016-05 chap. 5.12.5 - 5.12.7. Lying elements of a fire wall can be connected to columns directly by the installation of the Power Duo system 1 (Picture 13 and 14). For the connection of two lying walls to each other 2, an additional connection is required e.g. a fixation with cast-in anchor channels to the columns (Picture 15). Horizontal joints 3 have to be executed according to DIN 4102-4 (Picture 22 and 23).

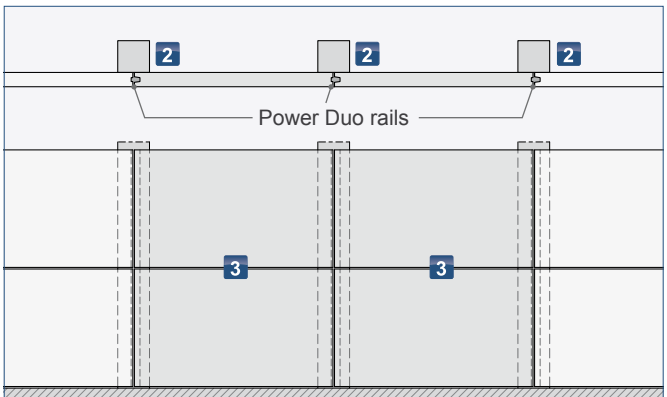
Details of the given connection possibilities in Picture 13 to 17 are shown on page 10 and 11.



Picture 13 Lying walls, non-loadbearing



Picture 14 Lying walls, non-loadbearing



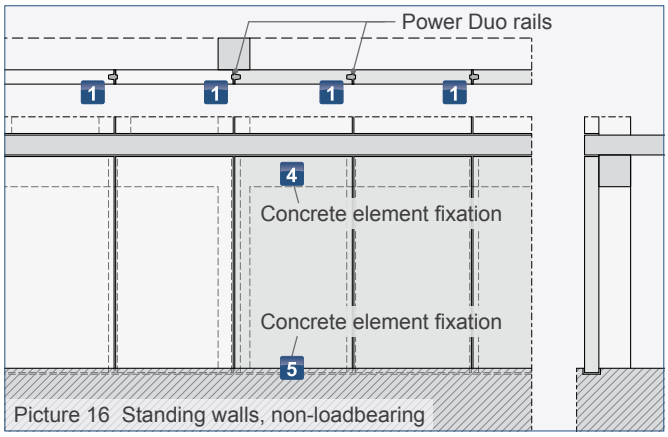
Picture 15 Lying walls, non-loadbearing

Application in case of fire

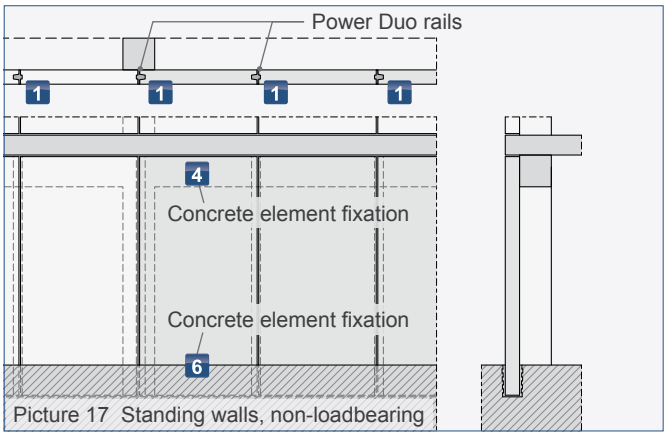
Standing, non-loadbearing walls

Following applications and construction details show connections of standing, non-loadbearing wall elements according to DIN 4102-04:2016-05 chap. 5.12.5. Standing elements of a fire wall can be connected to columns directly by the installation of the Power Duo system 1 (Picture 16 and 17).

Here, it is required to fix the walls at the top and the bottom according to DIN 4102-04:2016-05 to a bearing construction. At the top, a connection e.g. with a cast-in anchor channel to a beam 4 is possible. At the bottom of the wall e.g. a recess 5 or a sleeve foundation 6 can be used for this.

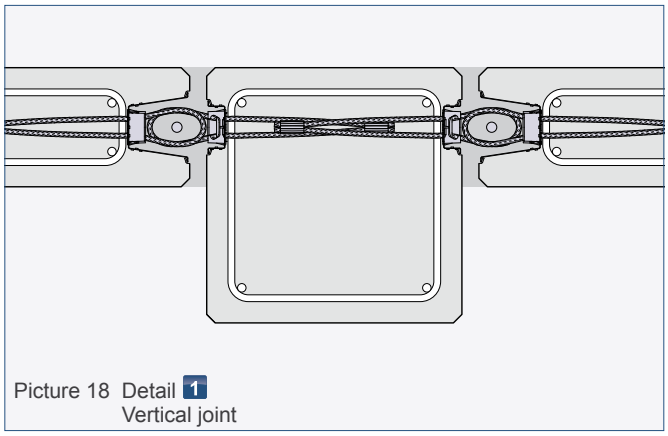


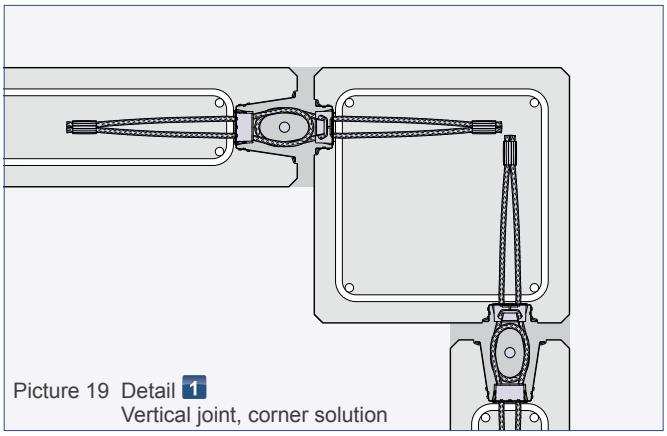
Picture 16 Standing walls, non-loadbearing

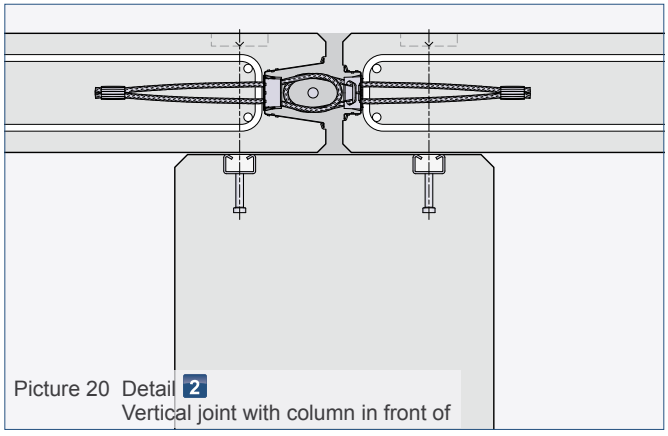


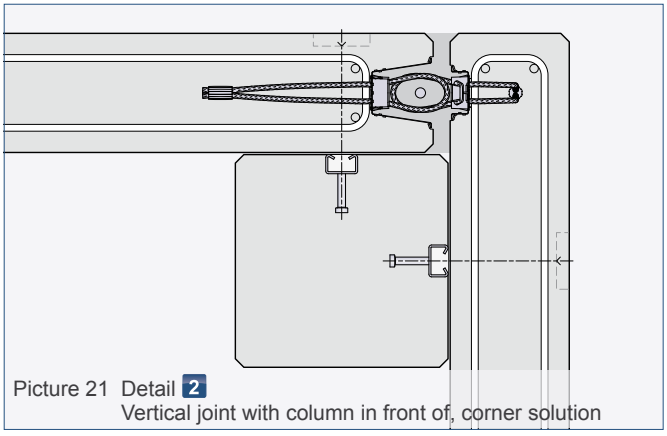
Picture 17 Standing walls, non-loadbearing

Details of vertical joints


Picture 18 Detail 1
Vertical joint


Picture 19 Detail 1
Vertical joint, corner solution

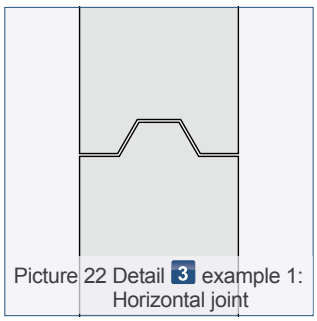

Picture 20 Detail 2
Vertical joint with column in front of


Picture 21 Detail 2
Vertical joint with column in front of, corner solution

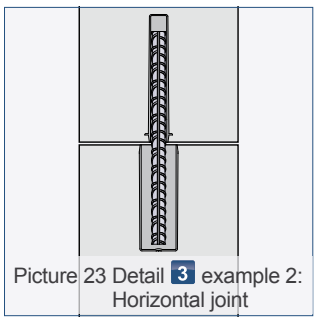
Application in case of fire

Horizontal joints

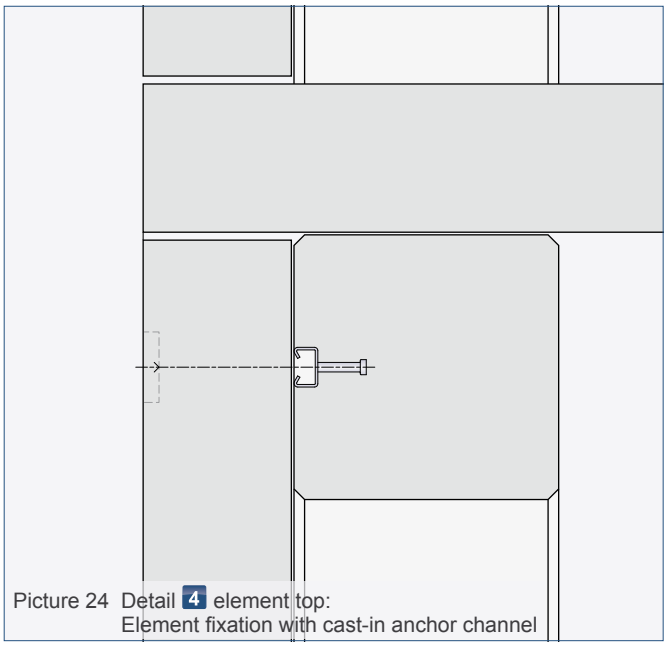
Construction details of horizontal joints between lying walls are given in chap. 5.12.7 of DIN 4102-04:2016-05. Both tongue-and-groove joints as well as plain joints with dowel connections (e.g. PHILIPP Dowelling system) are possible and must be done with a joint sealer based on cement mortar or synthetic resin-based mortar.



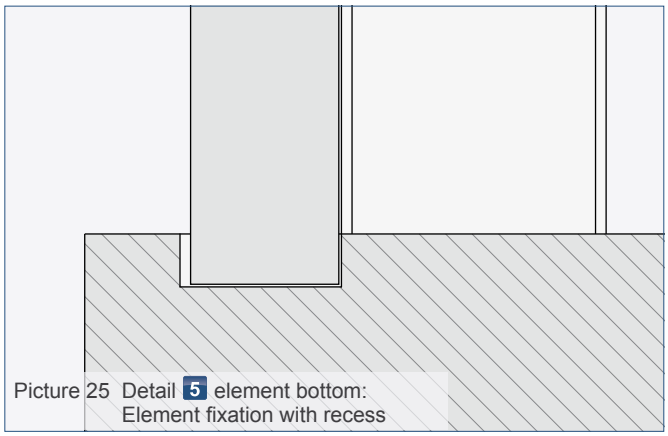
Picture 22 Detail 3 example 1: Horizontal joint



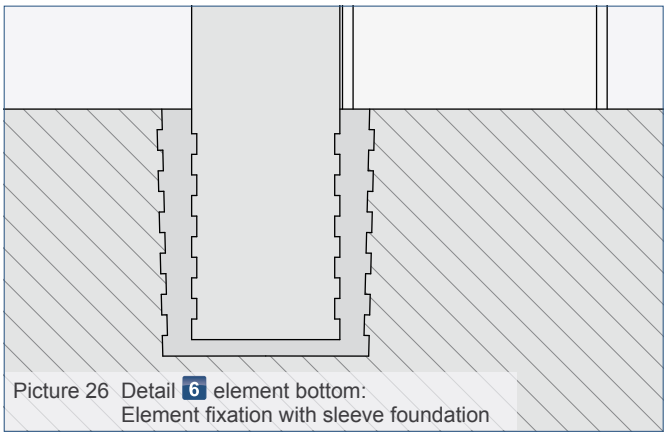
Picture 23 Detail 3 example 2: Horizontal joint



Picture 24 Detail 4 element top: Element fixation with cast-in anchor channel



Picture 25 Detail 5 element bottom: Element fixation with recess



Picture 26 Detail 6 element bottom: Element fixation with sleeve foundation

Design and construction

The precast concrete units to be connected must be designed according to EC 2. They have to be made of normal concrete with a concrete strength class of at least C30/37 according to DIN 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 Z-21.8-2028 (PHILIPP - BETEC®) and Z-21.8-2066 (P&T EuroGrout®) the thixotropic mortar as well as the grouting mortar are specified. In table 2 shear loads parallel to the joint ($v_{Rd,II}$) and in table 3 shear loads right-angled to the joint ($v_{Rd,\perp}$) are listed according 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 the diagrams in Picture 30 and Picture 31. Table 4 shows the bearing capacities for tensile forces (Z_{Rd}) of the Power Duo system in combination with thixotropic and grouting mortar. The acting tensile force has to be added as described below.

Here. the following cases have to be differentiate:

Case 1: (Design example see page 14)
No constructive solution, which takes the acting tensile force (table 5).

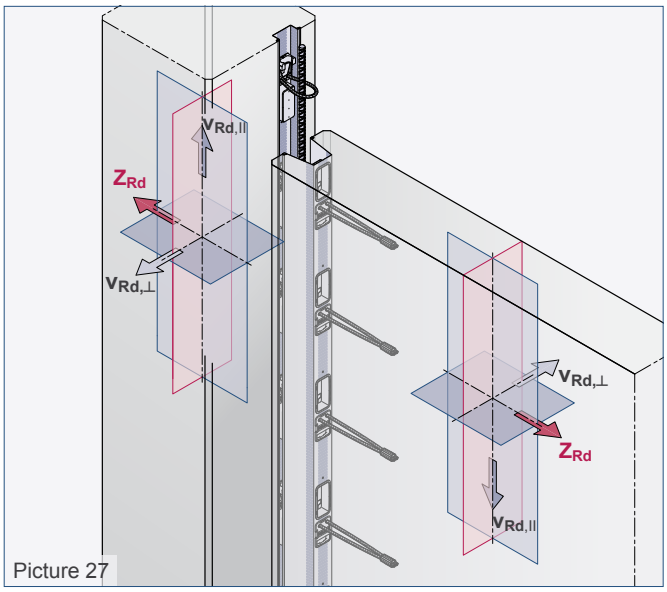
$$z_{Ed,ges} = z_{Ed,N} + 0.5 \times v_{Ed,II} + 0.25 \times v_{Ed,\perp}$$

Case 2: (Design example from see 16)
Constructive solution, which takes the acting tensile force (table 6).

$$z_{Ed,ges} = z_{Ed,N} + 0.25 \times v_{Ed,\perp}$$

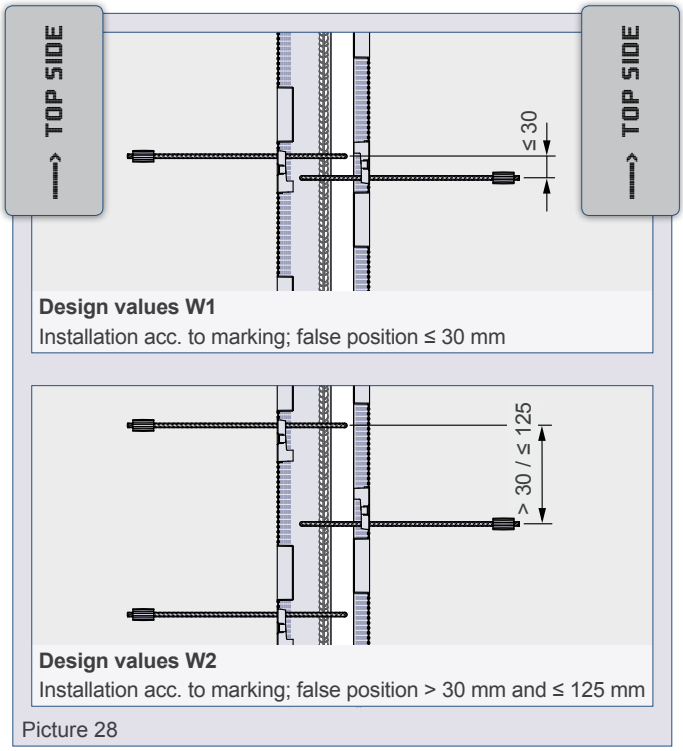
Case 3: (Design example see page 18)
No constructive solution, which takes the acting tensile force (table 5).

$$z_{Ed,ges} = V_{Rd,fi,II} (\alpha_{fi} \times V_{Rd,II}) + Z_{Rd,fi,II} (\alpha_{fi} \times Z_{Rd,II})$$

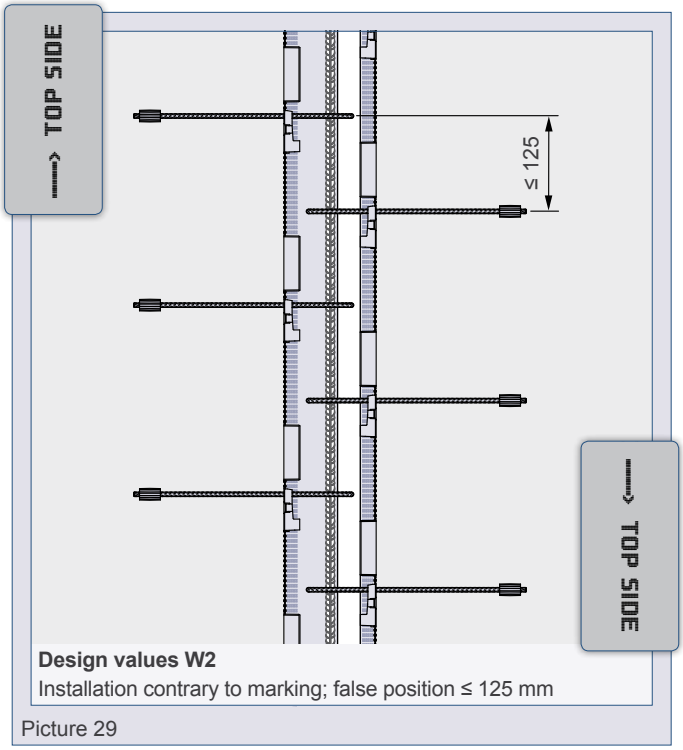


Picture 27

Design values for the shear force bearing capacity $v_{Rd,II}$ and tensile force bearing capacity Z_{Rd}



Picture 28



Picture 29

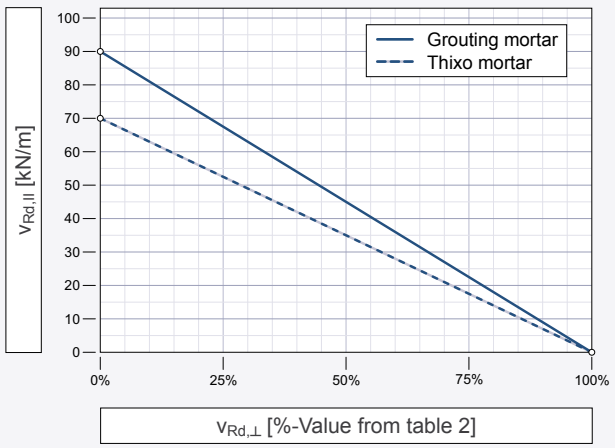
Design and construction

Table 2: Design values of the shear force bearing capacity parallel to the joint

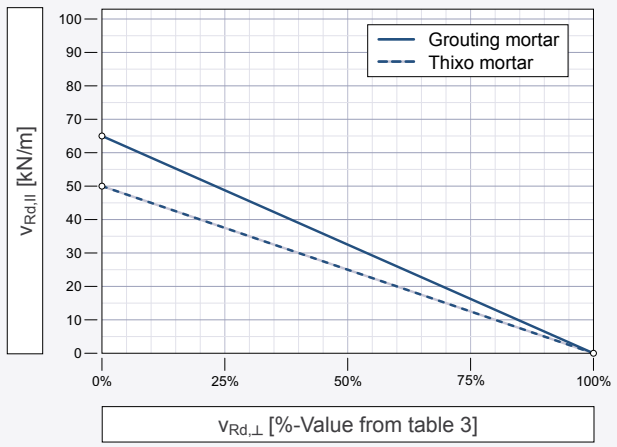
Wall thickness h [cm]	Design value of the shear force bearing capacity $v_{Rd,II}$ [kN/m]			
	Design values W1		Design values W2	
	Grouting mortar	Thixo mortar	Grouting mortar	Thixo mortar
≥ 14	90.0	70.0	65.0	50.0

Table 3: 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 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
14	9.7	9.7	11.1	11.1	11.9	11.9	12.6	12.6
15	11.2	11.2	12.7	12.7	13.7	13.7	14.5	14.5
16	12.7	12.7	14.4	14.4	15.5	15.5	16.5	16.5
17	14.2	14.2	16.2	16.2	17.4	17.4	18.6	18.6
18	15.9	15.9	18.1	18.1	19.4	19.4	20.7	20.7
19	17.5	17.5	20.0	20.0	21.4	21.4	22.8	22.8
20	19.3	19.3	21.9	21.9	23.5	23.5	25.1	25.1
21	21.0	21.0	24.0	24.0	25.7	25.7	27.4	27.4
22	22.8	22.8	26.0	26.0	27.9	27.9	29.7	29.7
23	24.7	24.7	28.1	28.1	30.2	30.2	32.2	32.2
24	26.6	26.6	30.3	30.3	32.5	32.5	34.6	34.6
25	28.5	28.5	32.5	32.5	34.9	34.9	37.2	37.2
26	30.5	30.5	34.8	34.8	37.3	37.3	37.5	37.5
27	32.5	32.5	37.1	37.1	37.5	37.5	37.5	37.5
28	34.6	34.6	37.5	37.5	37.5	37.5	37.5	37.5
29	36.7	36.7	37.5	37.5	37.5	37.5	37.5	37.5
≥ 30	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5



Picture 30 Design values W1
Interaction diagram of the shear forces parallel and right-angled to the joint

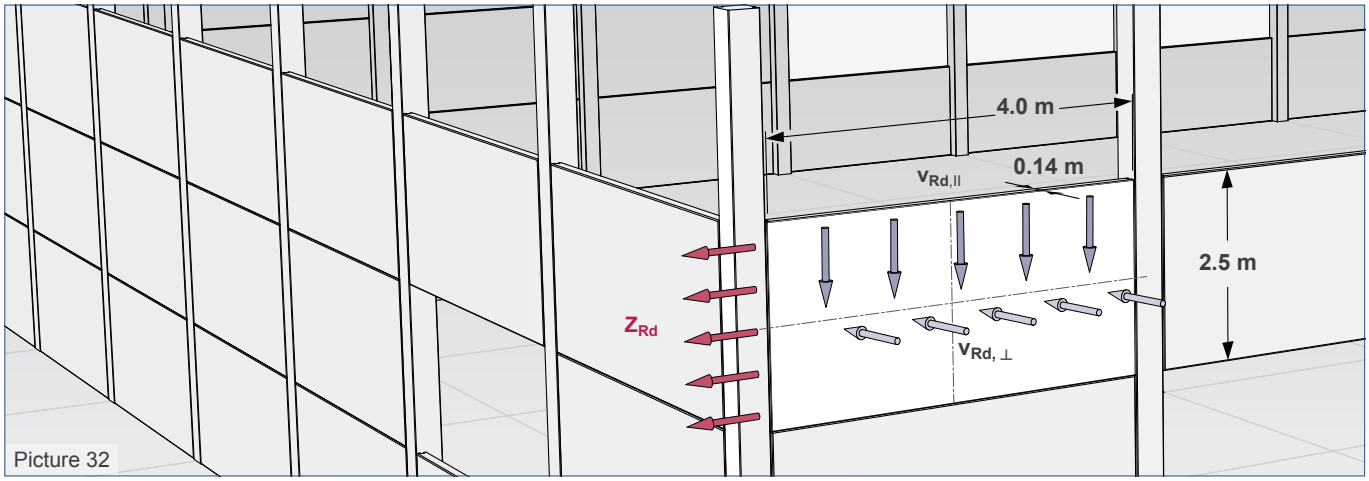


Picture 31 Design values W2 (faulty installation)
Interaction diagram of the shear forces parallel and right-angled to the joint

Table 4: Design value of the tensile force bearing capacity per wire rope 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
≥ 14	10.0	7.5	7.2	5.4

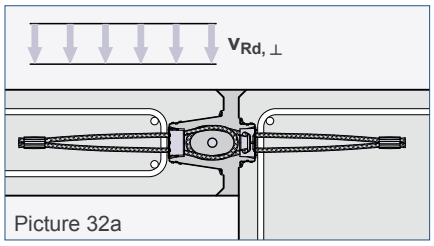
Design example case 1



Picture 32

Verification of tensile forces
(No load transfer of tensile forces by constructive solutions)

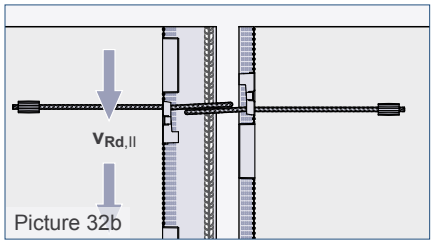
Because of the different load directions (shear force parallel and right-angled to the joint) single components of tensile forces result, which act in the direction of the wire rope. The sum of these single components (total tensile force) is verified on a basis of the tensile force resistance Z_{Rd} of the loops according to table 4.



Picture 32a

Design example: stiffening by a wall with tensile forces

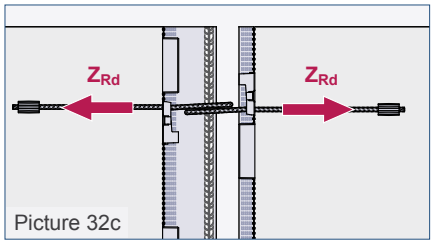
This example shows a wall, which shall be installed as a stiffening member. The resulting shear forces parallel to the joint are taken by the Power Duo System with Thixo mortar and added with shear forces right-angled to the joint caused by wind.



Picture 32b

Verification of the total force: $n \times Z_{Rd} \geq z_{Ed,VII} + z_{Ed,V\perp} + z_{Ed,N}$

n	[1/m]	: Numbers of wire rope loops per metre of joint, n = 4 loops/metre
Z_{Rd}	[kN]	: Design value of tensile force bearing capacity per wire rope loop acc. to table 4
$z_{Ed,N}$	[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



Picture 32c

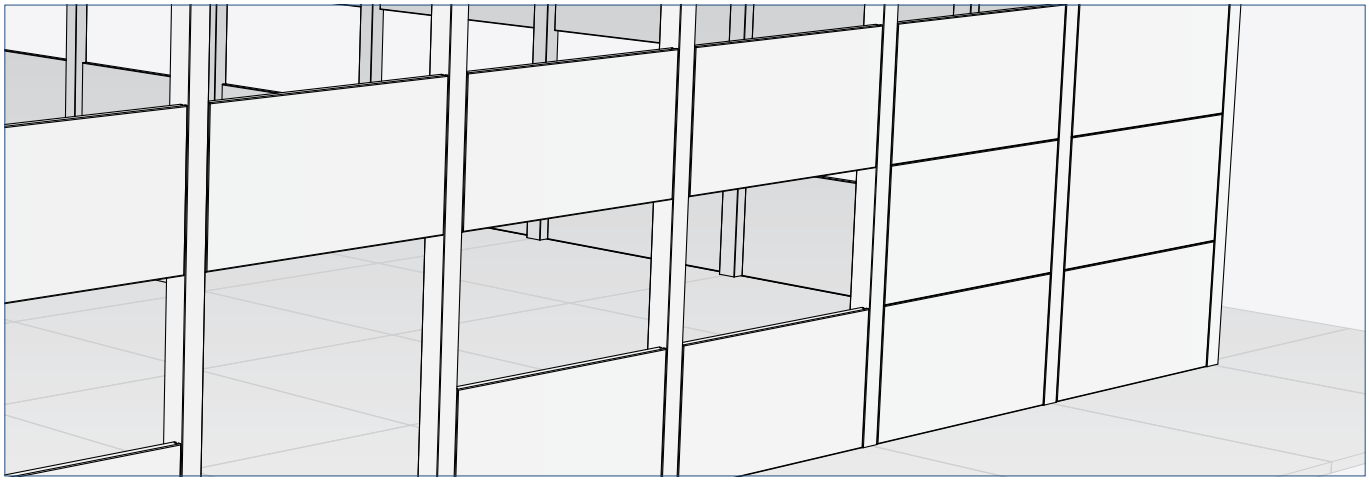
Table 5: Components of tensile force

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

Actions / boundary conditions:

- From wind
  - building height ≤ 10 m, wind load zone 3, midland, according to EC 1
  - $W_D = 1.5 \times (0.8\ kN/m^2 \times 1.0) = 1.2\ kN/m^2$
- Loads caused by the shear wall: 10.68 kN/m
- Wall thickness 14 cm
- Concrete strength C30/C37
- 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 false position ≤ 30 mm

Design example case 1



Resultant shear force parallel to the joint:
$v_{Ed,II}$ = 10.68 kN/m × 4.0 m / 2 / 2.5 m = 8.54 kN/m

The shear force right-angled to the wall results from the wind load:

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

Resistance values for Thixo mortar resulting from wall thickness and concrete strength:
Shear load parallel: $v_{Rd,II}$ = 70 kN/m (value from table 2, design value W1)
Shear force right-angled: $v_{Rd,\perp}$ = 9.7 kN/m (value from table 3)

If both forces occur at the same time, the interaction (Picture 30) 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 %:

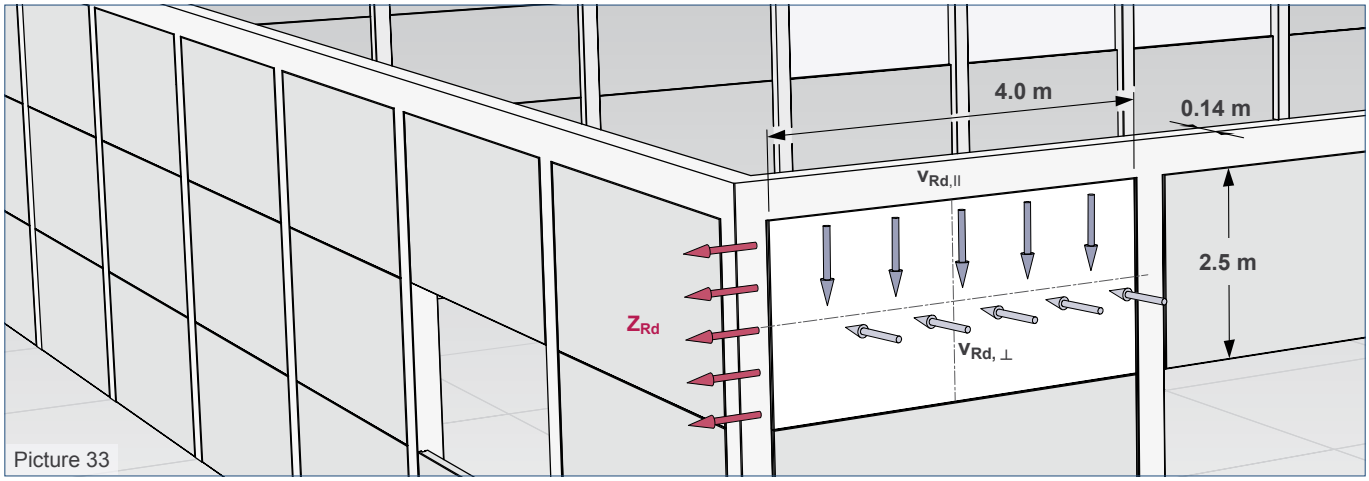
red. $v_{Rd,\perp}$ = 0.88 × 9.7 kN/m = 8.5 kN/m

It is shown that the interaction of both shear forces can be absorbed. Furthermore, it must be checked, if all occurring tensile forces can be absorbed (according to the approval).

$n \times Z_{Rd} \geq z_{Ed,VII} + z_{Ed,V\perp} + z_{Ed,N}$
$z_{Ed,VII}$ = 0.5 × 8.54 kN/m = 4.27 kN/m
$z_{Ed,V\perp}$ = 0.25 × 2.40 kN/m = 0.6 kN/m
$z_{Ed,N}$ = 10 kN/m

Z_{Rd} for Thixo Mortar = 7.5 kN/loop (Table 4)
per metre rail 4 loops => 4 × Z_{Rd} = 30 kN/m
30 kN/m ≥ 4.27 kN/m + 0.6 kN/m + 10 kN/m = 14.87 kN/m

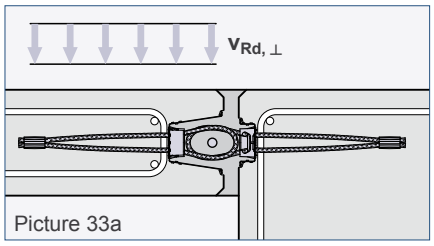
Design example case 2



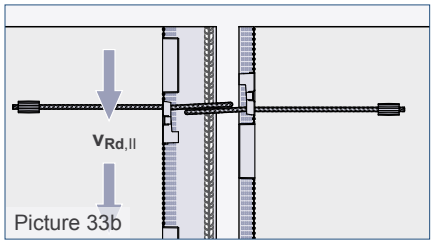
Picture 33

Design example stiffening by shear wall
(Special case - load transfer of the tensile forces by constructive solutions e.g. ring beam)

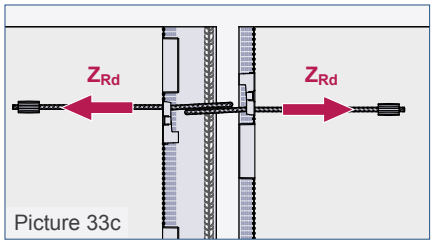
In this example the shear loads of the wall are absorbed by the Power Duo system. The occurring tensile forces are absorbed by suitable tension members (ring beam) or other constructive solutions (fixed column, friction forces with wall elements standing full-surfaced on ground).



Picture 33a



Picture 33b



Picture 33c

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

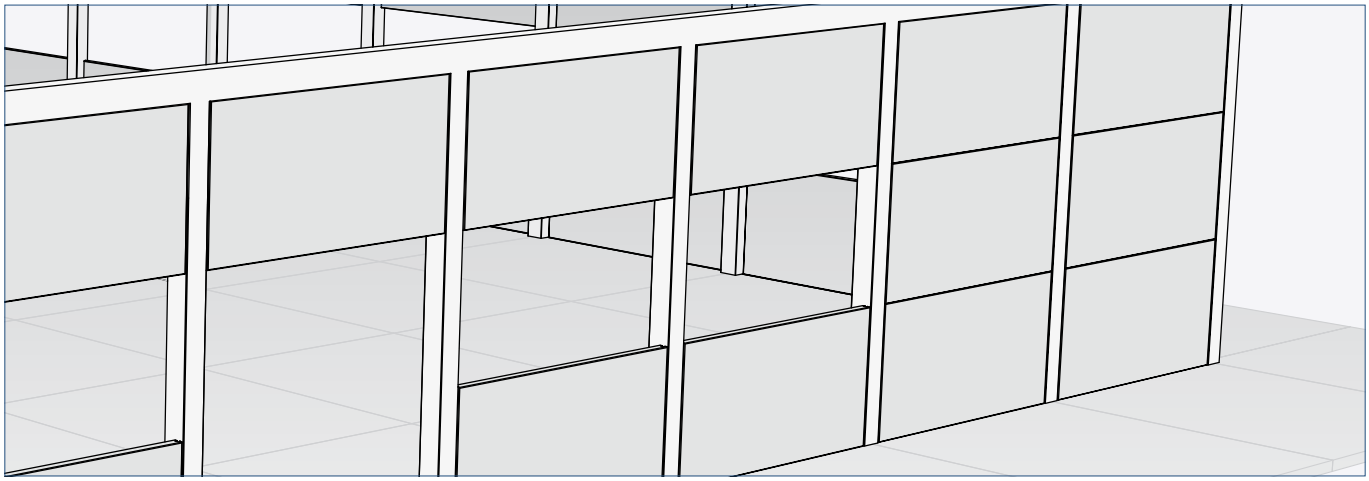
Table 6: Components of tensile force

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

Actions / boundary conditions:

- From wind
  - building height ≤ 10 m, wind load zone 3, midland, according to EC 1
  - $W_D = 1.5 \times (0.8\ kN/m^2 \times 1.0) = 1.2\ kN/m^2$
- Loads caused by the shear wall: 10.68 kN/m
- Wall thickness 14 cm
- Concrete strength C30/C37
- 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 false position ≤ 30 mm

Design example case 2



Resultant shear force parallel to the joint:
$v_{Ed,II}$ = 10.68 kN/m × 4.0 m / 2 / 2.5 m = 8.54 kN/m

The shear force right-angled to the wall results from the wind load:

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

Resistance values for Thixo mortar resulting from wall thickness and concrete strength:
Shear load parallel: $v_{Rd,II}$ = 70 kN/m (value from table 2, design value W1)
Shear force right-angled: $v_{Rd,\perp}$ = 9.7 kN/m (value from table 3)

If both forces occur at the same time, the interaction (Picture 30) 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

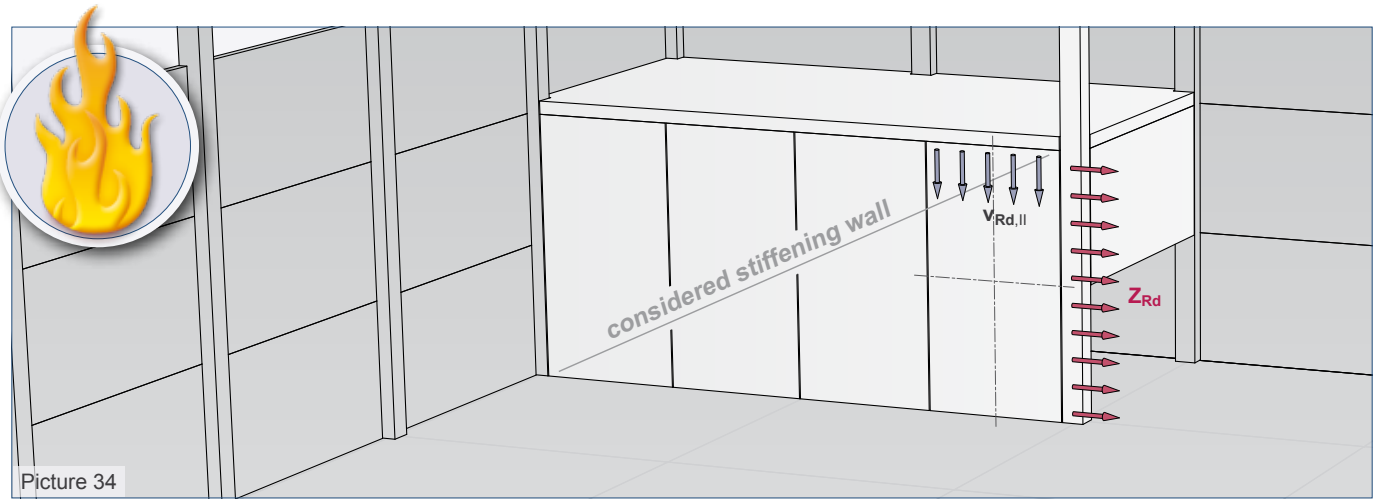
It is shown that the interaction of both shear forces can be absorbed. The tensile force to be absorbed by the tension member is calculated by using the formula given in table 6.

Resulting design tension resistance

$z_{Ed,ges}$ = $z_{Ed,V\perp}$ + $z_{Ed,N}$ [kN/m]
$z_{Ed,V\perp}$ = 0.25 × $v_{Ed,\perp}$ [kN/m]
$z_{Ed,N}$ = acting ”external” tensile forces per metre of joint [kN/m]
$z_{Ed,ges}$ = 0.25 × 2.4 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.

Design example case 3 (loadbearing fire-stressed wall)

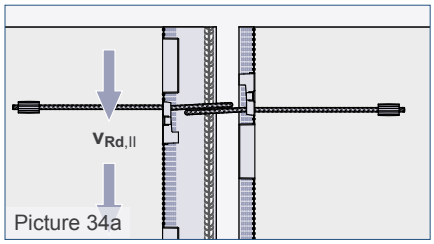


Picture 34

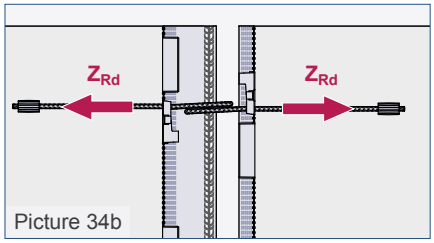
Proof of tensile force and shear force capacity parallel to the joint under fire stress

(No load transfer of tensile forces by constructive solutions)

For the proof of loadbearing, fire-stressed connections the loadbearing capacities according to table 7 may be used. Loads right-angled to the joint cannot be proofed in case of fire. Depending on the temperatures acting on the wire rope loop (see temperature profile DIN EN 1992-1-2:2012-12, picture A.2) the design resistances shall be reduced by α_{fi} as shown in picture 37.



Picture 34a



Picture 34b

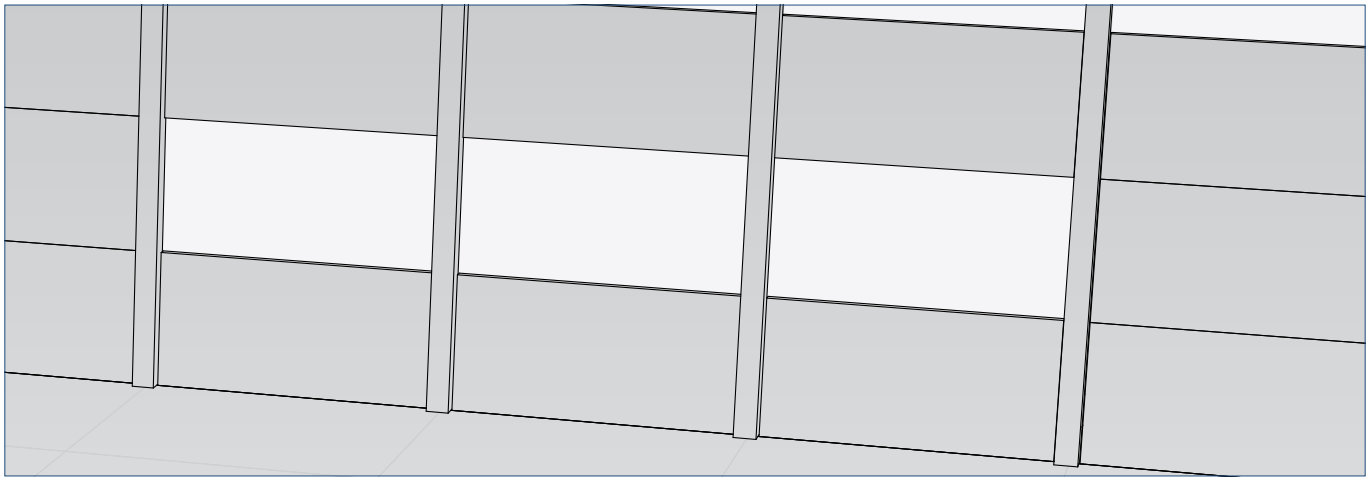
Table 7: Load bearing capacities in case of fire

Load from	Shear force parallel $V_{Rd,fi,II}$	Tensile force $Z_{Rd,fi}$
Design value of the load bearing capacity	$V_{Rd,fi,II} = \alpha_{fi} \times V_{Rd,II}$	$Z_{Rd,fi,II} = \alpha_{fi} \times Z_{Rd,II}$

Actions / boundary conditions:

- Wall thickness d = 140 mm
- Joint height h = 3.0 m
- Concrete strength class C30/37
- Mortar: Grouting mortar
- Outer shear force parallel to the joint $v_{Ed,II}$ = 40 kN/m (e.g. stiffening loads)
- 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 false position ≤ 30 mm
- Fire exposure R 90, one-sided fire exposure

Design example case 3 (loadbearing fire-stressed wall)



Verification: calculation of reduced load bearing capacities in case of fire

Determination of the temperature at the wire rope:

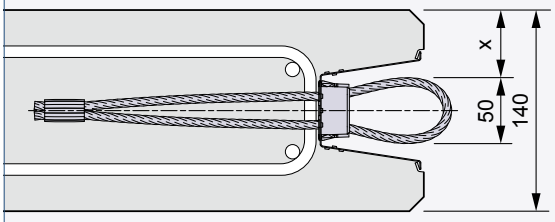
Distance x from the fire-stressed surface:

- 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) in diagram "Temperature profile for one-sided fire-stressed elements" (see DIN EN 1992-1-2, picture A.2)

Determined temperature: θ (°C) = 350 °C



Picture 35 Distance x from the fire-stressed surface

Calculation of reduced load bearing capacities in case of fire

$v_{Rd,fi,II} = v_{Rd,II} \times \alpha_{fi} = 90\ kN/m \times 0.56 = 50.4\ kN/m$

$z_{Rd,fi} = z_{Rd} \times \alpha_{fi} = 40\ kN/m \times 0.56 = 22.4\ kN/m$

Calculation of the tensile force components caused by shear loads:

$z_{Ed,VII} = 0.5 \times v_{Ed,II} = 0.5 \times 40\ kN/m = 20\ kN/m$

Calculation of total tensile force:

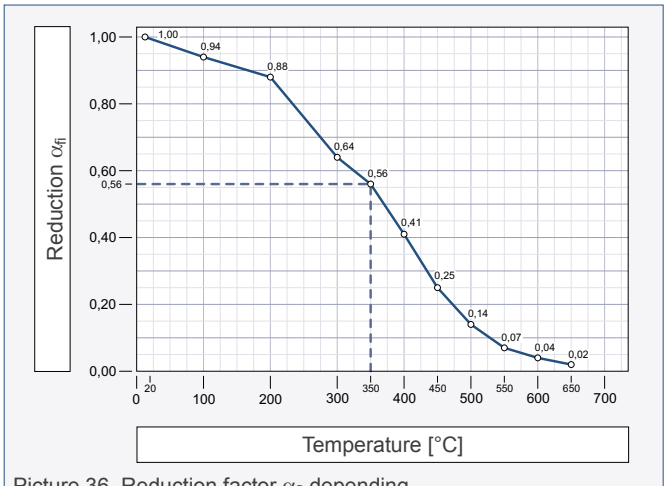
$z_{Ed,fi} = z_{Ed,VII} + z_{Ed,N} = 20 + 2 = 22\ kN/m$

Proof of total tensile force:

$z_{Rd,fi} = 22.4\ kN/m \geq 22\ kN/m = z_{Ed} \rightarrow$ OK

Proof of shear forces parallel to the joint

$v_{Rd,fi,II} = 50.4\ kN/m \geq 40\ kN/m = v_{Ed,II} \rightarrow$ OK

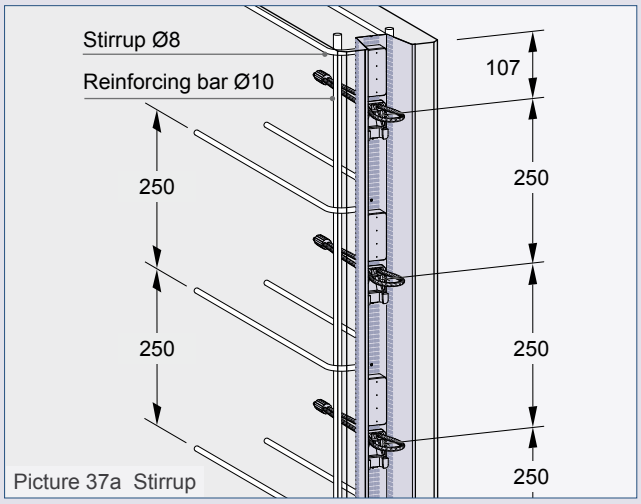


Picture 36 Reduction factor α_{fi} depending on the wire rope temperature

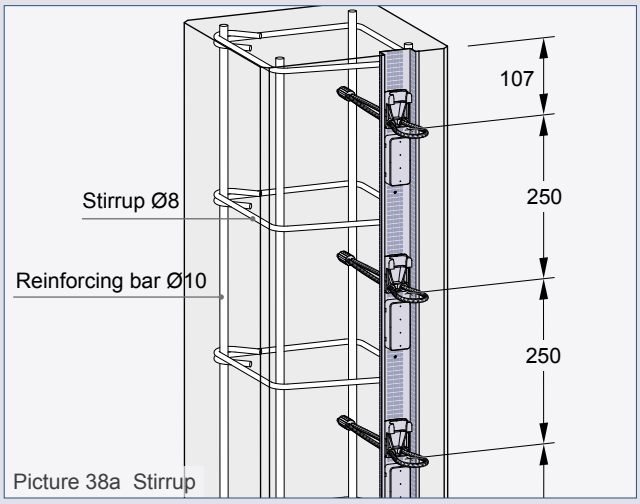
Reinforcement

If the Power Duo rails are installed flush and according to the direction of the arrow-marking all requirements of the German approval for the edge distances are met (Picture 37a, 37b, 38a, 38b). Please note also the part “Production of precasted reinforced concrete elements” in the approval.

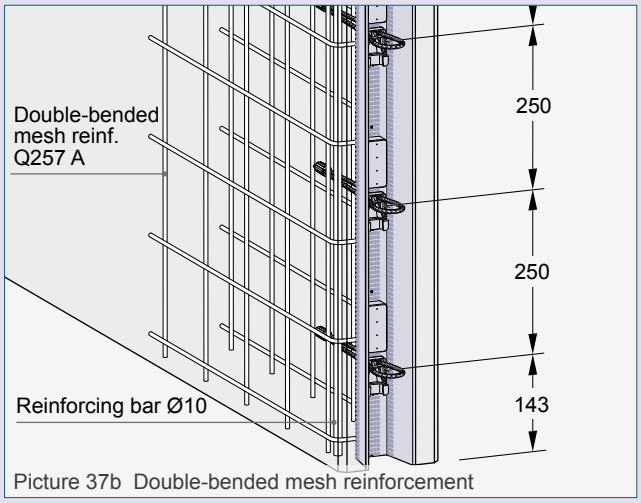
In the range of the Power Duo rails the precast elements must be provided with a minimum reinforcement. This reinforcement shall be stirrups Ø 8/25 for each wire rope loop and longitudinal reinforcement 2 Ø 10 (Picture 37a, 38a).



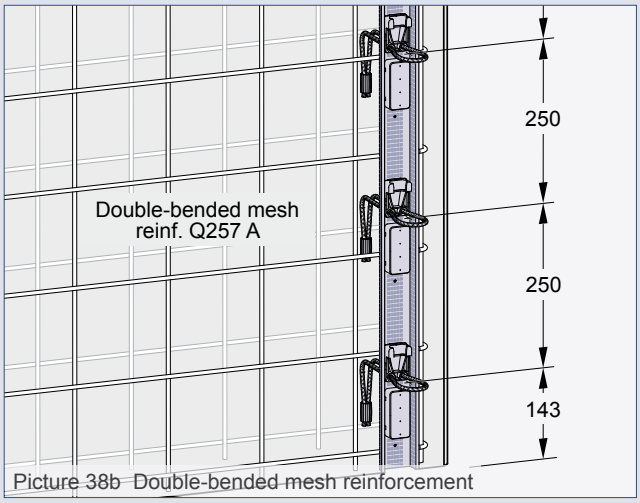
Picture 37a Stirrup



Picture 38a Stirrup



Picture 37b Double-bended mesh reinforcement

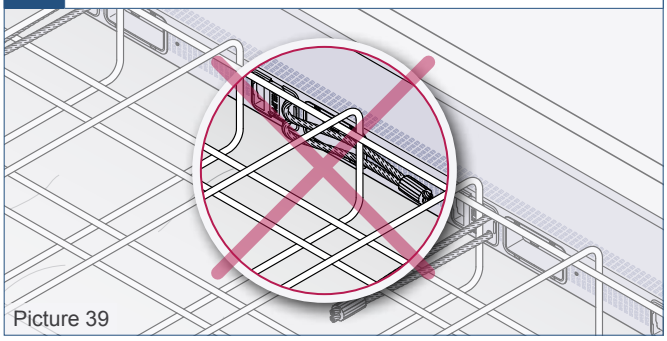


Picture 38b Double-bended mesh reinforcement

Alternatively the stirrups can be replaced by a comparable mesh reinforcement (picture 37b and 38b).

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.

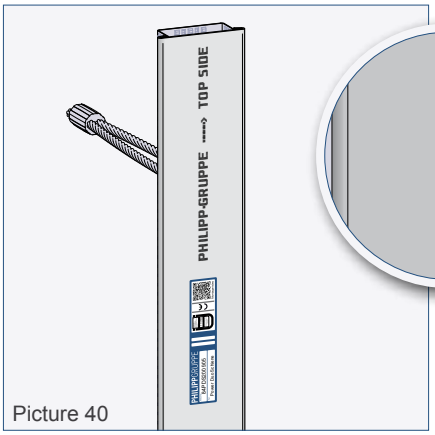
A bending of the end anchorage by the reinforcement is not permissible.


Picture 39

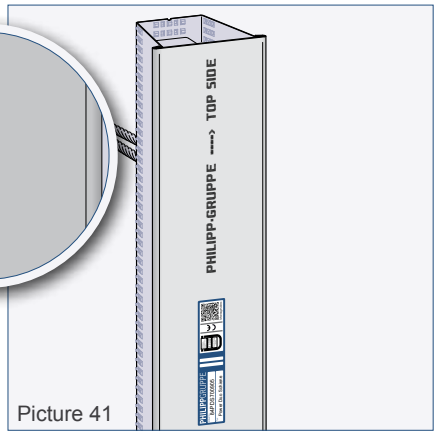
Installation

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.

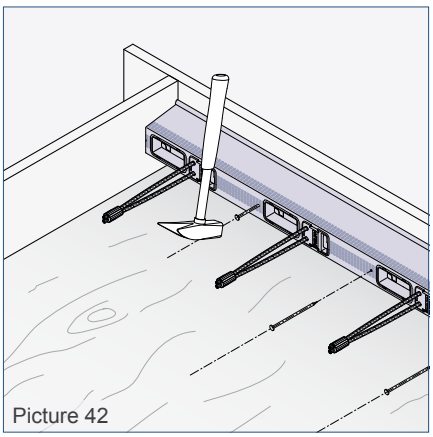


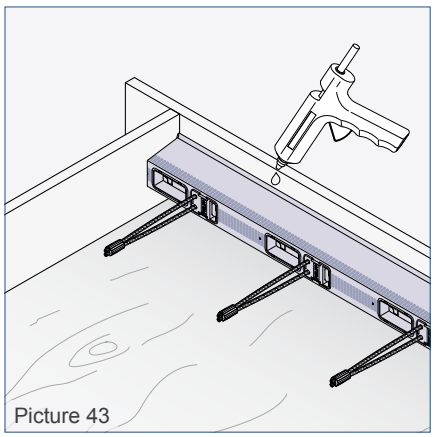
Picture 40



Picture 41

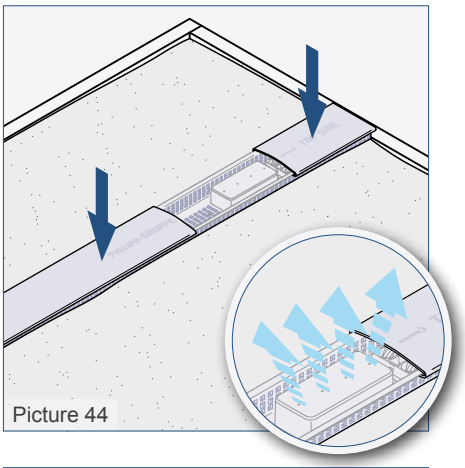
The Power Duo rails can be fixed to the mould by nailing as well as by hot bonding (picture 42 and 43).

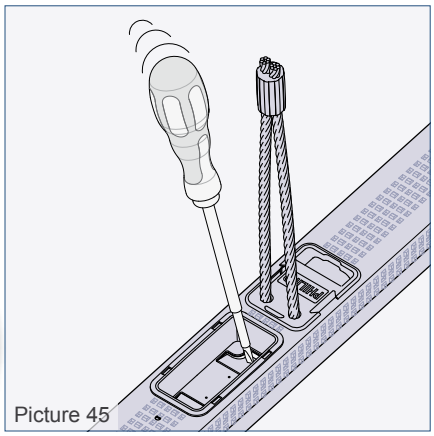

Picture 42


Picture 43

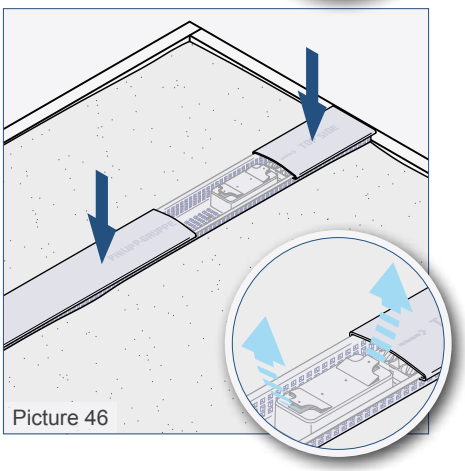
During concreting of elements attention must be paid to the ventilation of all plastic recesses to guarantee a complete filling with concrete.

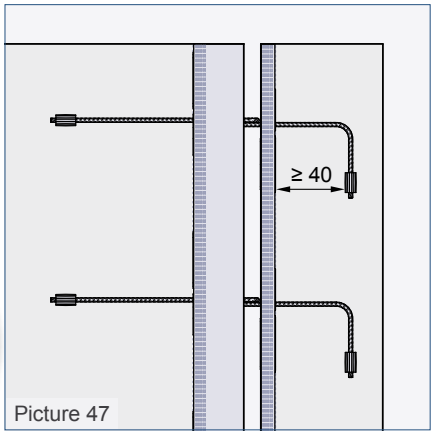
In order to ventilate a plastic recess box, e.g. when the Power Duo rails are installed on the concrete surface (plastic cover on the top, picture 44), it has four little holes on the top the air can pass off.
If necessary, the plastic recesses can be opened at the predetermined breaking point by using a spiky tool (e.g. screw driver - picture 45).
Hence, a complete filling of the concrete into the recesses is guaranteed.


Picture 44


Picture 45

If the anchorage of the wire rope loop is bent, attention must be paid that the horizontal anchorage part is ≥ 40 mm (picture 46).

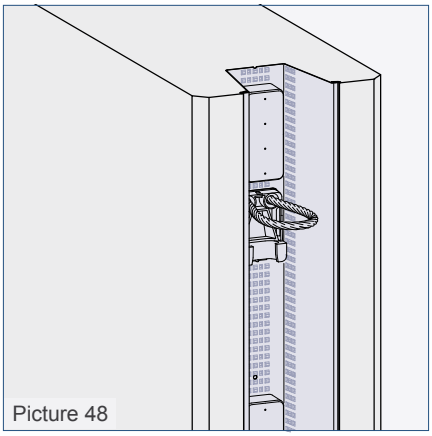

Picture 46

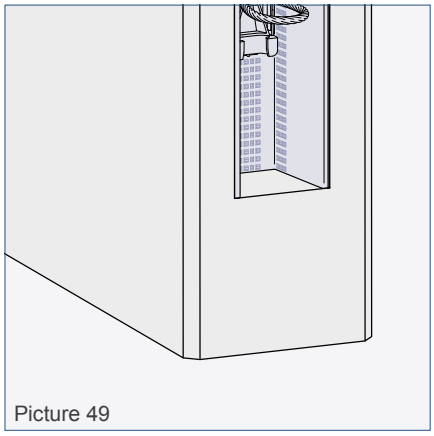


Picture 47

Installation

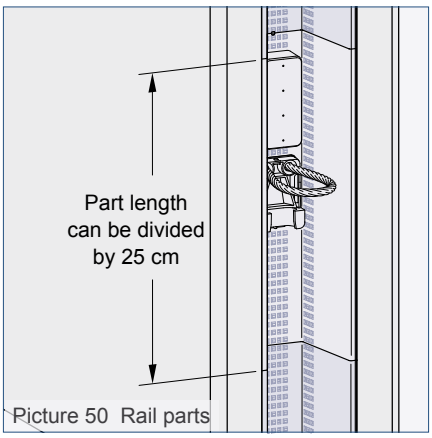
For elements with the same height it is recommended to start the installation at the upper elements edge (picture 48). So it is possible to concrete the rail-free part at the bottom of the element (Picture 49).


Picture 48

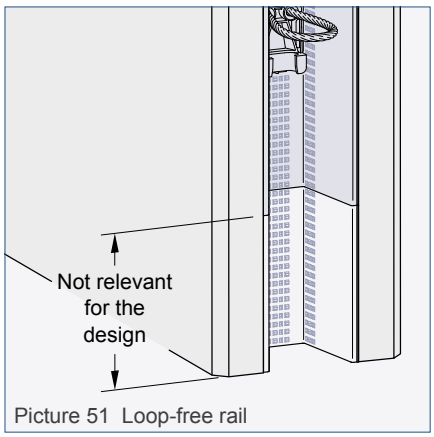

Picture 49

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 52) to create a recess.



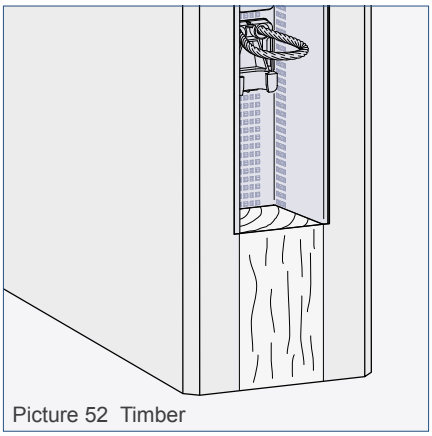
Picture 50 Rail parts

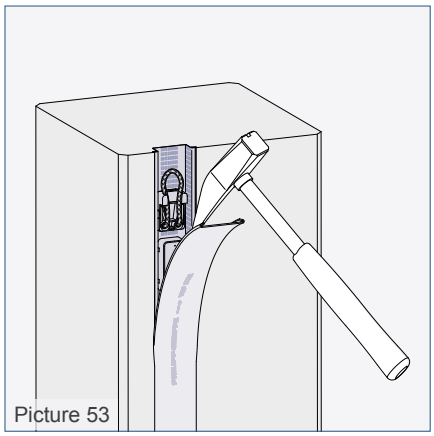


Picture 51 Loop-free rail

Preparing for mounting

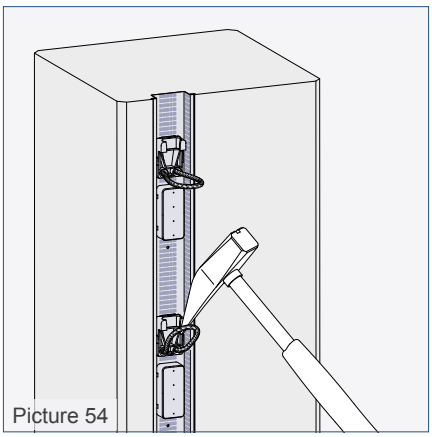
The plastic cover of the installed rail must be released at one rail end. Then, it can be removed easily from the complete rail (Picture 53).

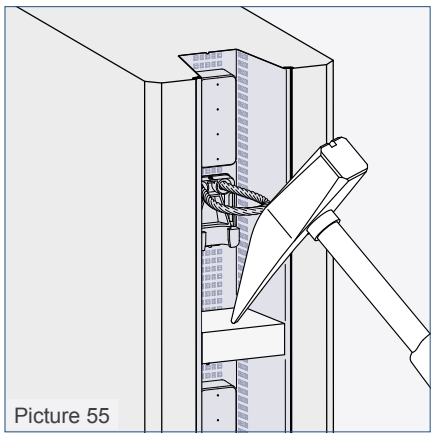

Picture 52 Timber


Picture 53

Now, the wire rope loops of the flat and the deep rail have to be folded right-angled to the rail (Picture 54).

From the deep Power Duo rail the polystyrene spacers have to be removed (Picture 55).


Picture 54

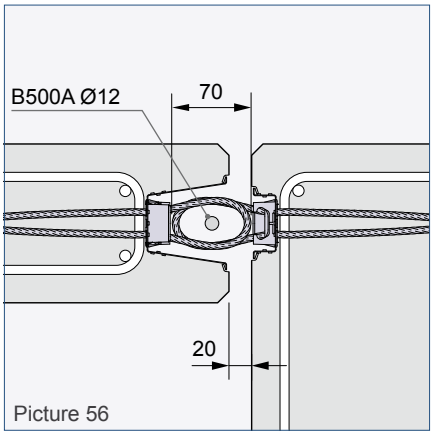

Picture 55

Mounting

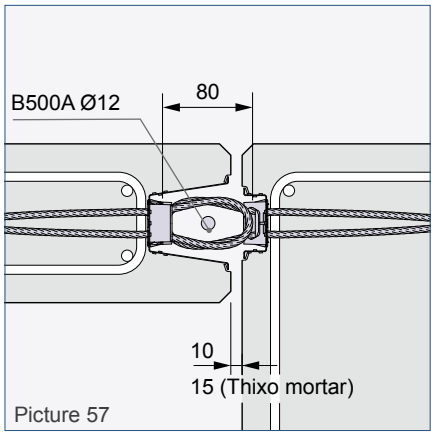
Mounting of the precast elements

If the Power Duo rails are installed correctly the loops overlap horizontally with the nominal dimension of 70 mm as shown in picture 56 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 57 and 58.

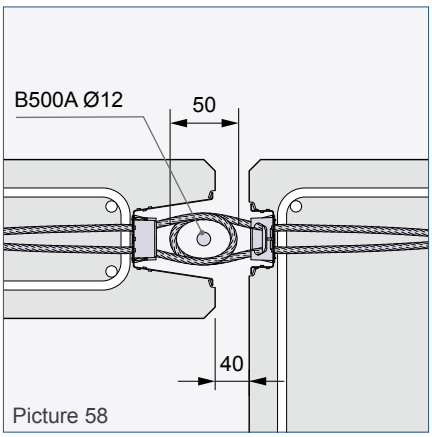
Prior the filling of the joint a reinforcing bar (Ø12 mm) shall be positioned along the entire joint length through the overlapping loops. The correct installation is to be checked visually.



Picture 56

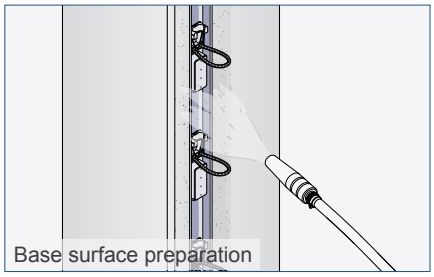


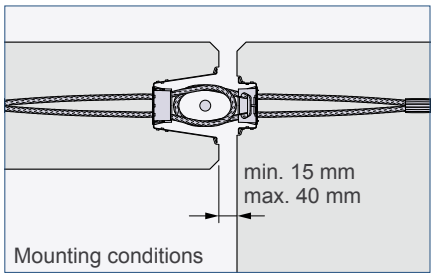
Picture 57

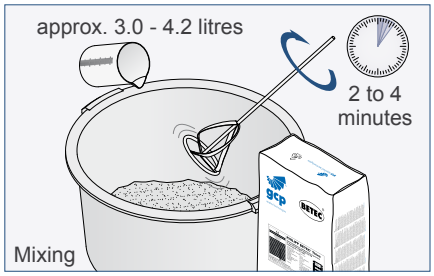


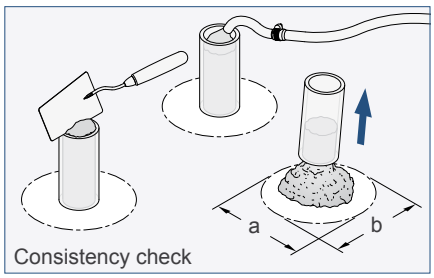
Picture 58

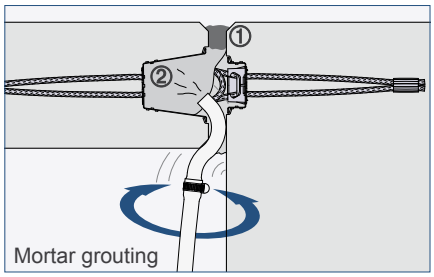
PHILIPP - BETEC® Thixo Mortar

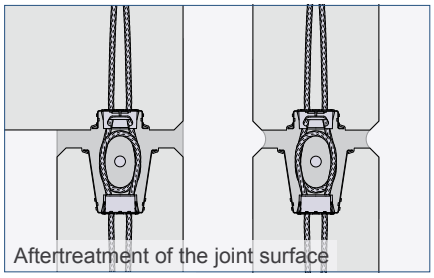












Mortar grouting with PHILIPP - BETEC® Thixo mortar

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) as well as the technical data sheet „PHILIPP - BETEC® Thixo“.

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.

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 winter time 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 DIN EN 1015-3 the flow diameter is determined with a defined funnel.

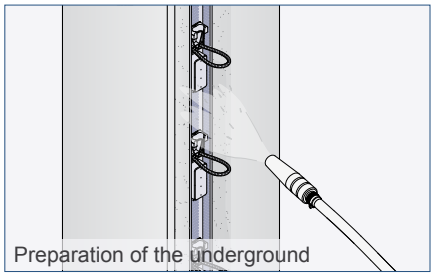
Mortar grouting

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 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)

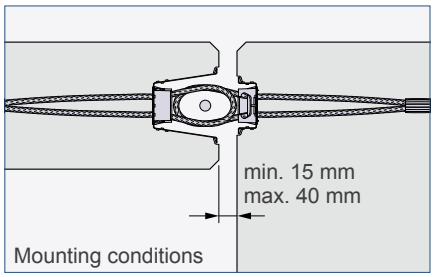

Preparation of the underground

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.

Preparation of the underground

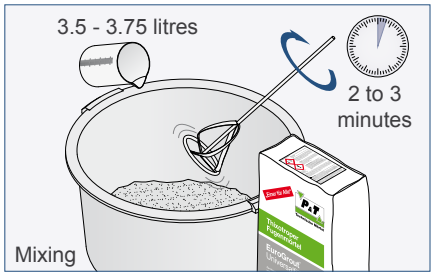
The joint flanks must be wetted before filling the Thixo mortar and pale damp-dried. Both the cross section of the joint and the flanks must meet the surface quality specified in the DIN. Adhesion-reducing parts in the joints have to be removed, the flanks must be free from dirt, cement slurry and grease.



Mounting conditions

Mounting conditions

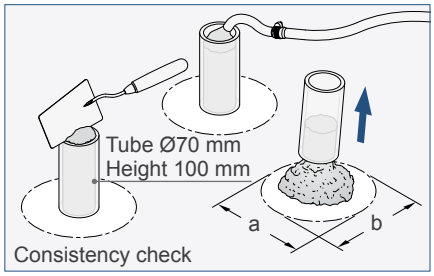
The distance of 15 - 40 mm between the concrete elements must be taken attention to. The unit and processing temperature of the Universalfüller must comply with the latest corresponding DAfStb regulation.



Mixing

Mixing process

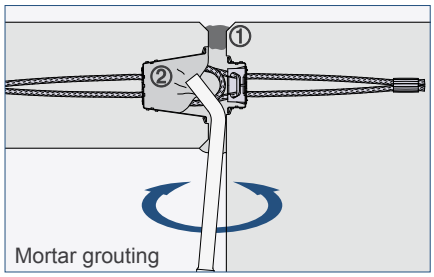
The Universalfüller is designed for a machine processing with mixing pumps. A machining with small, handy mixing pumps allows long draws without changing the position of the pump frequently.
For a manual processing, the Universalfüller must be mixed in a compulsory mixer or with a slow-running stirrer.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



Consistency check

Consistency check

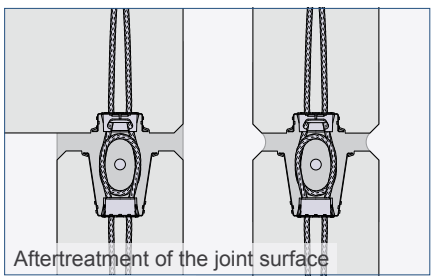
The flow diameter (a + b) / 2 must be between 11 and 15 cm and must be done according to the latest DAfStb regulation for cement based grouting concrete and mortar, appendix C. Instead of an ebonite ring a plastic tube (prepared with separating agent) with an inner diameter of d = 70 mm and a height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



Mortar grouting

Mortar grouting

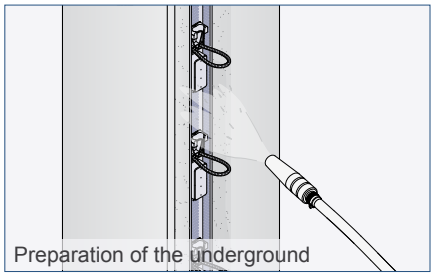
Equipment used for the grouting is either a screw pump or a continuous mixer. First, one joint flank is closed completely. Usually, a sealing cord resp. sealing hose or the Thixo mortar itself can be used here ①. Then, the remaining space of the joint is filled from the opposite side and from the bottom 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.

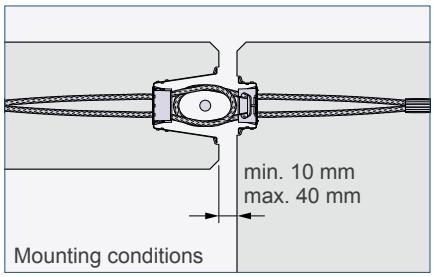

Aftertreatment of the joint surface

Aftertreatment of the joint surface

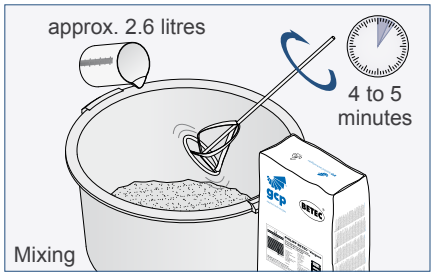
After grouting the joint must be trowelled. Waste material has to be removed for optical reasons before hardening.

PHILIPP - BETEC® Grouting mortar

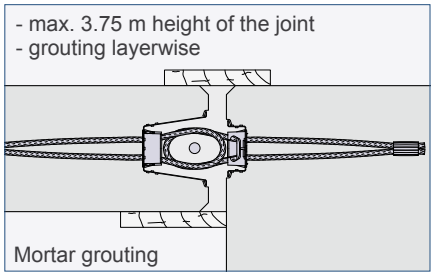

Preparation of the underground



Mounting conditions



Mixing



Mortar grouting

Hints

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.

Mortar grouting with PHILIPP - 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.

Preparation of the underground

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 from chlorides. Because of the controlled swelling the mortar is shrink-free and thus guarantees a force transmitting 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 flowability 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 wanted 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.)

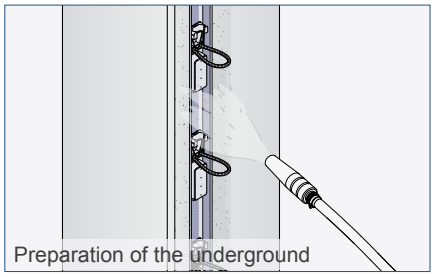
Processing temperature

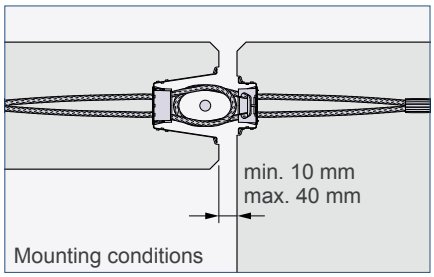
The processing temperature of the grouting mortar is at least +5°C and maximum +30°C. With lower temperatures specific measures in winter time must be started.

Aftertreatment

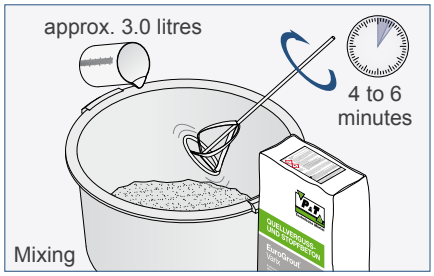
It should be prevented that grouting mortar dries up to fast for at least three days after application. Appropriate measures are covering with plastic sheets, wet tissues or irrigation.

P&T EuroGrout® Varix (Grouting mortar)


Preparation of the underground

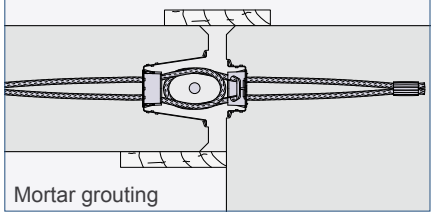


Mounting conditions



Mixing

- max. 3.75 m height of the joint
- grouting layerwise


Mortar grouting

Hints

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

Mortar grouting with EuroGrout® Varix

The EuroGrout® Varix grouting mortar is a mortar approved for the Power Duo System. It consists of a ready-for-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 from 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 deicing 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 winter time must be started.

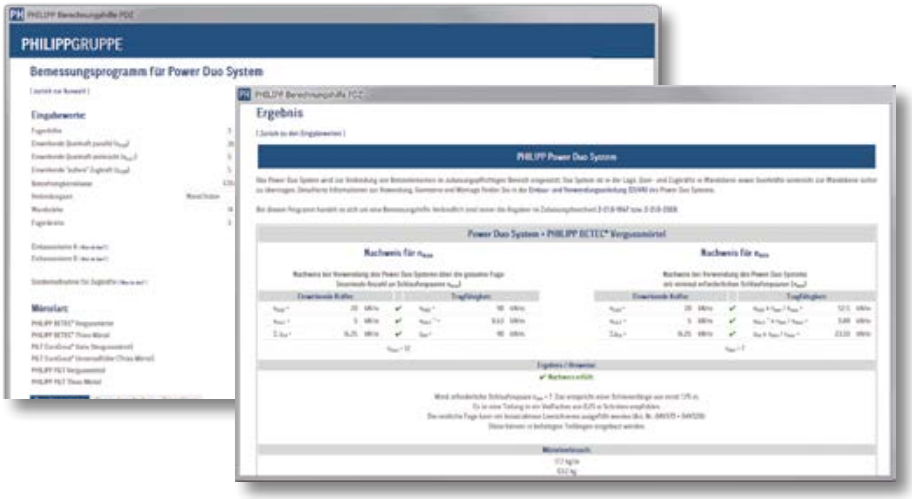
Aftertreatment

It should be prevented that the grouting mortar runs dry too fast for three to five days after application. Appropriate measures are covering with plastic sheets, wet tissues or watering.

Software / CAD

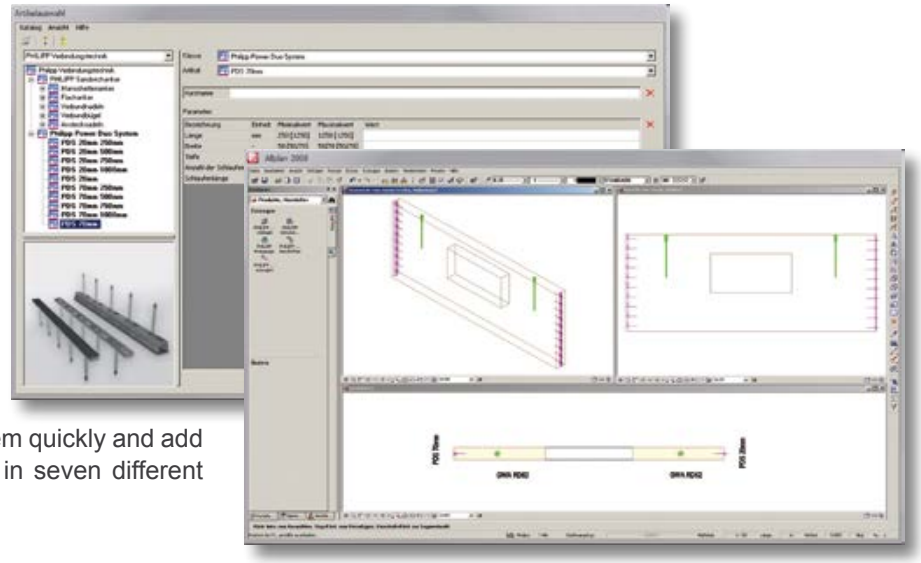
Calculation tool

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



ALLPLAN of company Nemetschek

Customers using the powerful CAD system ALLPLAN from Nemetschek can use the PHILIPP 3D part library already implemented. This CAD library makes the construction of connections with the PHILIPP Power Duo System much easier.
In the CAD library for ALLPLAN itself the products are logically structured and classified.



The user is able to choose the needed item quickly and add it to his plan. The products are offered in seven different views, as 3D model and symbol.

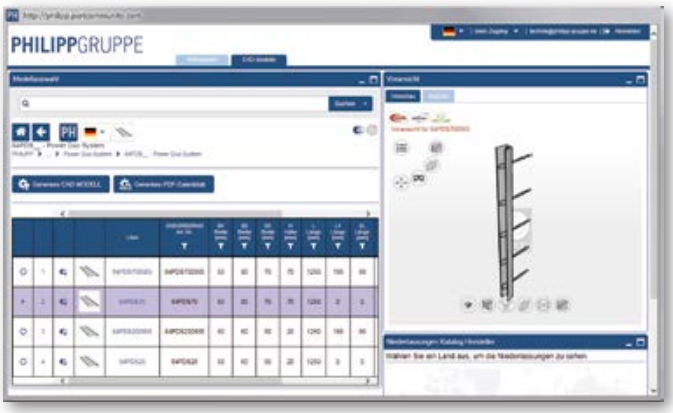
Tekla Structures from Company Trimble Solutions Germany

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

3D 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 1200 PHILIPP products are available as 3D model
- Universal CAD library with many export formats suitable 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 (e.g. weight, dimensions, material and documentations)



General notes

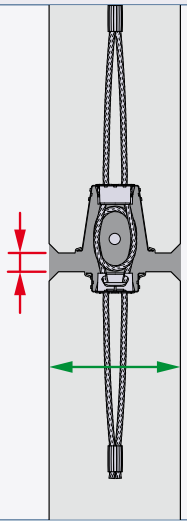
Table 8: Site check list

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 9: Mortar consumption per metre of joint [kg/m] for the PHILIPP Power Duo System (BETEC® / EuroGrout®)

Wall thick-ness	BETEC® Grouting mortar Joint width [cm]				BETEC® Thixo mortar Joint width [cm]			
[cm]	1.0	2.0	3.0	4.0	1.0	2.0	3.0	4.0
14	11.6	14.3	17.0	19.7	11.6	14.3	17.0	19.7
15	11.8	14.7	17.6	20.5	11.8	14.7	17.6	20.5
16	12.0	15.1	18.2	21.2	12.0	15.1	18.2	21.2
17	12.2	15.5	18.7	22.0	12.2	15.5	18.7	22.0
18	12.4	15.8	19.3	22.8	12.4	15.8	19.3	22.8
19	12.6	16.2	19.9	23.5	12.6	16.2	19.9	23.5
20	12.8	16.6	20.5	24.3	12.8	16.6	20.5	24.3
21	13.0	17.0	21.0	25.1	13.0	17.0	21.0	25.1
22	13.2	17.4	21.6	25.8	13.2	17.4	21.6	25.8
23	13.3	17.8	22.2	26.6	13.3	17.8	22.2	26.6
24	13.5	18.2	22.8	27.4	13.5	18.2	22.8	27.4
25	13.7	18.5	23.3	28.2	13.7	18.5	23.3	28.2
26	13.9	18.9	23.9	28.9	13.9	18.9	23.9	28.9
27	14.1	19.3	24.5	29.7	14.1	19.3	24.5	29.7
28	14.3	19.7	25.1	30.5	14.3	19.7	25.1	30.5
29	14.5	20.1	25.7	31.2	14.5	20.1	25.7	31.2
30	14.7	20.5	26.2	32.0	14.7	20.5	26.2	32.0

Joint width
Wall thickness
Mortar kg/m



Wall thick-ness	EuroGrout® Varix Joint width [cm]				EuroGrout® Universalfüller Joint width [cm]			
[cm]	1.0	2.0	3.0	4.0	1.0	2.0	3.0	4.0
14	12.1	14.9	17.7	20.5	11.0	13.5	16.1	18.6
15	12.3	15.3	18.3	21.3	11.2	13.9	16.6	19.3
16	12.5	15.7	18.9	22.1	11.3	14.3	17.2	20.1
17	12.7	16.1	19.5	22.9	11.5	14.6	17.7	20.8
18	12.9	16.5	20.1	23.7	11.7	15.0	18.3	21.5
19	13.1	16.9	20.7	24.5	11.9	15.3	18.8	22.3
20	13.3	17.3	21.3	25.3	12.1	15.7	19.3	23.0
21	13.5	17.7	21.9	26.1	12.3	16.1	19.9	23.7
22	13.7	18.1	22.5	26.9	12.4	16.4	20.4	24.4
23	13.9	18.5	23.1	27.7	12.6	16.8	21.0	25.2
24	14.1	18.9	23.7	28.5	12.8	17.2	21.5	25.9
25	14.3	19.3	24.3	29.3	13.0	17.5	22.1	26.6
26	14.5	19.7	24.9	30.1	13.2	17.9	22.6	27.3
27	14.7	20.1	25.5	30.9	13.3	18.3	23.2	28.1
28	14.9	20.5	26.1	31.7	13.5	18.6	23.7	28.8
29	15.1	20.9	26.7	32.5	13.7	19.0	24.3	29.5
30	15.3	21.3	27.3	33.3	13.9	19.3	24.8	30.3

Given consumption data are only guide values.

Table 10: Packing units (BETEC® / EuroGrout®)

Mortar Type	PU [kg]	Finished volume [l] BETEC®	EuroGrout®
Thixo	25	13.00	13.75
Grouting	25	13.00	12.50

Please refer also to the approvals of the PHILIPP Power Duo System and the Technical Data sheets of Thixo mortar and Grouting mortar. You can find all these brochures at www.philipp-group.de or are available on request.

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