Simple, robust, fast – the complete wall connecting system

PFEIFER VS® Wire Rope Loop System
# PFEIFER VS® System

Your zip-fastener solution for lightening-fast and troubleless erection of pre-cast concrete wall elements

## Contents:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages of the PFEIFER VS® System</td>
<td>2/3</td>
</tr>
<tr>
<td>PFEIFER VS® Box</td>
<td>4/5</td>
</tr>
<tr>
<td>PFEIFER VS® Rail</td>
<td>6/7</td>
</tr>
<tr>
<td>PFEIFER VS® Rail T 100</td>
<td>8/9</td>
</tr>
<tr>
<td>PFEIFER VS® Long Box</td>
<td>10/11</td>
</tr>
<tr>
<td>Application examples</td>
<td>12</td>
</tr>
<tr>
<td>Application information</td>
<td>13</td>
</tr>
<tr>
<td>Design information</td>
<td>14/15</td>
</tr>
<tr>
<td>Design instructions</td>
<td>16/17</td>
</tr>
<tr>
<td>Installation Instructions</td>
<td>18/19</td>
</tr>
<tr>
<td>Tender specification texts</td>
<td>19</td>
</tr>
<tr>
<td>PAGEL VS® casting mortar</td>
<td>20</td>
</tr>
<tr>
<td>Order form</td>
<td>21</td>
</tr>
</tbody>
</table>

Advantages for the design engineer

- Reliability from one source. The practical, harmonized PFEIFER VS® System program offers the designer an extensive range for all applications.
- Casting channels can be kept narrow thanks to the flexibility of the loops.
- The widely recognized safety risk due to bending and rebending of projecting reinforcement (cold setting) is not relevant.
- Safety due to steel ferrules, which transmit the full breaking force of the wire rope to the concrete element without additional retention reinforcement.
- Spring-back wire rope loops enable the designer to arrange precast concrete elements with flexibility.

Advantages for precast element producer

- Easily fixed by nailing to the formwork.
- Wide, flat sheet steel front flange simplifies gluing to steel form works using thermal adhesive.
- Careful machining and precision manufacture ensure that the highest demands on sealing against the penetration of concrete slurry are met.
- Flexible tape covering minimizes the amount of waste when opening the VS® Rail, VS® Long Box or VS® Box (little residual waste).

Advantages for the assembly crew on the job site

- Wire rope loops easily folded out using a roofing hammer or screw driver – no troublesome bending of reinforcing bars, no time-consuming bolting.
- No formation of rust, as the recess rail and the wire rope are galvanized.
- No risk of accident due to protruding reinforcement bars.
- No plastic parts to be removed, no residual waste.
- Flexible, spring-back loops enable precast concrete panels to be fitted in a gap.

Advantages for the purchaser

- PFEIFER offers a comprehensive, complete program with VS® Box, VS® Rail and VS® Long Box as well as threaded connections for reinforcement.
- Convenient handling due to deliveries in stackable cardboard boxes which provide additional protection from damage.
- Reduced costs for stock holding due to a few sizes covering all applications.
- Particularly cost-effective solution due to modern manufacturing plant.
- Easy handling saves erection time and labour.
- PAGEL-VS® casting mortar can be obtained at special rates from PAGEL Spezialbeton GmbH & Co. KG in Essen.
PFEIFER VS® Box
Our leading product in the VS® System for universal application

Advantages for the design engineer
- The stable and convenient sheet steel box can be fitted as required in any position where forces have to be transmitted.
- Axis spacing can be accurately and economically adapted to suit specific requirements using individually-mountable VS® Boxes.
- The sheet steel box with its equal depth over the whole length guarantees a good shear interlock for transmitting transverse forces.
- Shear interlocking due to the box shape without fitting or removing additional components.

Advantages for precast element producer
- The shallow box with a depth of only 2 cm can easily be fitted between or beneath the reinforcement.
- Shear interlocking due to the box shape without additional recess blocks.
- The stable sheet steel box holds its shape well due to its patented design and cannot swell like plastic.
- Coloured identification of the plastic sliders for each loop length enables fast and economic recognition.

Advantages for the assembly crew on the job site
- With the PFEIFER VS® Box, the perfect positioning of the wire rope loops after folding out is ensured due to the patented latching mechanism.

Advantages for the purchaser
- Convenient, short boxes with wire rope loop are easier to store and take up less space than metre-long sheet steel rails.
- No planning and procurement of different rails with different loop spacing, as VS® Boxes can be mounted as required with any spacing.
The PFEIFER VS® Box is used for joining together concrete elements. It consists of a sturdy sheet steel box suitable for building applications, which contains the foldout flexible wire rope connecting loops. Wall joints, whether butted or corner joints, as well as wall-ceiling joints can be manufactured cost effectively, easily and safely.

High-strength, self-compacting PAGEL-VS® casting mortar, which has very good flow characteristics, must be used for casting the joint (see Page 18). An expert report by the Brandenburg Technical University is available for qualifying the VS® Box. It is also intended to obtain a General German technical approval from the German Institute for Civil Engineering in Berlin. (For more information, see Page 13).

Materials:
galvanized, sheet steel box
galvanized, high tensile steel wire rope
tape cover

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05.030.48 Replacement tape, 50 m roll, silver-grey, 50 mm wide

Ordering example for 5000 PFEIFER VS® Boxes with 100 mm wire rope loop:
5000 PFEIFER VS® Boxes ref. no. 05.025.016.01.100

Please order in multiples of the packing unit (cardboard box).
Advantages for the design engineer

- The rail guarantees a perfect seating of the wire rope loops in the casting joint within the constructional tolerances. Make your own comparison. Here, the geometry of two opposing rails plus the loops fits perfectly – with absolutely no design effort. You do not have to worry about depth, width or the length of the loop. Simply nail it on – finished – and it fits!

Advantages for precast element producer

- Robust, galvanized sheet steel rail for easy handling on site.
- Sheet steel rail is easily cut using a disc cutter.
- Easy sealing of cut sections by means of polystyrene blocks and replacement tape.
- The lateral texture of the rail sides ensures a firm bond in the concrete – even when removing the formwork.
- VS® Rails as an integral part of the form work make recess blocks for making the casting channel superfluous.
- Storey-high casting channels easily manufactured by in-line arrangement of VS® Rails.

Advantages for the assembly crew on the job site

- A continuous casting channel can be easily created by removing the polystyrene end pieces – without additional tools.
- Optimum casting of the joint is possible due to the simple rail geometry.
The PFEIFER VS® Rail is used for joining together concrete elements. It consists of a sturdy sheet steel rail suitable for building applications, which contains the foldout flexible wire rope connecting loops. Different loop spacings cover all applications. Wall joints, whether butted or corner joints, as well as wall-ceiling joints can be manufactured cost effectively, easily and safely. The length of the loop is matched to the profile of the rail to maintain optimum jointing conditions in the casting channel. The trapezoidal rail guarantees that the casting channel can be safely and easily filled over the entire height of the storey. A high-strength, self-compacting PAGEL-VS® casting mortar (Page 20) with very good flow characteristics must be used for this purpose.

Materials:
galvanized, sheet steel box
galvanized, high tensile steel wire rope
tape cover

The PFEIFER VS® Rail is used for joining together concrete elements. It consists of a sturdy sheet steel rail suitable for building applications, which contains the foldout flexible wire rope connecting loops. Different loop spacings cover all applications. Wall joints, whether butted or corner joints, as well as wall-ceiling joints can be manufactured cost effectively, easily and safely. The length of the loop is matched to the profile of the rail to maintain optimum jointing conditions in the casting channel. The trapezoidal rail guarantees that the casting channel can be safely and easily filled over the entire height of the storey. A high-strength, self-compacting PAGEL-VS® casting mortar (Page 20) with very good flow characteristics must be used for this purpose.

Ordering example: 480 PFEIFER VS® Rails with 200 mm loop spacing
480 PFEIFER VS® Rails ref. no. 05.027.200

Please order in multiples of the packing unit (cardboard box).
Advantages for the design engineer

- In combination with the VS® Long Box, wall joints, whether butted or corner joints, as well as shear wall connections, can be simply, economically and reliably designed and produced.
- The range of five loop spacings corresponds with the spacings of the VS® Long Box to provide solutions for all typical applications.
- Without the requirement for any special design consideration, every possible configuration is automatically catered for, guaranteeing the correct loop spacing and the overlap to achieve the safe transmission of load.

Advantages for the precast element producer

- Robust, galvanized steel sheet rail profile to facilitate accurate installation and handling.
- Additional recess formers no longer necessary.
- Rail profile serves simultaneously as a casing for the loop and as a former to provide the correctly dimensioned joint recess – no additional trapezoidal timber formers are necessary.
- Easy cutting to the required length using a disc cutter.
- Easy to close the ends using the polystyrene blocks and cover tape.
- No requirement for the removal of timber formers from the joint, together with the lateral stabilizing effect of the rail sides prevents damage to the concrete recess flanges.
- Lateral texturing to the rail profile provides an effective bond to the concrete.

Advantages for the assembly crew on the job site

- User friendly implementation of the continuous joint by simply removing the tape and the polystyrene stop ends, without any requirement for special tools.
- Optimum joint casting and precise interlocking of loops due to corresponding rail geometry.
- Protruding loops secured within the rail profile.

The VS® Rail T100 provides a continuous and accurately dimensioned recess to achieve the most efficient shear wall panel connection.
The Pfeifer VS® Rail T100 is used to join together concrete elements. It consists of robust sheet steel rail suitable for building applications, which contains the flexible wire rope connecting loops. The T100 Rail profile is designed to house the loops which, when the cover tape has been removed, will interlock precisely with the loops of the corresponding VS® Long Box. The overlap zone falls within the T100 profile.

The loop length is designed to provide the optimum overlap with the corresponding VS® Long Box. The trapezoidal rail guarantees secure and simple sealing of the joint over the entire floor-to-floor height. To facilitate this a high-strength, very fluid and self-compacting Page® VS® casting mortar (Page 20) should be used.

### Materials:
- galvanized, high-strength, steel rope
- galvanized, sheet-steel rail
- tape cover

### Table: VS® Rail T100 Specifications

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<th>No. of loops</th>
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<th>Approx. weight/item</th>
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</tbody>
</table>

**Order example:**

480 PFEIFER VS® Rails T100 with 200 mm loop spacing
480 PFEIFER VS® Rails T100, ref. no. 05.031.200
PFEIFER VS® Long Box
Continuous like the VS® Rail
Low profile like the VS® Box

Advantages for the design engineer
- In conjunction with the VS® Long Box, wall joints, whether butted or corner joints, as well as wall-ceiling joints can be manufactured cost effectively, easily and safely.
- Five different loop spacings and an empty long box satisfy almost any applications.
- No increased design consideration for casting recesses – these are automatically an integral part of the VS® Rail.

Advantages for the precast element producer
- Robust, galvanised sheet steel long box for easy handling on site.
- Sheet steel VS® Long Box is easily cut using a disc cutter.
- Easy sealing of cut sections by means of polystyrene end pieces and replacement tape.
- The texture of the VS® Long Box sides ensures a firm bond in the concrete – even when removing the formwork.
- The VS® Long Box does not interfere with your continuous reinforcement. It is low profile and is accommodated in the concrete cover on one side of the joint.

Advantages for the assembly crew on the job site
- A continuous casting recess can be easily created by removing the polystyrene end pieces – without additional tools.

Advantages for the purchaser
- PFEIFER offers a comprehensive, complete program with VS® Box, VS® Rail and VS® Long Box as well as threaded connections for reinforcement.
- Convenient handling due to deliveries in stackable mesh boxes or cardboard boxes which provide additional protection from damage.
- Easy selection due to a minimised number of different products.
PFEIFER VS® Long Box

Item-No. 05.030

The PFEIFER VS® Long Box is used for joining together concrete elements. It consists of a sturdy but very flat sheet steel strip suitable for building applications, which contains the foldout flexible wire rope connecting loops. Space can be saved by incorporating the flat strip before the reinforcement. Different loop spacings cover all applications. Wall joints, whether butted or corner joints, as well as wall-ceiling joints can be manufactured cost effectively, easily and safely. The casting joint can be easily precast over the entire height of the storey using high-strength self-compacting PAGEL-VS® casting mortar (Page 20) which has very good flow characteristics.

Materials:
galvanized, sheet steel box
galvanized, high tensile steel wire rope
tape cover

Ref. No. | Type | Dimensions in mm | No. of loops | Packing unit / qty. | Weight ca. / each
--- | --- | --- | --- | --- | ---
05.030.000 | VS®-20/000 | 50 20 1180 – – – – – 60 | 0 3 | 250 | 0,68
05.030.150 | VS®-20/150 | 50 20 1180 100 180 147 26 125 60 | 8 3 | 80 | 1,48
05.030.200 | VS®-20/200 | 50 20 1180 100 180 200 55 125 60 | 6 3 | 80 | 1,28
05.030.250 | VS®-20/250 | 50 20 1180 100 180 250 55 125 60 | 5 3 | 80 | 1,18
05.030.300 | VS®-20/300 | 50 20 1180 100 180 300 105 175 60 | 4 3 | 80 | 1,08
05.030.600 | VS®-20/600 | 50 20 1180 100 180 600 280 300 60 | 2 3 | 80 | 0,88
05.030.048 | Replacement tape for cut off rails | 50 m roll, silver-grey, 50 mm wide | |

Ordering example: 400 PFEIFER VS® Long Box 20 mm high, galvanized, with 250 mm loop spacing
400 PFEIFER VS® Long Box ref. no. 05.030.250

Please order in multiples of the packing unit (cardboard box).
Application examples

PFEIFER VS® Box and PFEIFER VS® Long Box

Figure 1 Butt jointing of two walls
Figure 2 Wall junction

PFEIFER VS® Rail

Figure 3 Butt jointing of two walls
Figure 4 Wall junction

PFEIFER VS® System components in combination

Of course, it is also possible to use the different PFEIFER VS® System components in combination with one another. For example, it is practical to choose a combination of VS® Rail T100 and VS® Box or VS® Long Box when buttjoining two wall panels as shown in Figs. 6 and 7. The same can be applied in a similar way to joints between walls and building columns.

Figure 5 Butt jointing of two walls
Figure 6 Building column-wall junction

Application example PFEIFER VS® Box

Figure 7 Building columns with VS® Boxes

Figure 8 Wall elements with VS® Boxes ready for use

Figure 9 Erection of wall sections: Position – fix – cast – finished!
1. General information

The PFEIFER VS® System is a system of installation components for precast concrete elements - preferably wall elements - consisting of one or more wire rope loops as well as a sheet steel box or a sheet steel rail or long box. It is used to transmit forces within working joints as shown in Figures 1 to 6. At the same time, it is possible to join precast concrete elements together to advantage and also to make connections between precast parts and concrete structures on site. The PFEIFER VS® System is designed for use with PAGEL-VS® casting mortar. All values are referred to the characteristics of this casting mortar (Page 20).

With the system components VS® Box, VS® Rail and VS® Long Box, PFEIFER offers a practical, complete program and a comprehensive range for all applications in precast engineering.

2. Technical approvals in Europe

An application was made to the German Institute for Civil Engineering in May 1998 for the issue of a General German technical approval for the PFEIFER VS® Box. A wire rope in conjunction with concrete was a completely new component in civil engineering practice.

Particularly in practical terms, this system has been rapidly taken up in recent years due to the many advantages in civil engineering practice. The VS® System has already also been used several times for static loading applications in Germany.

When using the VS® System in constructions which do not affect the stability of a component or building, a general approval or agreement in individual cases is not necessary.

In the following European countries technical approvals have already been issued:

- Poland
- Denmark
- Finland
- The Czech Republic
Design information

1. Transmission of tensile forces perpendicular to the joint

Tensile forces are transferred by overlapping the wire rope loops (Fig. 10). Pressure is exerted on the casting mortar inside the wire rope loop by the curvature of the loop. A tensile force is produced perpendicular to the plane of the loops, which must be covered by a transverse rod or assembly rod (Fig. 11).

When the joint is properly cast and the wire rope loops overlap as designed, the wire rope is the determining element and is thus the critical factor for calculating the maximum permissible tensile force perpendicular to the joint. The wire rope force usable in civil structures has been calculated in a similar manner to DIN 18800 (edition 3.81).

It has been shown as a result of several trials that, in many cases, the wire rope force is the decisive element, but that this can be in the same range as the compression failure of the casting mortar. For this reason, the usable wire rope force calculated from the minimum breaking force with a global safety factor of $\gamma = 3.0$.

The minimum breaking force of the wire rope used according to DIN 3060 is $F_{\text{min}} = 21.2$ kN.

From this it follows that for each wire rope loop:

$$F_{\text{admissible}} = \frac{F_{\text{min}} \cdot 2}{\gamma} = \frac{21.2 \cdot 2}{3.0} = 14\text{ kN}$$

By arranging several VS® Loops above one another or side-by-side, the value can be multiplied by the respective number used as long as the individual VS® Loops do not interact with one another.

**warning reference:**

In these considerations elongations and crack width have not been taken into account. These conditions can reduce the capacity of the system especially in external use.

**Attention:** The described static system is only for the common understanding of the VS® system bearing behaviour. They can only be used for connections which are not needed for the stability of a construction.

2. Transmission of transverse forces parallel to the joint

Transverse forces can act parallel to the joint (Fig. 12). These come about, for example, as a result of the longitudinal bracing of a building against wind loading. Transverse forces parallel to the joint can be transmitted using the VS® Box, the VS® Rail or the VS® Long Box.

When several wind panels are joined together to form one slab, 1045-1, requires that the shear force is resolved into a tensile component acting horizontally and a compression component acting at an angle $\alpha$.

The absorption of the tensile force by reinforcement must always be proved by the transmission of the compressive component at shear stresses $\tau > 0.2\text{ N/mm}^2$.

**PFEIFER VS® Box**

For the calculation of the transverse force carrying capacity parallel to the joint, it can be assumed from the conceptional model that an angled compression strut extends from a retaining box in precast element 1 to an opposite retaining box in precast element 2, and the tensile force is absorbed by the overlapping wire rope loops in the area of the joint.

With regard to the failure of the joint, two failure modes are conceivable:

1. Failure of the tension tie Z (the wire rope)
2. Failure of the compression struts (the concrete)

**PFEIFER VS® Rail**

In the case of the PFEIFER VS® Rail, the transmission of transverse forces parallel to the cast joint can be well described by the results of comprehensive trials.

The VS® Rail consists of several wire rope loops (4 to 8 depending upon the spacing between them) in a sheet steel box of length 1180 mm. The individual loops are the same as those in the VS® Box.

The sheet steel box has a trapezoidal cross section, which at the same time represents half of the profile of the casting joint to be used later (see data sheet for the PFEIFER VS® Rail).

In contrast to the VS® Box, the VS® Rail consists of a continuous steel profile in which the snug contact for transmitting the transverse forces is formed by the lateral texture tie of the rail. From the static point of view, a simple strut-and-tie-model can be described with a tensile tie and compression strut similar to Fig. 13. The angled compression strut resulting from the model must therefore be introduced to the concrete via this sheet steel box profile. Tensile forces are absorbed and transmitted by the overlapping wire rope loops in the area of the joint.
3. Transmission of transverse forces perpendicular to the joint

In special cases, transverse forces can also occur perpendicular to the joint (Fig. 14). This can, for example, be the case in areas with external forces such as wall panels subject to earth or wind pressure. These transverse forces can be absorbed and transmitted with the PFEIFER VS® System. The dimensions of the joint geometry must be chosen in accordance with the hints given below.

For the calculation of the transverse force carrying capacity perpendicular to the joint, it can be assumed from the conceptional model that an angled compression strut (Fig. 15, 16) extends from a concrete edge in precast panel 1 to an opposite concrete edge in precast panel 2 and the tensile force is covered by the overlapping wire rope loops in the area of the joint.

With regard to the failure of the joint, two failure modes are conceivable:
1. Failure of the concrete edges
2. Failure of the steel wire rope

The model shows that the admissible transverse force reduces with increasing joint depth.

4. Combined loading

When tensile and transverse forces act at the same time, usually parallel to the joint, additive tensile forces are produced in the overlapping wire rope loops. It should be noted that the admissible tensile force must not be exceeded under this combined loading and that tensile forces are produced in the overlapping wire rope loops even when transverse forces are acting. Depending on the inclination of the compression struts that exists for a particular transverse force situation, the usable tensile and transverse force is less than with purely tensile loading. From a static point of view, the utilisation factor is calculated as a function of the angle of inclination of the compression strut.

5. Information on fire prevention

The PFEIFER VS® System has been assessed with respect to fire prevention in a report by the Institute of Materials Testing for Civil Engineering in Brunswick as well as in an expert opinion produced by the Technical University, Cottbus. According to DIN 4102, Table 1, the critical temperature above which the yield point of the BSt 500 reinforcement starts to reduce under the steel tension present is crit. $T = 500 \, ^\circ C$. According to DIN 4102, for reinforcing steel in walls, a minimum axis spacing of $u = 35 \, mm$ would be required in order to achieve $F90-A$. In this case, this figure refers especially to the vertical reinforcement that is at risk of buckling or to reinforcement where it is not possible to rearrange the load.

In the PFEIFER VS® System, instead of being made from reinforcing steel, the loop is made from high-tensile steel round stranded wire rope with a rated wire strength of 1770 $N/mm^2$, the strength thus corresponding to that of a stranded prestressing tendon.

From a fire prevention point of view, the VS® System, like prestressing strands, can thus be evaluated in comparison with DIN 4102-4, 1994-03, Fig. 2. Here, the critical steel temperature for these strands is $T_{crit} = 350 \, ^\circ C$.

With regard to fire prevention, there need therefore be no concern about using the VS® System in the same way as prestressing strands. The required concrete cover must therefore be referred to a critical temperature of crit. $T = 350 \, ^\circ C$. At the same time, it should be noted that, according to DIN 4102-4, the minimum axis spacings $u$ and $u_T$ must be increased by a value $\Delta u = 15 \, mm$.

Information: VS®Rails and VS® Long Boxes without wire rope loops cannot transmit forces!
Design instructions

1. General information

The respective component and recess design are shown in Figs. 17 to 20. The depth of the recess in particular must be matched to the length of the wire rope loop. A recess that is not deep enough will not allow a suitable overlapping of the wire rope loops so that the full carrying capacity will not be guaranteed. The wire rope loop should be prevented from striking the far edge of the recess and having to be bent out of the way in order to bring the sections together at all. There should be sufficient room in the casting recess for the loops in the unfolded state without hitting (see Table 1). It is sensible for the casting recess to extend over the full height of the wall so that no gaps are left open when casting.

Furthermore, the careful design of the recess with the resulting concrete edge dimensions is important for transmitting transverse forces perpendicular to the length of the joint or the plane of the slab.

The PFEIFER VS® System is designed for a minimum slab thickness of 14 cm and above.

It is of particular advantage in the case of a continuous wall or a building column where the VS® Long Box can be accommodated in the concrete covering without having to interrupt the reinforcement. At 20 mm, the VS® Long Box is designed to be low profile so that it can be accommodated in the concrete covering as shown in Fig. 20. The appropriate casting space for the cast joint is then created in the wall section to be connected. To achieve this, the VS® Rail T100 has a depth of 100 mm to enclose the complete loop overlapping. This type of joint is suitable both for wall-wall junctions, Fig. 5, and also for building support-wall junctions as shown in Fig. 6 on page 10.

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Table 1: Recess depth and overlap

Figure 17 VS Box® – Casting recess design

Figure 18 VS Strip® – Casting recess design

Figure 19 VS Rail® – Casting recess design

Figure 20 VS® Rail T100 and VS® Long Box – Casting recess design
2. Minimum installation spacing
When arranging several VS® Boxes above one another or side-by-side, the forces that can be transmitted by an individual box can only be multiplied by the number used as long as the individual VS® Boxes do not interact with one another. This can be assumed to be the case if the spacing between adjacent VS® Boxes is chosen to be sufficiently large. As a general rule, if the minimum area reinforcement is used, the length of a VS® Box must be maintained as the spacing between them (Fig. 21).

3. Reinforcement
The vertical bar in the centre of the joint (BST 500 S, ø 12 mm), also known as the assembly bar, functions as a transverse reinforcement bar. It is needed to cover the tensile forces occurring in the jointing concrete.

In order to ensure that the full load is directed from the PFEIFER VS® System components into the precast concrete panel, an appropriate minimum surface reinforcement must be provided. A U-stirrup (BST 500 S, ø 8 mm) must be inserted for each wire rope loop. It is assumed that the wire rope anchorage forms an overlapping joint with the reinforcement (Fig. 21a and 22a).

Alternatively, insert-stirrups ø 6 mm can be arranged at a spacing a, which corresponds to half the loop spacing (Fig. 21b).

Minimum reinforcement
The VS® System components are to be installed in such a way that the axes of the loops lie symmetrically with respect to the section axis in order to ensure that all loops are equally loaded.

Q 188 meshes (Fig. 22a and 22b), which are connected to insert-stirrups at the joint end, are to be provided as the minimum reinforcement. Two or in case b) one Lw, 8 mm over the hole height of the joint have to be added.

If the intended minimum surface reinforcement or the U-stirrup has not been provided, then the minimum edge distances given above do not apply. The fact that the wire rope loop is anchored in the concrete at its end must then be used as a basis (Fig. 22c). The rules of fixing technology are applicable in this case where, according to DIN, the minimum spacing must be three times the depth of the anchor. For an anchoring depth of 250 mm, this corresponds to a minimum axis spacing of 750 mm. The minimum surface reinforcement to be provided is shown schematically in the following drawings.

4. Installation tolerances for the VS® Elements
The PFEIFER VS® Box and also the loops of the PFEIFER VS® Rails and Long Boxes act as overlapping joints. For this reason, the loops must always be arranged to overlap within certain tolerances. To this end, a position deviation of 4-times the wire rope diameter must be maintained for each loop (Fig. 23).

For the full supporting effect, the loops must lie orthogonally to the joint in order to achieve a clean overlap (Fig. 24).

This is helped in the case of the PFEIFER VS® Boxes by the patented latching mechanism. The overlap must also be fixed with PFEIFER VS® Rails and Long Boxes using binding wire if necessary.
Installation instructions

General
The PFEIFER VS® System includes the different individual components VS®-Box, VS®-Rail and VS® Long Box.

In detail, the PFEIFER VS® Box consists of a robust, steel sheet box, in the inside of which is secured the wire rope loop. The different loop lengths can be easily distinguished by the coloured embossed sealing slide. Two nail holes are punched into the steel sheet block as an aid to fitting. The VS® Box is sealed using a robust but flexible tape cover.

The PFEIFER VS® Rail, like the VS® Long Box, consists of several wire rope loops (4 to 8-off depending upon the spacing between them) in a sheet steel box of length l = 1180 mm. The number of nail holes per element always corresponds to the number of wire rope loops selected per rail. These two system components also have the robust but flexible tape covering mentioned above. The open ends are tightly sealed against the ingress of concrete or concrete water by polystyrene end pieces.

The VS® System components can of course also be glued in position here.

When using steel or plastic formworks, it must always be ensured that the surface is smooth and has previously been adequately degreased. Otherwise, the intended VS® System components could come loose and shift when pouring the concrete or during the tamping process.

After removing the formwork
After removing the formwork, the flexible tape cover is easily removed from the appropriate profile (Fig. 30 and 31). The inside of the VS® System component is then exposed and the wire rope loops are visible.

The wire rope loops can then easily be folded out using an ordinary roofing hammer or a screw driver for example (Fig. 32 and 33). Immediately after folding out, the wire rope loop should stand out roughly perpendicular to the section and also spring back to this position after deflecting. This is important in order to guarantee an adequate and controlled overlap of the opposing wire rope loops.

When fitting the VS® System components to the formwork, it must be ensured that the end of the wire rope is threaded as straight as possible between the reinforcement. Subsequently, the VS® Boxes are fixed one by one and the VS® Rails, VS® Rails T100 or VS® Long Boxes one after the other simply by nailing to the wooden formwork (Fig. 26, 27).

If it is not possible to nail the box or the rail to the formwork, for instance in the case of steel form works, we have a practical solution at the ready:
A double-sided adhesive tape is stuck to the tape cover and simply stuck to the de-greased, smooth formwork (steel or plastic). Thermal adhesives (melting glue) can also be used for this purpose (Fig. 28, 29).

Casting recess design
Depending on the application and the choice of VS® System components (see also Pages 10, 14, 15), the casting recess must be designed accordingly. For example, with a wall-wall connection, implemented by using a VS® Rail, the casting recess is automatically formed by the 50 mm deep rail profile. This means that no additional recessing elements are required. For a building support – wall connection, a combination of VS® Rail T100 and VS® Box/Long Box, the prescribed recess depth, no separate recessing piece must be inserted to achieve the necessary dimension. The deeper installation position is provided by the VS® Rail T100 as shown in Fig. 25. The external surface reinforcement should in this case be continued up to the foremost edge in order to prevent this edge from possibly breaking away when removing the formwork. A slight tape-ring and good lubrication of the shuttering can ease this process.

Fitting to the formwork
When fitting the VS® System components to the formwork, it must be ensured that the end of the wire rope is threaded as straight as possible between the reinforcement. Subsequently, the VS® Boxes are fixed one by one and the VS® Rails, VS® Rails T100 or VS® Long Boxes one after the other simply by nailing to the wooden formwork (Fig. 26, 27).

If the material of the front element of the formwork should happen to be steel, the VS® System components can of course also be glued in position here.

If it is not possible to nail the box or the rail to the formwork, for instance in the case of steel form works, we have a practical solution at the ready:
A double-sided adhesive tape is stuck to the tape cover and simply stuck to the de-greased, smooth formwork (steel or plastic). Thermal adhesives (melting glue) can also be used for this purpose (Fig. 28, 29).
Casting the joint

When the concrete sections to be joined have been brought into position, a reinforcing rod of ø 12 mm is inserted from above (Fig. 34 and 35).

The weakest point of a channel joint between wall sections is always the channel casting. Channel joints are only able to transmit the specified forces without any problems when the channels have been correctly and completely cast and an appropriate compression of the casting mortar has been ensured.

A concrete with as fine aggregate as possible (largest gravels < 8 mm) must be used for casting in order to completely fill the relatively small channels without forming gravel pockets. The consistency must be adjusted so that the concrete can flow properly into the intermediate spaces. Particular importance should be given to careful compression. For this purpose, a smaller internal vibrator could be used, which is mounted on the top of the assembly bar and vibrates the concrete for an appropriate length of time. In view of the small quantities required to cast the joints on site, it is practical to use ready-mixed casting grouts for this purpose. We recommend the exclusive use of PAGEL-VS® casting mortar, as we have achieved very good overall results with this in the trials for the granting of the General German Technical Approval. Vibration is not required with this, as it is self-compacting. You will find more information on this recommended casting mortar and its use on page 20.

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Tender specification text for PFEIFER VS® Systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Designation / Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFEIFER VS® Box</td>
<td>off PFEIFER VS® Box for positive connection of precast concrete panel. Fix the component to the formwork in accordance with the relevant PFEIFER Installation Instructions and remove the protective tape cover after concreting the precast concrete panel. By agreement with the erection company, fold out the wire rope loops if required (e.g. by using a roofing hammer) and latch into recesses. Component: .......... _/each Labour: .......... _/each Total: .......... _/each.</td>
</tr>
<tr>
<td>PFEIFER VS® Rail</td>
<td>off PFEIFER VS® Rail at 1.18 m (equivalent to ....... running metres) for positive connection of precast concrete panel. Fix the component to the formwork in accordance with the relevant PFEIFER Installation Instructions and remove the protective tape cover after concreting the precast concrete panel. By agreement with the erection company, fold out the wire rope loops if required (e.g. by using a roofing hammer). Component: .......... _/each Labour: .......... _/each Total: .......... _/each.</td>
</tr>
<tr>
<td>PFEIFER VS® Long Box</td>
<td>off PFEIFER VS® Long Box at 1.18 m (equivalent to ....... running metres) for positive connection of precast concrete panel. Fix the component to the formwork in accordance with the relevant PFEIFER Installation Instructions and remove the protective tape cover after concreting the precast concrete panel. By agreement with the erection company, fold out the wire rope loops if required (e.g. by using a roofing hammer). Component: .......... _/each Labour: .......... _/each Total: .......... _/each.</td>
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<tr>
<td>Erection of prefabricated elements</td>
<td>Erection, alignment and fixing of the prefabricated elements. Check the required position of the PFEIFER VS® Box loops. Ancillary equipment, crane: .......... _/each Labour: .......... _/each Total: .......... _/each.</td>
</tr>
<tr>
<td>Shuttering for the casting recess</td>
<td>Fit shuttering closely to both sides of the joint. Remove shuttering after casting. Ancillary equipment: .......... _/each Labour: .......... _/each Total: .......... _/each.</td>
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<tr>
<td>Casting precast concrete panel joints</td>
<td>Supply casting mortar (PAGEL-VS® casting mortar or equivalent), mix using a mechanical mixer and pour. Casting mortar: .......... _/kg Labour: .......... _/kg Total: .......... _/each.</td>
</tr>
</tbody>
</table>
PAGEL-VS® casting mortar

Information and tips
The characteristics of the casting mortar in the joint play a significant role in producing a positive connection between concrete sections and the PFEIFER VS® System elements. We recommend the exclusive use of PAGEL-VS® casting mortar, as we have achieved very good overall results with this in the trials for the granting of the General German Technical Approval. This high-quality but inexpensive mortar combines the optimum characteristics for filling the channels in our PFEIFER VS® System and has been developed in conjunction with PAGEL GmbH & Co. KG in Essen.

Characteristics
✓ highly free-flowing for at least 90 minutes
✓ controlled volume and positive bonding
✓ low heat development
✓ low modulus of elasticity
✓ resistant to de-icing salt
✓ can be pumped and is easily workable even with mixing and feed pumps
✓ the casting process is carried out immediately after the ready-to-pour mixture has been made
✓ impermeable to water, extensively resistant to oil
✓ corrosion-resistant
✓ remote and self-monitoring production control in accordance with the “Instructions for Casting Mortar” (DBV)
✓ General German Technical Approval for the PAGEL concrete additive has been granted
✓ production certified to DIN ISO 9001
✓ supplied as a bagged product (bags of 25 kg) - in special cases, larger quantities in so-called BIG-BAGS with a content of 1 t are available.

Technical parameters
(according to current data sheet produced by PAGEL GmbH & Co. KG)

<table>
<thead>
<tr>
<th>Aggregate size:</th>
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<tbody>
<tr>
<td>Grouting height:</td>
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<tr>
<td>max. Qty. of water:</td>
<td>%*</td>
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<tr>
<td>Amount:</td>
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<td>Expansion:</td>
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<tr>
<td>Working time:</td>
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<td>Slump:</td>
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<td></td>
<td>60 min. cm</td>
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<tr>
<td>Swelling value:</td>
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<tr>
<td></td>
<td>28 d Vol. %</td>
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<td>Compressive strength:</td>
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<td>3 d N/mm²</td>
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<td>7 d N/mm²</td>
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<td>28 d N/mm²</td>
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<td>90 d N/mm²</td>
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<td>Bending strength:</td>
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<td></td>
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<td>28 d N/mm²</td>
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<tr>
<td></td>
<td>90 d N/mm²</td>
<td>11,9</td>
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<tr>
<td>Modulus of elasticity 28d (cylinder):</td>
<td>N/mm²</td>
<td>35,200</td>
</tr>
</tbody>
</table>

*percentage of the mass of dry mortar

The technical product data refer to an average water quantity of 11%.

Storage: 9 months dry and in well-sealed bags

Form of supply: Bags of 25 kg

Risk category: Non-hazardous material. Pay attention to information on packaging

Additives: 3.21 - 1451 Approval Certificate No. 219 000

Information for use

Preparing the base layer
Before fitting the joint shuttering or before casting the joint, the precast concrete elements contact surfaces must be pre-moistened. In the case of prefabricated reinforced concrete sections it is assumed that there is no cement slurry or any substances with a separating action present in the area of the joint. If this should be the case contrary to expectations, suitable measures must be taken to remove any contamination from the contact surfaces of the edges of the joint before fitting the joint shuttering.

Mixing PAGEL-VS® casting mortar
PAGEL-VS® casting mortar is mixed with a mechanical mixer. To make the mixture, approximately 2/3 of the maximum amount of water required is put into the mechanical mixer. After mixing for approximately 3 minutes, the rest of the water is added and mixed for a further 2 minutes. The casting process is carried out immediately after the ready-to-pour mixture has been made.

Casting the joint
The casting mortar is poured in continuously until the desired level is achieved. The casting process can be considerably simplified by using a hose and funnel system. The use of worm-driven, open feed systems is recommended for larger casting jobs. Separate working recommendations can be obtained directly from PAGEL.

Use in poor weather conditions and in difficult circumstances
According to DIN 1045-1, cement-bonded building materials must not be used in ambient temperatures or with component temperatures below +5 °C, as hydration is delayed when used at lower temperatures and there is a risk of frost damage if temperatures should drop towards freezing. Frost damage can only occur however if the initial compressive strength is less than 5 N/mm².

For this reason, when working with cement-bonded building materials, it must be ensured that the component or material temperature is maintained at +5 °C until a compressive strength of 5 N/mm² has been achieved.

With PAGEL-VS® casting mortar, a period of at least 36 hours at +5 °C must be allowed so that this frost-resistant compressive strength is reached. Once this compressive strength has been achieved, a further increase in compressive strength follows relatively quickly.

In order to keep the heat losses from the introduced concrete as low as possible, we suggest the following options:
• Cover the fresh concrete surfaces in contact with the air with heat insulation
• Use heat-insulating shuttering
• Remove shuttering later
• Enclose the workplace

The heat-treatment measures must be carried out for at least 36 hours as otherwise there will be a risk of frost damage.

At low product temperatures the wetting of the cement particles with water takes place more slowly than at 20 °C for example. Added to this is the fact that the chemicals used for diluting (high power liquirifiers) also react more slowly at low temperatures. To counteract this, we suggest the following measures:
• Extend the mixing process, be sure to use a mechanical mixer and pre-mix with 2/3 - 3/4 of the water until viscous and add the remainder of the water slowly.
• Mixing water temperature > 15 °C

Modulus of elasticity 28d (cylinder): N/mm² 35,200
Order Form

PFEIFER SEIL- UND HEBETECHNIK GMBH
Geschäftsbereich BAUTECHNIK
Postfach 1754 · D-87687 Memmingen

Fax +49 (0) 83 31-937-342

Order for PFEIFER VS® System

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<th>Type</th>
<th>Qty.</th>
<th>Ref. No.</th>
<th>Price each in EUR</th>
<th>Total price per item in EUR</th>
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</table>

The order is subject to the PFEIFER Conditions of Sale and Supply with which you are familiar.

Please state all dimensions in mm

Order confirmation
(Will be completed by PFEIFER and faxed back to you!)

Total in EUR:

EUR

PAGEL-VS® casting mortar Please order from: Pagel-Spezialbeton GmbH & Co. KG, Wolfsbankring 9, D-45355 Essen,
Tel. +49 (0)201/68 50 411, Fax +49 (0)201/68 50 415, Internet: www.pagel.de

Please order in multiples of the packing unit (mesh box or cardboard box).