Deutsches Institut für Bautechnik DIBt

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments



# European Technical Assessment

# ETA-05/0202 of 4 September 2018

English translation prepared by DIBt - Original version in German language

**General Part**

| | |
|---|---|
| Technical Assessment Body issuing the European Technical Assessment: | Deutsches Institut für Bautechnik |
| Trade name of the construction product | BBV-Internal Bonded Strand Post-tensioning System, type i |
| Product family to which the construction product belongs | PAC 16, Post-Tensioning kits (internal bonded for strands) |
| Manufacturer | BBV Systems GmbH<br>Industriestraße 98<br>67240 Bobenheim-Roxheim<br>DEUTSCHLAND |
| Manufacturing plant | BBV Systems GmbH<br>Industriestraße 98<br>67240 Bobenheim-Roxheim<br>DEUTSCHLAND |
| This European Technical Assessment contains | 27 pages including 20 annexes which form an integral part of this assessment |
| This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of | EAD 160004-00-0301 |
| This version replaces | ETA-05/0202 issued on 26 August 2016 |

The European Technical Assessment is issued by the Technical Assessment Body in its official language. Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and shall be identified as such.

Communication of this European Technical Assessment, including transmission by electronic means, shall be in full. However, partial reproduction may only be made with the written consent of the issuing Technical Assessment Body. Any partial reproduction shall be identified as such.

This European Technical Assessment may be withdrawn by the issuing Technical Assessment Body, in particular pursuant to information by the Commission in accordance with Article 25(3) of Regulation (EU) No 305/2011.

## Specific part

## 1 Technical description of the product

### 1.1 Definition of the construction product

The present European Technical Assessment applies to the post-tensioning kit for prestressing of structures with the trade name:

**BBV-Internal Bonded Strand Post-Tensioning System, type i**

consisting of 3 to 31 strands with a nominal tensile strength 1770 N/mm² or 1860 N/mm² (Y1770 S7 or Y1860 S7 in according with prEN 10138-3:2009, table 4), nominal diameter 15.3 mm (0.6" - 140 mm²) or 15.7 mm (0.62" - 150 mm²) which are used in normal-weight concrete with the following anchors (stressing and fixed anchors and couplers):

1. Stressing (active) anchor type S and fixed (passive) anchor type F and Fe with bearing plate and anchor head for tendons of 3, 4, 5, 7 and 9 strands,
2. Stressing (active) anchor type S and fixed (passive) anchor type F and Fe with cast-iron anchor body and anchor head for tendons of 12, 15, 19, 22, 27 and 31 strands,
3. Coupler ÜK (fixed (FÜK) and movable (BÜK)) for tendons of 3, 4, 5, 7, 9, 12, 15, 19, 22, 27 and 31 strands,
4. Single strand coupler EÜK (movable) for tendons of 3, 4, 5, 7, 9, 12, 15, 19, 22, 27 and 31 strands

Additional components of the present Post-tensioning system are:

- Bursting reinforcement (helixes and stirrups),
- Sheathing (ducts),
- Corrosion protection.

The anchorage of the strands in anchor heads and couplers is done by means of wedges.

The components and the system setup of the product are given in Annex A.

### 1.2 Strands

The tensioning system shall only use with 7-wire prestressing steel strands which comply with the national regulations and the properties given in Table 1:

Table 1: Dimensions and properties of 7-wire strands

| Designation | Symbol | Unit | Value | |
|---|---|---|---|---|
| Tensile strength | $R_m$ | MPa | 1770 or 1860 | |
| Strand | | | | |
| Nominal diameter | D | mm | 15.3 | 15.7 |
| Nominal cross section | $A_p$ | mm² | 140 | 150 |
| Nominal mass | M | g/m | 1093 | 1172 |
| Individual wires | | | | |
| External wire diameter | d | mm | 5.0 ± 0.04 | 5.2 ± 0.04 |
| Core wire diameter | d' | mm | 1.02 to 1.04 d | 1.02 to 1.04 d |

To avoid confusions only strands with one nominal diameter shall be installed on one site. If the use of the strands with $R_m$ = 1860 MPa is intended on site, these shall solely be used there. Only strands stranded in the same direction shall be used in a tendon. Further characteristic values of the strands see Annex A7.

## 1.3 Wedges

The determined performance of the tensioning system applies only to smooth or knurled type 30 wedges (see Annex A3). The knurled wedges shall only be used for pre-wedged (pre-locked) ones at fixed anchors. The segments of the wedges for strands Ø 15.7 mm shall be marked with "0.62".

## 1.4 Anchor heads and couplers

The conical drills of the anchor heads and couplers shall be clean and free of rust and provided with a corrosion protection agent.

## 1.5 Bearing plates

For tendons of 3 to 9 strands rectangular bearing plates shall be used. The long side of the bearing plates shall be installed parallel to the biggest centre or edge distance (see Annex A2 page 1 and 3 and Annex A4).

## 1.6 Cast-iron anchor bodies

For the anchorage of tendons with 12 to 31 strands multi-surfaced cast-iron anchor bodies shall be used (see Annex A4).

## 1.7 Helixes and stirrups

The steel grades and dimensions of the helixes and of the stirrups shall comply with the values given in the Annexes. The central position in the structural concrete member on site shall be ensured according to Annex B, section 3.1.3.

## 1.8 Ducts, tubes and trumpets

Ducts shall be used according to EN 523:2003. For tendons BBV L3 and BBV L4 use may also be made of oval ducts. For these ducts EN 523:2003 applies accordingly. The dimensions of the ducts shall comply with the values given in Annex A2. The trumpets at stressing and fixed anchors (see Annexes A3, A4) are manufactured from 3.5 mm thick PE material (BBV L3 to L31).

Only for the steel transition pipes FÜK L3 to L7 PE pipes with a wall thickness of at least 4 mm and a length of 120 mm shall be installed in the deflection area in order to avoid contact between the strand and the steel. The PE pipes shall be fixed reliably in the right position to avoid moving during tensioning.

When using trumpets made of plastic with a minimum thickness of 3.5 mm, it is not necessary to install a PE pipe. It shall be made sure that at anchors and couplers for 3 to 22 and 31 strands (1.part, Annex A6) the maximum deflection angle of the strand is 2.6° (at the end of the wedge and at the deviation point between trumpet and duct). For 27 strands the maximum deflection angle is 2,1°, only for bearing plate type 2 with a maximum of 2,6°.

The deflection at couplers (Annex A6) is 7° (at the deviation point between trumpet and duct). At the end of the wedge normally there is no deflection.

For single strand coupling the max deviation angle is 2.2°. At the end of wedge there is no deviation angel.

Also plastic ducts which meet the requirements according to EAD 160004-00-0301 clause 2.2.10 and in accordance with regulations valid at the place of use can be used. For plastic ducts and the accompanying boundary conditions are no performance assessed in ETA-05/0202.

## 1.9 Grout

Grout shall be used according to EN 447:2007

## 2 Specification of the intended use in accordance with the applicable European Assessment Document

The performances given in Section 3 are only valid if the PT-System is used in compliance with the specifications and conditions given in Annex B.

### 2.1 Specification

Specific details for installation and use are given in Annex B1.

### 2.2 working life

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the PT-System of at least 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

## 3 Performance of the product and references to the methods used for its assessment

### 3.1 Mechanical resistance and stability (BWR 1)

| No. | Essential characteristic | Performance |
|---|---|---|
| 1 | Resistance to static load | The acceptance criterion to EAD 160004-00-03-01 clause 2.2.1 is fulfilled, see Annex B1 |
| 2 | Resistance to fatigue | The acceptance criterion to EAD 160004-00-03-01 clause 2.2.2 is fulfilled, see Annex B1 |
| 3 | Load transfer to structure | The acceptance criterion to EAD 160004-00-03-01 clause 2.2.3 is fulfilled, see Annex B1 |
| 4 | Friction coefficient | The acceptance criterion to EAD 160004-00-03-01 clause 2.2.4 is fulfilled, see Annex C |
| 5 | Deviation/ deflection (limits) for internal bonded and internal unbonded tendon | The acceptance criterion to EAD 160004-00-03-01 clause 2.2.5 is fulfilled, see Annex B1 |
| 6 | Deviation/ deflection (limits) for external tendon | No performance assessed |
| 7 | Assessment of assembly | The acceptance criterion to EAD 160004-00-03-01 clause 2.2.7 is fulfilled |
| 8 | Resistance to static load under cryogenic conditions for applications with anchorage/coupling outside the possible cryogenic zone | No performance assessed |
| 9 | Resistance to static load under cryogenic conditions for applications with anchorage/coupling inside the possible cryogenic zone | No performance assessed |
| 10 | Material properties, component performance, system performance of plastic duct | No performance assessed |

| | | |
|---|---|---|
| 11 | Material properties, component performance, system performance of plastic duct to provide an encapsulated tendon | No performance assessed |
| 12 | Material properties, component performance, system performance of plastic duct to provide an electrically isolated tendon | No performance assessed |
| 13 | Corrosion protection | No performance assessed |
| Monostrand, sheating base material | | |
| 14 | Melt index | No performance assessed |
| 15 | Density | No performance assessed |
| 16 | Carbon black | No performance assessed |
| 17 | Tensile strenght | No performance assessed |
| 18 | Elongation | No performance assessed |
| 19 | Thermal stability | No performance assessed |
| Monostrand, manufactured sheating | | |
| 20 | Tensile strenght | No performance assessed |
| 21 | Elongation | No performance assessed |
| 22 | Surface of sheating | No performance assessed |
| 23 | Environtal stress cracking | No performance assessed |
| 24 | Temperatur resistance | No performance assessed |
| 25 | Resistance to externally applied agents (mineral oil, acid, base, solvents and salt water) | No performance assessed |
| 26 | Sheating minimum thickness | No performance assessed |
| Monostrand, manufactured monostrand | | |
| 27 | External diameter of sheating | No performance assessed |
| 28 | Mass of sheating per metre | No performance assessed |
| 29 | Mass of filling material per metre | No performance assessed |
| 30 | Alteration of dropping point caused by monostrand manufacturing | No performance assessed |
| 31 | Alteration of oil separation caused by monostrand facturing | No performance assessed |
| 32 | Impact resistance | No performance assessed |
| 33 | Friction between shealting and strand | No performance assessed |
| 34 | Leak tightness | No performance assessed |

## 3.2 Safety in case of fire (BWR 2)

| No. | Essential characteristic | Performance |
|---|---|---|
| 35 | Reaction to fire | No performance assessed |

## 3.3 Hygiene, health and the environment (BWR 3)

| No. | Essential characteristic | Performance |
|---|---|---|
| 36 | Content, emmission and/or release of dangerous substances | No performance assessed |

## 4 Assessment and verification of constancy of performance AVCP) system applied, with reference to its legal base

In accordance with the European assessment document EAD 160004-00-0301 the applicable European legal act is: [98/456/EC].

The system to be applied is: 1+

## 5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

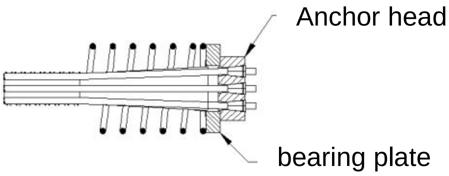
Issued in Berlin on 4 September 2018 by Deutsches Institut für Bautechnik

BD Dipl.-Ing. Andreas Kummerow
Head of Department

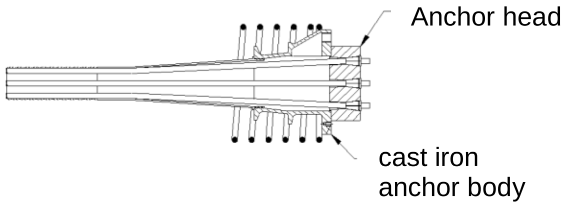
*beglaubigt:*
Ascher

## GENERAL VIEW OF ANCHORS AND COUPLINGS

**1. Passive anchor (S) and active anchor (F)**
**BBV L3 – BBV L9 (with anchor plate):**

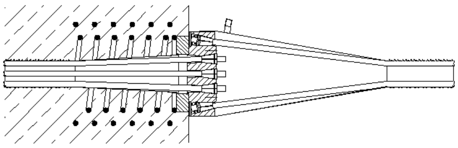



**BBV L12 – BBV L31 (with cast iron anchor body):**

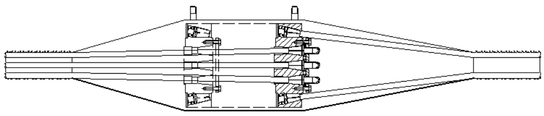



**2. Fixed and movable coupling BBV L3 – BBV L9:**

Fixed coupling (FÜK)

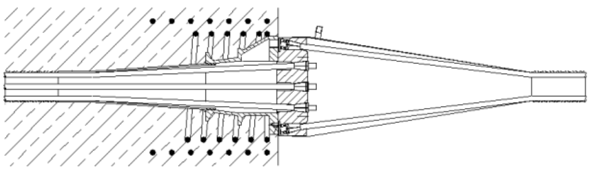


movable coupling (BÜK)

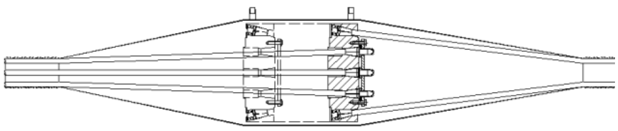


**3. Fixed and movable coupling (ÜK) BBV L12 – BBV L31:**

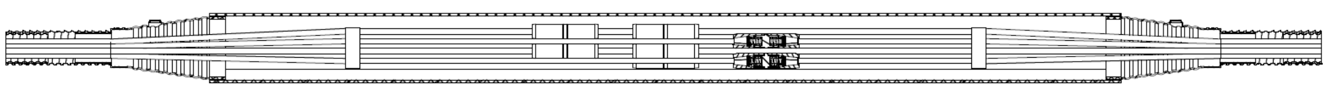
Fixed coupling (FÜK)



movable coupling (BÜK)



**4. Movable single strand coupling (EÜK) BBV L3 – BBV L31:**

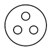
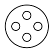
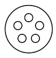
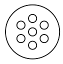
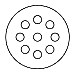




| | |
|---|---|
| 8 BBV-Litzenspannverfahren Typ i | Anhang A1 |
| **Description of the product**<br>General view of anchors and couplings | |

Deutsches Institut für Bautechnik DIBt

# TECHNICAL DETAILS BBV L 3 – BBV L 9
## Steel Grade Y1770 and Y1860
## Anchors (S), (F), (Fe), Coupler (FÜK), (BÜK), (EÜK)

| **Tendon Type** | | **BBV L 3** | **BBV L 4** | **BBV L 5** | **BBV L 7** | **BBV L 9** |
|---|---|---|---|---|---|---|
| **Strand Pattern** | |  |  |  |  |  |
| **Number of strands** | n | 3 | 4 | 5 | 7 | 9 |
| **150mm² :** Nominal Cross Section $A_p$ | mm² | 450 | 600 | 750 | 1050 | 1350 |
| **150mm² :** Nominal mass M | kg/m | 3.52 | 4.69 | 5.86 | 8.20 | 10.55 |
| **150mm² :** $F_{pk}$ ( **$f_{pk}$=1770N/mm²**) | kN | 797 | 1062 | 1328 | 1859 | 2390 |
| **150mm² :** $F_{pk}$ ( **$f_{pk}$=1860N/mm²**) | kN | 837 | 1116 | 1395 | 1953 | 2511 |
| **140mm² :** Nominal Cross Section $A_p$ | mm² | 420 | 560 | 700 | 980 | 1260 |
| **140mm² :** Nominal mass M | kg/m | 3.28 | 4.37 | 5.47 | 7.65 | 9.84 |
| **140mm² :** $F_{pk}$ ( **$f_{pk}$=1770N/mm²**) | kN | 743 | 991 | 1239 | 1735 | 2230 |
| **140mm² :** $F_{pk}$ ( **$f_{pk}$=1860N/mm²**) | kN | 781 | 1042 | 1302 | 1823 | 2344 |
| **Wobble Coefficient k** | °/m | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 |
| at max. Support Distance | m | 1.80 | 1.80 | 1.80 | 1.80 | 1.80 |
| Friction Coefficient $\mu$ | - | 0.21 | 0.20 / 0.19 / 0.19 | 0.20 / 0.19 / 0.20 | 0.20 / 0.20 / 0.19 | 0.20 / 0.20 / 0.19 |
| **Friction Losses** | | | | | | |
| Active Anchor $\Delta P_\mu S$ | % | 1.2 | 1.2 | 1.2 | 1.1 | 1.0 |
| Coupling (BÜK) $\Delta P_\mu ÜK$ | % | 1.2 | 1.2 | 1.2 | 1.1 | 1.2 |
| **Ducts** | | | | | | |
| Inner Diameter | mm | 40*** | 45/50/55*** | 50/55/60 | 55/60/65 | 65/70/75 |
| Outer Diameter | mm | 46 | 51/56/62 | 56/61/67 | 61/67/72 | 72/77/82 |
| **Eccentricity, 150mm²** | mm | 5.4 | 6.3/9.7/12.6 | 7.5/10.7/13.8 | 5.7/9.0/12.1 | 8.4/12.1/15.4 |
| **Eccentricity, 140mm²** | mm | 6.1 | 6.9/10.1/13.1 | 8.8/11.9/15.0 | 7.2/10.4/14.2 | 10.5/13.9/17.1 |
| **Strand Protrusion** ** | cm | 21.5 | 21.5 | 70 | 71 | 82 |
| **Anchors ( S), ( F), ( Fe ), Couplers (FÜK), (BÜK), (EÜK)** | | | | | | |
| **Min. Centre Distance** *, **** | | | | | | |
| $f_{cmj,cube}$ = 30 N/mm² | mm | 215 x 190 | 245 x 220 | 275 x 245 | 325 x 285 | 370 x 325 |
| $f_{cmj,cube}$ = 34 N/mm² | mm | 200 x 175 | 230 x 205 | 260 x 230 | 305 x 270 | 345 x 305 |
| $f_{cmj,cube}$ = 40 N/mm² | mm | 185 x 160 | 215 x 185 | 235 x 210 | 280 x 245 | 320 x 275 |
| $f_{cmj,cube}$ = 45 N/mm² | mm | 170 x 150 | 200 x 175 | 225 x 195 | 260 x 230 | 295 x 265 |

* Distances can be reduced to 85 % of the given values in one direction, if increased correspondingly in the other direction

** Distance from anchor head for placing of jack

*** Oval ducts allowed to use for: BBV L 3 (60 x 21mm)
(inner dimensions) BBV L 4 (80 x 21mm)

Wobble coefficient k to be considered for oval ducts is: k = 0.8 °/m

| Friction coefficient $\mu$ to be considered is: | BBV L 3 | BBV L 4 |
|---|---|---|
| Bending round the stiff axis: | $\mu$ = 0.23 | $\mu$ = 0.26 |
| Bending round the weak axis: | $\mu$ = 0.15 | $\mu$ = 0.15 |

**** Min. edge distance : min. centre distance/2+20 mm

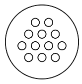
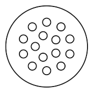
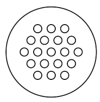
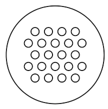
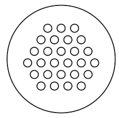
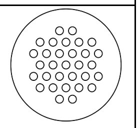


BBV-Internal Bonded Strand Post-tensioning System, type i

**Description of the product**
Technical Details BBV L3 – BBV L9
Steel Grade Y1770 and 1860

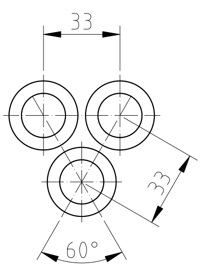
Annex A2
Page 1 of 2

# TECHNICAL DETAILS BBV L 12 – BBV L 31
## Grade Y1770 and Y1860
## Anchors (S), (F), (Fe), Coupler (FÜK), (BÜK), (EÜK)

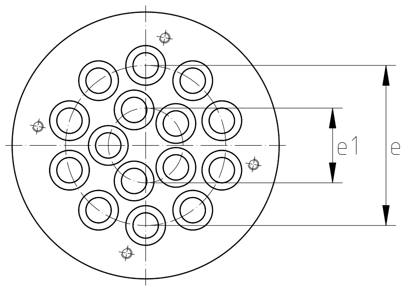
| Tendon type | | BBV L 12 | BBV L 15 | BBV L 19 | BBV L 22 | BBV L 27 | BBV L 31 |
|---|---|---|---|---|---|---|---|
| **Strand Pattern** | |  |  |  |  |  |  |
| **Number of strands** | n | 12 | 15 | 19 | 22 | 27 | 31 |
| **150mm² :** Nominal Cross Section $A_p$ | mm² | 1800 | 2250 | 2850 | 3300 | 4050 | 4650 |
| **150mm² :** Nominal Mass M | kg/m | 14.06 | 17.58 | 22.27 | 25.78 | 31.64 | 36.58 |
| **150mm² :** $F_{pk}$ ( **$f_{pk}$=1770N/mm²)** | kN | 3186 | 3983 | 5045 | 5841 | 7169 | 8231 |
| **150mm² :** $F_{pk}$ ( **$f_{pk}$=1860N/mm²)** | kN | 3348 | 4185 | 5301 | 6138 | 7533 | 8649 |
| **140mm² :** Nominal Cross Section Ap | mm² | 1680 | 2100 | 2660 | 3080 | 3780 | 4340 |
| **140mm² :** Nominal Mass M | kg/m | 13,12 | 16,40 | 20,77 | 24,05 | 29,51 | 34,07 |
| **140mm² :** $F_{pk}$ ( **$f_{pk}$=1770N/mm²)** | | 2974 | 3717 | 4708 | 5452 | 6691 | 7682 |
| **140mm² :** $F_{pk}$ ( **$f_{pk}$=1860N/mm²)** | kN | 3125 | 3906 | 4948 | 5729 | 7031 | 8072 |
| **Wobble Coefficient k** | °/m | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| at max. Support Distance | m | 1.80 | 1.80 | 1.80 | 1.80 | 1.80 | 1.80 |
| Friction Coefficient μ | - | 0.19/0.19/0.19 | 0.20/0.20 / 0.19 | 0.21 / 0.20 | 0.21/0.20 / 0.19 | 0.20 / 0.20 | 0.20 / 0.20 |
| **Friction Losses** | | | | | | | |
| Active Anchor Δ $P_{\mu}S$ | % | 0.8 | 0.8 | 0.8 | 0.6 | 0.8 | 0.8 |
| Coupler (BÜK) Δ $P_{\mu}ÜK$ | % | 1.2 | 1.1 | 1.0 | 1.2 | 1.2 | 1.2 |
| **Ducts** | | | | | | | |
| Inner Diameter | mm | 75/80/90 | 80/85/90 | 90/95 | 95/100/110 | 110/115 | 115/125 |
| Outer Diameter | mm | 82/87/97 | 87/92/97 | 97/102 | 102/107/117 | 117/125 | 122/135 |
| **Eccentricity, 150mm²** | mm | 10.3/13.9/20,2 | 9.0/12.4/15.8 | 9.9/13.1 | 9,7/13.3/20.1 | 14.1/17.3 | 12.1/19.6 |
| **Eccentricity, 140mm²** | mm | 11.7/14.9/21.1 | 10.1/14.0/17.7 | 10.2/15.8 | 11.9/15.9/22.1 | 15.7/19.0 | 14.2/21.5 |
| **Strand Protrusion** ** | cm | 80 | 80 | 110 | 110 | 120 | 120 |
| **Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK), (EÜK)** | | | | | | | |
| **Min. Centre / Edge Distance** * | | | | | | | |
| $f_{cmj,cube}$ = 28 N/mm² | mm | 405/225 | 450/245 | 505/275 | 545/295 | 605/325 | 645/345 |
| $f_{cmj,cube}$ = 34 N/mm² | mm | 370/205 | 415/230 | 465/255 | 500/270 | 550/295 | 595/320 |
| $f_{cmj,cube}$ = 40 N/mm² | mm | 340/190 | 380/210 | 430/235 | 460/250 | 510/275 | 545/295 |
| $f_{cmj,cube}$ = 45 N/mm² | mm | 325/185 | 360/200 | 405/225 | 435/240 | 485/265 | 520/280 |

* and ** see Annex A2 page 1

Strand Pattern BBV L 12; 19; 22; 27; 31
Conical borings are in line,
lines result in a grid




BBV L 3; 4; 5; 7; 9; 15
All conical borings are aligned on one or two circles
e1 and e 2). See Annex A4




Example: BBV L15

| | |
|---|---|
| 8 BBV-Internal Bonded Strand Post-tensioning System, type i | Annex A2<br>Page 2 of 2 |
| **Description of the product**<br>Technical Details BBV L12 – BBV L31<br>Steel Grade Y1770 and Y1860 | |

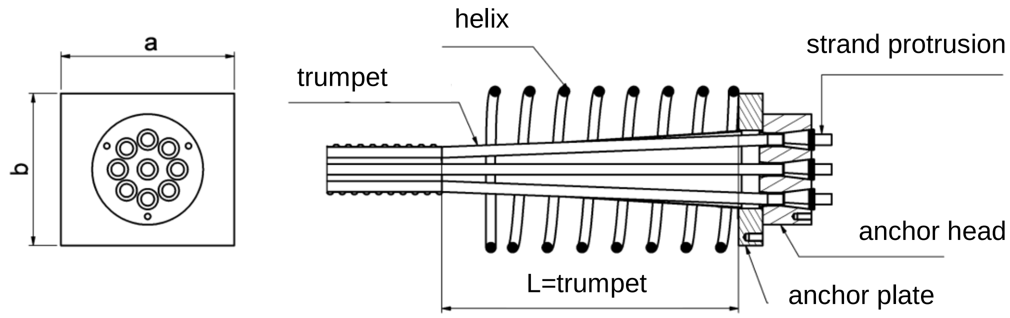
# Description of Wedge Anchorages

## Active Anchors (S)
## Passive Anchors (F), (Fe)

Active anchors (S) with bearing plate and anchor head
Accessible passive anchor (F) with bearing plate and anchor head

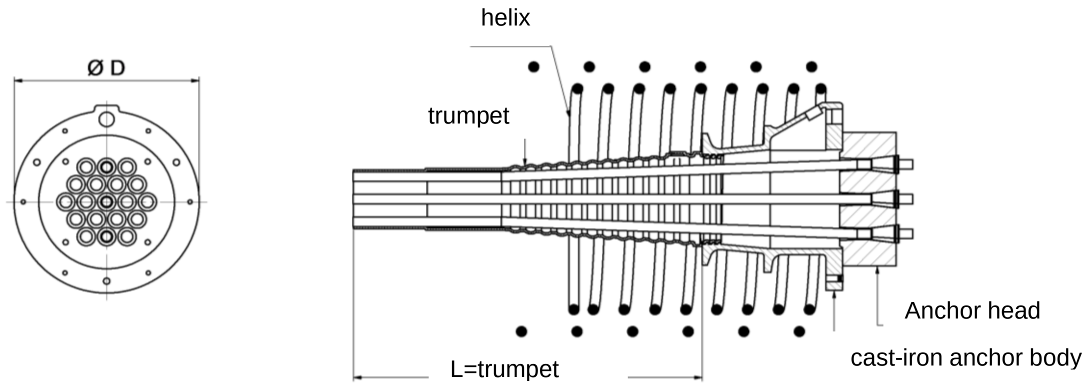
For embedded Passive Anchor (Fe) the anchor head is installed to the bearing plate, the wedges are sealed and secured in their cones by a retainer plate. The area around the wedges of embedded passive anchors is to be filled with corrosion protection mass and filled sealing caps are to be applied.

**L 3 – L 9**



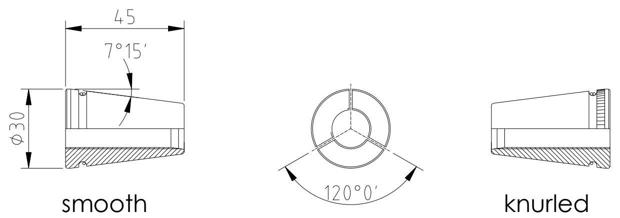

Tendon Type BBV L 3 – L9: active anchor and passive anchor with rectangular bearing plate *a x b* and anchor head.

**L 12 – L 31**




Tendon Type BBV L 12 – L 31: active anchor with cast-iron anchor body of diameter *d* and anchor head.

Wedges Type 30




Optional knurled wedges for pre-wedged passive anchors

Wedges for 150 mm² strands are marked with "0.62" on the front face.

| | |
|---|---|
| 8 BBV-Internal Bonded Strand Post-tensioning System, type i | Annex A3 |
| **Description of the product**<br>Sketch of Wedge Anchorages | |

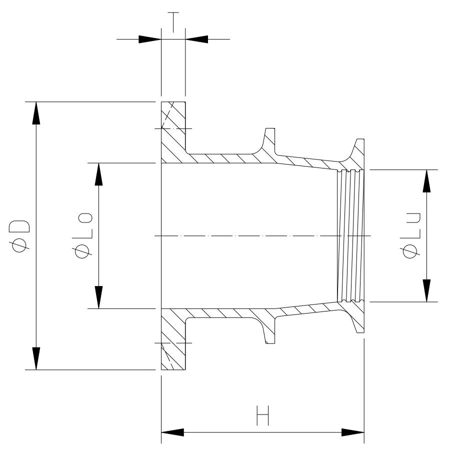
# Dimensions of anchor components

| Tendon Type | | L3 | L4 | L5 | L7 | L9 | L12 | L15 | L19 | L22 | L27 | L31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bearing Plate** | | | | | | | | | | | | |
| Side length a | mm | 160 | 180 | 195 | 215 | 250 | | | | | | |
| Side length b | mm | 140 | 160 | 170 | 190 | 220 | | | | | | |
| Thickness | mm | 25 | 25 | 30 | 35 | 35 | | | | | | |
| Hole diameter | mm | 72 | 81 | 83 | 93 | 113 | | | | | | |
| **Cast-iron Anchor** | | | | | | | | | | | | |
| Diameter D | mm | | | | | | 240 | 270 | 300 | 327 | 360 | 382 |
| Height H | mm | | | | | | 182 | 203 | 227 | 248 | 272 | 294 |
| Thickness $1^{st}$ plane T | mm | | | | | | 22 | 23 | 27 | 28 | 32 | 34 |
| Hole - dia. top Lo | mm | | | | | | 131 | 150 | 163 | 183 | 199 | 208 |
| Hole - dia. bottom Lu | mm | | | | | | 123 | 139 | 148 | 165 | 176 | 182 |
| **Anchor Head** | | | | | | | | | | | | |
| Diameter D | mm | 104 | 104 | 115 | 132 | 160 | 180 | 200 | 220 | 245 | 265 | 280 |
| Thickness T | mm | 65 | 65 | 70 | 75 | 75 | 80 | 82 | 92 | 105 | 120 | 125 |
| centering flange A | mm | 68 | 77 | 81 | 89 | 109 | 129 | 146 | 161 | 179 | 197 | 204 |
| Diameter (type 2) D | mm | 104 | 114 | 120 | 133 | 160 | 180 | 194** | 220 | 245 | 265 | 280 |
| Thickness (type 2) T | mm | 45 | 50 | 50 | 50 | 50 | 61 | 60 | 77 | 77 | 91 | 87 |
| centering flange (type 2) A | mm | 70 | 79 | 81 | 91 | 111 | 129 | 148 | 161 | 181 | 197 | 206 |
| Diameter circle e1 | mm | 45 | 54 | 56 | 66 | 86 | grid 1) | 56 | grid 1) | grid 1) | grid 1) | grid 1) |
| Diameter circle e2 | mm | | | | | | | 120 | | | | |
| **Trumpet** | | | | | | | | | | | | |
| Length (see annex 3) L | mm | ≥430 | ≥414 | ≥414 | ≥455 | ≥615 | ≥420 | ≥551 | ≥572 | ≥685 | ≥732 3) | ≥575 |

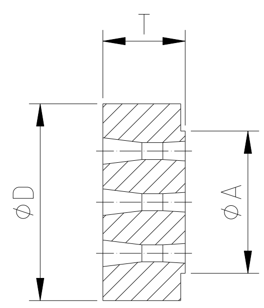
1) Grid according to Annex A2 page 2
2) optional 200mm possible
3) optional 712mm (only type 2)

Bearing Plate see Annex A3

**Cast-iron Anchor Body**




**Anchor Head**





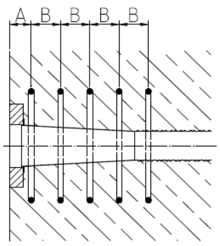

| BBV-Internal Bonded Strand Post-tensioning System, type i | Annex A4 |
|---|---|
| **Description of the product**<br>Dimensions of Anchor Components | |

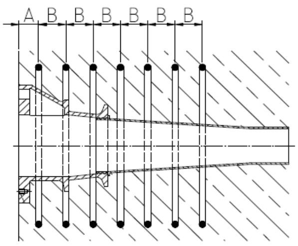
Deutsches Institut für Bautechnik DIBt

## HELIX AND ADDITIONAL REINFORCEMENT (STIRRUPS)

| Tendon Type | | L3 | L4 | L5 | L7 | L9 | L12 | L15 | L19 | L22 | L27 | L31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Helix** | | | | | | | | | | | | |
| **Bar Diameter** | | | | | | | | | | | | |
| $f_{cmj,cube}$=28/30 N/mm² | mm | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 16 | 16 | 16 | 16 |
| $f_{cmj,cube}$ =34 N/mm² | mm | 14 | 14 | 14 | 14 | 14 | 14 | 16 | 16 | 16 | 16 | 16 |
| $f_{cmj,cube}$ =40 N/mm² | mm | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 16 | 16 | 16 | 16 |
| $f_{cmj,cube}$ =45 N/mm² | mm | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 16 | 16 | 16 | 16 |
| **Outer Diameter** | | | | | | | | | | | | |
| $f_{cmj,cube}$=28/30 N/mm² | mm | 140 | 160 | 180 | 200 | 240 | 300 | 345 | 390 | 430 | 490 | 520 |
| $f_{cmj,cube}$ =34 N/mm² | mm | 135 | 150 | 170 | 190 | 230 | 300 | 340 | 380 | 410 | 450 | 480 |
| $f_{cmj,cube}$ =40 N/mm² | mm | 130 | 135 | 160 | 190 | 225 | 285 | 320 | 360 | 380 | 430 | 460 |
| $f_{cmj,cube}$ =45 N/mm² | mm | 120 | 120 | 140 | 180 | 220 | 270 | 315 | 340 | 365 | 410 | 430 |
| **Min. Length** | | | | | | | | | | | | |
| $f_{cmj,cube}$=28/30 N/mm² | mm | 200 | 230 | 250 | 300 | 350 | 350 | 400 | 450 | 450 | 550 | 550 |
| $f_{cmj,cube}$ =34 N/mm² | mm | 180 | 210 | 240 | 270 | 310 | 300 | 350 | 400 | 450 | 470 | 470 |
| $f_{cmj,cube}$ =40 N/mm² | mm | 170 | 200 | 220 | 250 | 290 | 300 | 300 | 350 | 350 | 450 | 450 |
| $f_{cmj,cube}$ =45 N/mm² | mm | 160 | 180 | 200 | 250 | 275 | 250 | 250 | 300 | 300 | 350 | 350 |
| **Pitch** | | | | | | | | | | | | |
| $f_{cmj,cube}$=28/30 N/mm² | mm | 40 | 40 | 40 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| $f_{cmj,cube}$ =34 N/mm² | mm | 40 | 40 | 40 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| $f_{cmj,cube}$ =40 N/mm² | mm | 40 | 40 | 40 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| $f_{cmj,cube}$ =45 N/mm² | mm | 40 | 40 | 40 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| **Helix Turns** | | | | | | | | | | | | |
| $f_{cmj,cube}$=28/30 N/mm² | n | 6 | 7 | 7.5 | 7 | 8 | 8 | 9 | 10 | 10 | 12 | 12 |
| $f_{cmj,cube}$ =34 N/mm² | n | 5.5 | 6.5 | 7 | 6.5 | 7 | 7 | 8 | 9 | 10 | 10.5 | 10.5 |
| $f_{cmj,cube}$ =40 N/mm² | n | 5.5 | 6 | 6.5 | 6 | 7 | 7 | 7 | 8 | 8 | 10 | 10 |
| $f_{cmj,cube}$ =45 N/mm² | n | 5.0 | 5.5 | 7 | 6 | 6.5 | 6 | 6 | 7 | 7 | 8 | 8 |
| **Stirrup reinforcement** | | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. | Nos x dia. |
| $f_{cmj,cube}$=28/30 N/mm² | mm | 4x Ø10 | 4x Ø12 | 4x Ø14 | 4x Ø14 | 5x Ø14 | 6x Ø12 | 5x Ø14 | 6x Ø16 | 7x Ø16 | 11x Ø16 | 12x Ø16 |
| $f_{cmj,cube}$ =34 N/mm² | mm | 4x Ø10 | 5x Ø10 | 5x Ø12 | 5x Ø12 | 5x Ø14 | 6x Ø14 | 8x Ø14 | 7x Ø16 | 8x Ø16 | 9x Ø20 | 10x Ø20 |
| $f_{cmj,cube}$ =40 N/mm² | mm | 4x Ø8 | 4x Ø12 | 5x Ø12 | 5x Ø12 | 5x Ø14 | 5x Ø16 | 6x Ø16 | 7x Ø16 | 6x Ø20 | 8x Ø20 | 10x Ø20 |
| $f_{cmj,cube}$ =45 N/mm² | mm | 4x Ø8 | 4x Ø10 | 4x Ø12 | 4x Ø12 | 6x Ø12 | 5x Ø16 | 6x Ø16 | 8x Ø16 | 8x Ø16 | 8x Ø20 | 9x Ø20 |
| **Position behind Bearing plate or** | | | | | | | | | | | | |
| **Cast-iron anchor body** | | A/B | A/B | A/B | A/B | A/B | A/B | A/B | A/B | A/B | A/B | A/B |
| $f_{cmj,cube}$=28/30 N/mm² | mm | 45 / 60 | 45 / 70 | 50 / 75 | 55 / 95 | 55 / 80 | 50 / 70 | 50 / 95 | 50 / 90 | 50 / 80 | 60 / 60 | 60 / 55 |
| $f_{cmj,cube}$ =34 N/mm² | mm | 45 / 55 | 45 / 50 | 50 / 55 | 55 / 65 | 55 / 75 | 50 / 65 | 50 / 55 | 50 / 70 | 50 / 65 | 60 / 65 | 60 / 55 |
| $f_{cmj,cube}$ =40 N/mm² | mm | 45 / 55 | 45 / 60 | 50 / 50 | 55 / 60 | 55 / 70 | 50 / 70 | 50 / 65 | 50 / 60 | 50 / 75 | 60 / 65 | 60 / 55 |
| $f_{cmj,cube}$ =45 N/mm² | mm | 45 / 50 | 45 / 55 | 50 / 60 | 55 / 75 | 55 / 50 | 50 / 65 | 50 / 60 | 50 / 55 | 50 / 50 | 60 / 60 | 60 / 55 |

L3 – L9




L12 – L31

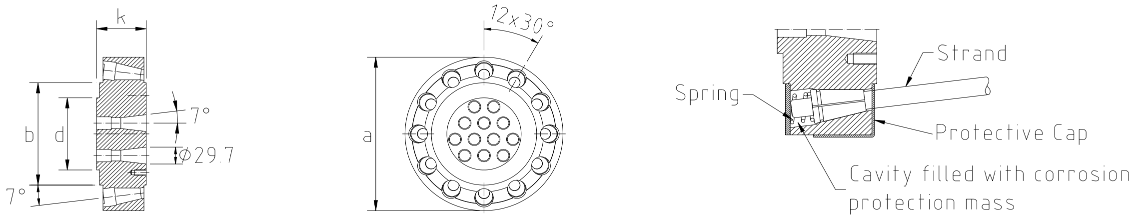
8 BBV-Internal Bonded Strand Post-tensioning System, type i

**Description of the product**
Helix and Additional Reinforcement

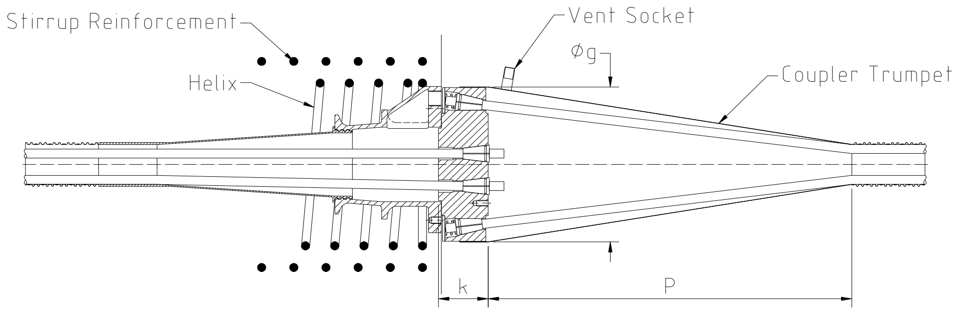
Annex A5

Deutsches Institut für Bautechnik DIBt

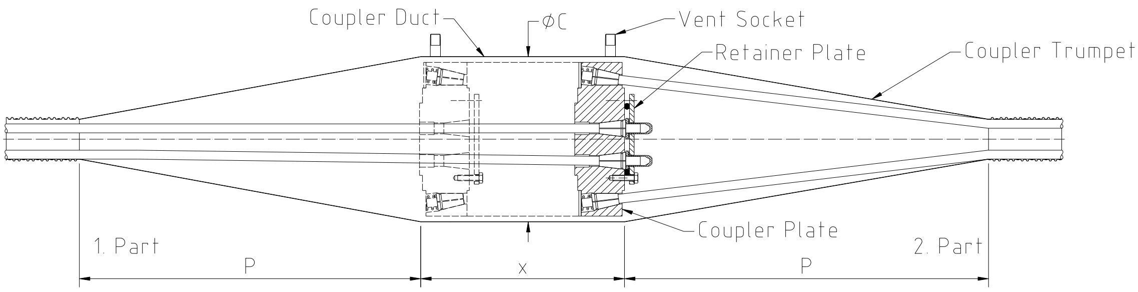
## COUPLER (ÜK)




## Fixed Coupler (FÜK)




## Movable Coupler (BÜK)




Min. length of coupler duct: for one-end stressing x = k+ 1,15 Δl + 45mm
for both ends stressing x = k+ 1,15 Δl + 90 mm
(Δl = elongation at coupling)

| **Tendon type** | | | **L3** | **L4** | **L5** | **L7** | **L9** | **L12** | **L15** | **L19** | **L22** | **L27** | **L31** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **<u>Coupler Plate</u>** | | | | | | | | | | | | | |
| Diameter | Øa | mm | 194 | 194 | 205 | 222 | 245 | 270 | 290 | 310 | 335 | 380 | 405 |
| Thickness | k | mm | 85 | 85 | 85 | 85 | 85 | 85 | 90 | 98 | 110 | 120 | 130 |
| Diameter bearing area | b | mm | 104 | 104 | 115 | 132 | 160 | 180 | 200 | 220 | 245 | 265 | 280 |
| **<u>Coupler Trumpet</u>** | | | | | | | | | | | | | |
| Length* | P | mm | ≥440 | ≥420 | ≥440 | ≥490 | ≥545 | ≥605 | ≥640 | ≥710 | ≥765 | ≥875 | ≥920 |
| Diameter fixed coupler | g | mm | 197 | 197 | 208 | 225 | 248 | 273 | 293 | 313 | 338 | 383 | 408 |
| Diameter movable coupler | C | mm | 214 | 214 | 225 | 242 | 265 | 290 | 310 | 330 | 355 | 400 | 425 |

* The lengths and diameters of the coupler duct shall be designed so that a strand angle of 7° is ensured. Anchor plate, trumpet, helix and reinforcement see Annexes A4 and A5

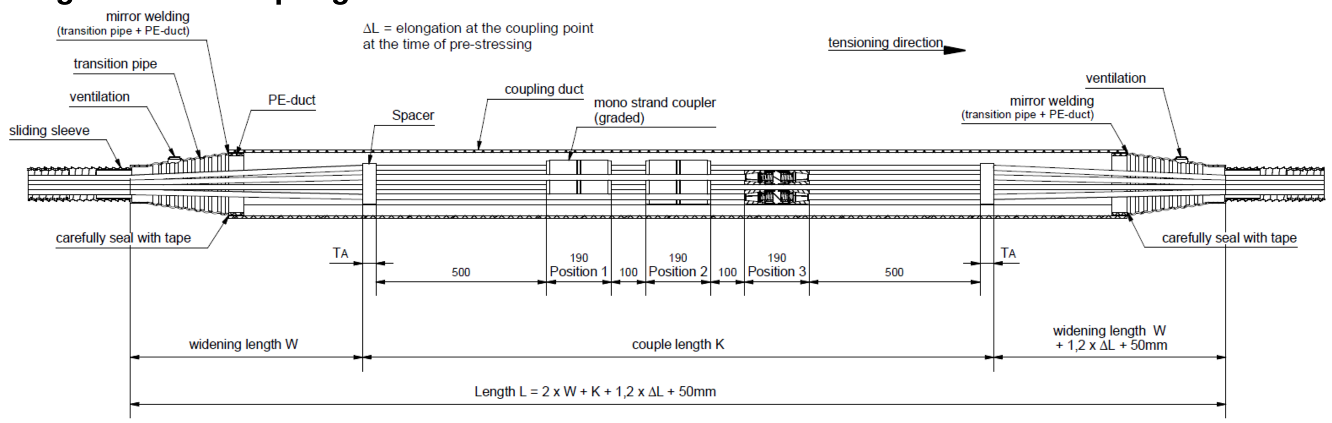


8BBV-Internal Bonded Strand Post-tensioning System, type i

**Description of the product**
Coupling (ÜK)

Annex A6

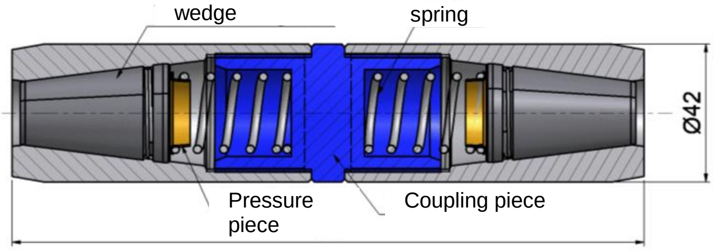
## Single strand coupling EÜK




### Dimensions of spare parts

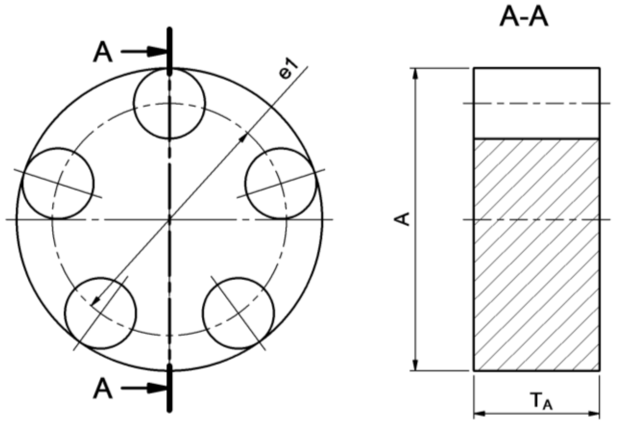
| Tendon type | Einh. | L3 | L4 | L5 | L7 | L9 | L12 | L15 | L19 | L22 | L27 | L31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spacer** | | | | | | | | | | | | |
| Outside diameter A | mm | 62 | 71 | 73 | 83 | 103 | 118 | 127 | 139 | 158 | 173 | 177 |
| Thickness $T_A$ | mm | 30 | 30 | 30 | 50 | 50 | 40 | 50 | 70 | 70 | 70 | 70 |
| Hole pattern (outside) e2 | mm | 45 | 54 | 56 | 66 | 86 | *Grid | 120 | *Grid | *Grid | *Grid | *Grid |
| Hole pattern (inside) e1 | mm | - | - | - | - | - | - | 56 | - | - | - | - |
| **Coupling duct** | | | | | | | | | | | | |
| Coupling length K | mm | 1830 | 1540 | 1830 | 1870 | 1870 | 1850 | 1870 | 1910 | 1910 | 1910 | 1910 |
| Inside diameter $d_i$ | mm | 96.8 | 110.2 | 110.2 | 147.6 | 147.6 | 184.6 | 184.6 | 184.6 | 230.8 | 230.8 | 230.8 |
| Outside diameter $d_a$ | mm | 110 | 125 | 125 | 160 | 160 | 200 | 200 | 200 | 250 | 250 | 250 |
| **Trumpet + PE-Connection tube** | | | | | | | | | | | | |
| Transition length W | mm | 450 | 520 | 480 | 550 | 680 | 680 | 1030 | 1010 | 1140 | 1130 | 1300 |
| Outside diameter $d_a$ | mm | 90 | 110 | 110 | 140 | 140 | 180 | 180 | 180 | 225 | 225 | 225 |
| Inside diameter $d_i$ | mm | 79.2 | 96.8 | 96.8 | 129.2 | 129.2 | 166.2 | 166.2 | 166.2 | 207.8 | 207.8 | 207.8 |
| **Steel strip sheats (EN 523)** | | | | | | | | | | | | |
| Inside diameter $d_i$ | mm | 55 | 55 | 60 | 65 | 75 | 80 | 90 | 95 | 110 | 115 | 125 |
| Outside diameter $d_a$ | mm | 61 | 61 | 67 | 72 | 82 | 87 | 97 | 102 | 117 | 125 | 135 |
| **Slide sleeve** | | | | | | | | | | | | |
| Inside diameter $d_i$ | mm | 70 | 70 | 75 | 75 | 90 | 90 | 110 | 110 | 130 | 130 | 130 |
| Outside diameter $d_a$ | mm | 77 | 77 | 82 | 82 | 97 | 97 | 117 | 117 | 139 | 139 | 158 |

## Dimension of single strand coupling



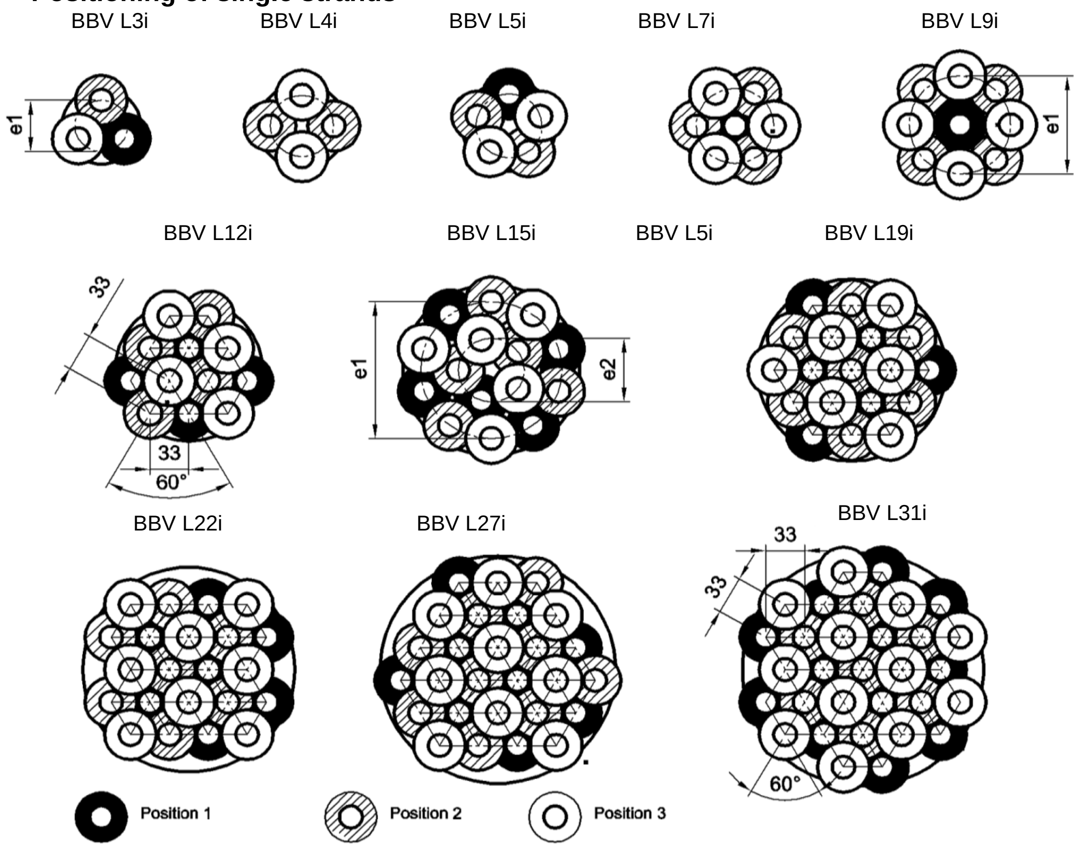

Note:
The outer dimensions are identical for both strand sizes. When installing the wedges, pay attention to the inscription. Wedge for the 150 mm² strands (0.62 ") have a print 0.62 at the top

## Spacer (for example size L5)




Detailed information about pattern of single strands see positioning of single strands

## Positioning of single strands



# Dimensions and Properties of 7-Wire Strands

**(After Table 4 of prEN 10138-3: 2009)**

| Designation | Symbol | Unit | Value | |
|---|---|---|---|---|
| Tensile strength | $R_m/F_{pk}$ | MPa | 1770 or 1860 | |
| **Strand** | | | | |
| Nominal diameter | D | mm | 15.3 | 15.7 |
| Nominal cross section | $A_p$ | mm² | 140 | 150 |
| Nominal mass | M | g/m | 1093 | 1172 |
| Surface configuration | - | - | plain | |
| Strength at 0,1% | $f_{p0,1k}$ | MPa | 1560 or 1640* | |
| Strength at 0,2% | $f_{p0,2}$ | MPa | 1570 or 1660 | |
| Modulus of elasticity | E | MPa | ≈ 195,000 | |
| **Individual wires** | | | | |
| External wire diameter | d | mm | 5.0 ± 0.04 | 5.2 ± 0.04 |
| Core wire diameter | d' | mm | 1.02 to 1.04 d | 1.02 to 1.04 d |

* The indicated values are maximum values. The actual values are at the place of use applicable standards and regulations.

As long as prEN 10138-3: 2009 has not been introduced, 7-wire prestressing steel strands according to the national regulations and the characteristic values in the table above should be used.

# Technical boundary conditions

## 1 Intended use

The Post-Tensioning System is assumed to be used for internal bonded tendons for normal-weight concrete structures or elements.

No optional use category is intended. The structural members used to be designed in accordance with national regulations.

## 2 Methods of verification

### 2.1 General

The structural members prestressed by means of the BBV-Internal Bonded Strand Post-Tensioning System type I have to be designed in accordance with national regulations.

### 2.2 Tendons

Prestressing and overtensioning forces are specified in the respective national provisions.

The maximum force $P_{max}$ applied to a tendon shall not exceed the force $P_{max} = 0.9\ A_p\ f_{p0,1k}$ (see Table B 1 (140 mm²) or Table B 2 (150 mm²) for $f_{p0,1k}$ = 1560 N/mm² or 1640 N/mm²).

The value of the prestressing initial prestress force $P_{m0}(x)$ applied to the concrete after tensioning and anchoring shall not exceed the force $P_{m0}(x) = 0.85\ A_p\ f_{p0,1k}$ (see Table B 1 (140 mm²) or Table B 2 (150 mm²) for $f_{p0,1k}$ = 1560 N/mm² or 1640 N/mm²).

Table B 1: Maximal prestressing forces[1] for tendons with $A_p$ = 140 mm²

| Tendon Designation | Number of strands | Cross section $A_p$ [mm²] | Prestressing force Y1770 S7 $f_{p0,1k}$ = 1560 N/mm² | | Prestressing force Y1860 S7 $f_{p0,1k}$ = 1640 N/mm² | |
|---|---|---|---|---|---|---|
| | | | $P_{m0}(x)$ [kN] | $P_{max}$[2] [kN] | $P_{m0}(x)$ [kN] | $P_{max}$[2] [kN] |
| BBV L3 | 3 | 420 | 557 | 590 | 585 | 620 |
| BBV L4 | 4 | 560 | 743 | 786 | 781 | 827 |
| BBV L5 | 5 | 700 | 928 | 983 | 976 | 1033 |
| BBV L7 | 7 | 980 | 1299 | 1376 | 1366 | 1446 |
| BBV L9 | 9 | 1260 | 1671 | 1769 | 1756 | 1860 |
| BBV L12 | 12 | 1680 | 2228 | 2359 | 2342 | 2480 |
| BBV L15 | 15 | 2100 | 2785 | 2948 | 2927 | 3100 |
| BBV L19 | 19 | 2660 | 3527 | 3735 | 3708 | 3926 |
| BBV L22 | 22 | 3080 | 4084 | 4324 | 4294 | 4546 |
| BBV L27 | 27 | 3780 | 5012 | 5307 | 5269 | 5579 |
| BBV L31 | 31 | 4340 | 5755 | 6093 | 6050 | 6406 |

[1] The indicated values are maximum values. The actual values are at the place of use applicable standards and regulations. Compliance with the stabilisation and crack width criteria in the load transfer test was verified to a load level of 0,80*Fpk.

[2] Over-tensioning is allowed according to EN 1992-1-1, if the force of the clamping press can be measured with an accuracy of ± 5% of the final value of the prestressing force and this is allowed according to the national requirements

Table B 2: Maximal prestressing forces[1] for tendons with $A_p$ = 150 mm²

| Tendon Designation | Number of strands | Cross section $A_p$ [mm²] | Prestressing force Y1770 S7 $f_{p0,1k}$ = 1560 N/mm² | | Prestressing force Y1860 S7 $f_{p0,1k}$ = 1640 N/mm² | |
|---|---|---|---|---|---|---|
| | | | $P_{m0}(x)$ [kN] | $P_{max}$[2] [kN] | $P_{m0}(x)$ [kN] | $P_{max}$[2] [kN] |
| BBV L3 | 3 | 450 | 597 | 632 | 627 | 664 |
| BBV L4 | 4 | 600 | 796 | 842 | 836 | 886 |
| BBV L5 | 5 | 750 | 995 | 1053 | 1046 | 1107 |
| BBV L7 | 7 | 1050 | 1392 | 1474 | 1464 | 1550 |
| BBV L9 | 9 | 1350 | 1790 | 1895 | 1882 | 1993 |
| BBV L12 | 12 | 1800 | 2387 | 2527 | 2509 | 2657 |
| BBV L15 | 15 | 2250 | 2984 | 3159 | 3137 | 3321 |
| BBV L19 | 19 | 2850 | 3779 | 4001 | 3973 | 4207 |
| BBV L22 | 22 | 3300 | 4376 | 4633 | 4600 | 4871 |
| BBV L27 | 27 | 4050 | 5370 | 5686 | 5646 | 5978 |
| BBV L31 | 31 | 4650 | 6166 | 6529 | 6482 | 6863 |

The number of strands in a tendon may be reduced by leaving out strands lying radial-symmetrically in the anchor head (not more than four strands). The assessment for tendons with anchors (basic types) completely filled also applies to tendons with anchor heads only partly filled under following requirements. Into the free drills in the anchor head the short pieces of strands with wedges have to be pressed to prevent slipping out. The prestressing forces from Tables B1 and B2 are reduced per strand left out as shown in Table B 3.

Table B 3: Reduction of the prestressing force[1] when leaving out a strand

| $A_p$ | Y1770 S7 | | Y1860 S7 | |
|---|---|---|---|---|
| | $\Delta P_{m0}(x)$ [kN] | $\Delta P_{max}$ [kN] | $\Delta P_{m0}(x)$ [kN] | $\Delta P_{max}$ [kN] |
| 140 mm² | 186 | 197 | 195 | 207 |
| 150 mm² | 199 | 211 | 209 | 221 |

Further characteristic values of the tendons (mass per meter, ultimate stressing force $F_{pk}$) see Annex A2.



[1, 2] see previous page

## 2.3 Radius of curvature of the tendons in the structure

According to EAD 160004-00-0301 clause 2.2.5 the following radii of curvature are indicated as performance (at the place of use it must be checked, if national regulations are fulfilled):

$$R_{min} = \frac{2 \cdot F_{pm0} \cdot d_{strand}}{p_{R,max} \cdot d_{duct,i}} \geq 2{,}50 \text{ m} \qquad (1)$$

with:

- $R_{min}$ minimum allowable radius of curvature [m]
- $F_{pm0}$ initial prestressing force of the tendon in [kN]
- $d_{strand}$ diameter of strand in [mm]
- $p_{R,max}$ recommended maximum allowable pressure under critical strand in the absence of national regulations [kN/m] (= 130, 150 oder 230 kN/m)
- $d_{duct,i}$ internal diameter of circular duct [mm]

The minimum allowable radius of curvature must be specified with an accuracy of 0,1m (round up every time).

## 2.4 Concrete strength

The performance was determined with concrete according EN 206-1:2001, EN 206-1/A1:2004 and EN 206-1/A2:2005. At the time of transmission of the full prestressing force the mean concrete strength of the normal weight concrete in the anchor zone shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Table B 4. The mean concrete strength shall be verified by means of at least three specimens (cylinder or cube with the edge length of 150 mm), which shall to be stored under the same conditions as the concrete member, with the individual values of specimen not differ more than 5 %.

Table B 4: Necessary mean concrete strength fcmj of the specimens at time of prestressing

| $f_{cmj,cube}$ [N/mm²] | $f_{cmj,cyl}$ [N/mm²] |
|---|---|
| 28*)/30**) | 23*)/25**) |
| 34 | 28 |
| 40 | 32 |
| 45 | 35 |

*) 12 to 31 strands

**) 3 to 9 strands

For partial prestressing with 30 % of the full prestressing the minimum value of the concrete compressive strength to be available of 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values can be interpolated lineally.

## 2.5 Centre and edge distances of the tendon anchorages, concrete cover

The minimum of centre and edge distances of the tendon anchorages must not be smaller than the values given in the Annexe A2 depending on the minimum concrete strength. In case of anchorages BBV L3 to BBV L9 the large side of the bearing plate (side length a according to Annex A4) shall be installed parallel to the large concrete side (the maximum spacing of concrete axis).

The minimum values of the centre or edge distances of the anchors given in the Annexes may be reduced in one direction up to 15 %, however, not to a smaller value than the external dimensions of the additional reinforcement (stirrups or the outer diameter of the helix, Annex A5). In this case the Minimum of centre and the edge distances in the other direction shall be increased for keeping the same concrete area in the anchor zone.

All centre and edge distances have only been specified with a view to load transfer to the structure; therefore, the concrete cover given in national standards and provisions shall be taken into account additionally.

Under no circumstances should the concrete cover be less than 20 mm or not less than the concrete cover of the reinforcement installed in the same section. The concrete cover of the anchorage must be at least 20 mm. The locally applicable standards and regulations regarding concrete cover must be taken into account.

### 2.6 Reinforcement in the anchorage zone

The anchorages (including reinforcement) for the transfer of the prestressing forces to the structural concrete are verified by means of tests.

The resistance to the forces occurring in the structural concrete in the anchorage zone outside (behind) the helix shall be verified. An adequate transverse reinforcement shall be provided here in particular for the occurring transverse tension forces (not shown in the attached drawings).

Basis for this assessment is the reinforcement of steel B 500 B according DIN 488-1. It can be assumed that the use of equivalent or better reinforcing steels in accordance with the rules at the place of use does not have a lasting effect on the function of the anchoring.

The dimensions of the additional reinforcement (stirrups) shall follow the values given in the Annexes. This reinforcement must not be taken into account as part of the statically required reinforcement. However, existing reinforcement in a corresponding position more than the statically required reinforcement may be taken into account for the additional reinforcement. The given reinforcement consists of closed stirrups (stirrups closed by means of bends or hooks or an equivalent method). The stirrup locks (bends or hooks) shall be placed staggered.

In the anchorage zone vertically led gaps for concreting shall be provided for concreting properly. If in exceptional case[3] - due to an increased amount of reinforcement - the helix or the concrete cannot be properly placed, the helix can be replaced by different equivalent reinforcement.

### 2.7 Slip at the anchorages

The slip at the anchorages shall be taken into account in the static calculation and the determination of the tendon elongation.

### 2.8 Resistance to fatigue of the anchorages and couplers

With the fatigue tests carried out in accordance with EAD 160004-00-0301 the stress range of 80 N/mm² of the strands at the maximum stress of 0.65 $f_{pk}$ at $2\times10^6$ load cycles was demonstrated.

### 2.9 Increased tension losses at couplers

For verification of crack control and stress ranges increased tension losses of prestressing forces shall be taken into account at the couplers due to creep and shrinkage of the concrete. The losses in prestressing force of the tendons, determined without the influence of the couplers, shall be multiplied in the coupling zone by the factor 1.5. No increase need be taken into account for the movable couplers.

### 2.10 Couplers

The couplers shall only be used if the calculated stressing force at the coupler is at least 0.7 $P_{m0}(x)$. Couplers shall be positioned in straight tendon sections with straight length of at least 1.0 m to each side. For movable couplers the position and length of the coupler duct shall ensure that a movement is possible over the length of at least 1.15 $\Delta\ell$ + 45 mm, where $\Delta\ell$ is the maximum elongation length at the time of prestressing and at the place of coupling.

For movable couplers BÜK it shall be ensured that the final position of the coupler plate after prestressing corresponds to that shown in the lower figure of Annex A6. The single-strand coupling shall be ensured that the final position of parts corresponds to figure of annex A7.

The prestressing force in the 2nd construction stage of fixed couplers shall be lower than in the 1st construction stage.

[3] This requires the approval for individual case according to the national regulations and administrative provisions.

## 3 Installation

### 3.1 General

The assembly of the tendons can be done on site or in the factory (prefabricated tendons). Assembly and installation of the tendons shall only be performed by qualified post-tensioning specialist companies which have the required technical skills and experiences with this BBV-Post-tensioning System.

The company's site manager shall have a certificate of the manufacturer certifying that he is instructed by the manufacturer and has the required knowledge and experience with this post-tensioning system. Standards and regulations valid on site shall be considered.

The manufacturer is responsible to inform anyone concerned about the use of this BBV-Post-tensioning System. Additional information shall be distributed from manufacturer.

The tendons and the components shall be handled carefully.

### 3.2 Welding

Welding at the anchorages is only possible at the following points:

a) Welding of the end of the helix to a closed ring.

b) For ensuring of the central position the helix may be attached to the bearing plate by tack-welding.

If, after installing the prestressing steel strands in the ducts, welding work is carried out elsewhere, the stated performance is at risk.

### 3.3 Installation of the tendon

The central position of the helix or stirrups shall be ensured by tack-welding to the bearing plate or the cast-iron anchor or by means of mounting brackets. The bearing plate or cast-iron anchor and the anchor head shall be in direction vertical to the axis of the tendon.

The tendon shall be placed straightforward the first meter at the anchorage.

PE pipes shall be fixed in the right position and the length of the trumpets shall ensure the right deflection angle of the strands.

The connection between trumpet and duct and all joints shall be sealed carefully by tape in order to prevent the penetrating of concrete. Diameter tolerances must be balanced so that the cladding coaxial run into each other and no kinks can occur.

### 3.4 Coupler

The outer strands shall be colour-marked for showing the necessary depth of putting in.

### 3.5 Wedging force, slip at anchorages, wedge securing and corrosion protection mass

If the calculated prestressing force is less than 0.7 $P_{m0}(x)$ or if knurled wedges type 30 are used, the wedges of fixed anchorages shall be pre-wedged with 1.1 $P_{m0}(x)$.

The knurled wedges of movable couplers in the parallel drills shall be pre-wedged with 1.1 $P_{m0}(x)$ (see Annex B1, section 2.2).

Without pre-wedging the slip within the anchorage to be taken into account for the determination of the elongations is 4 mm at the fixed anchorages and 8 mm at the movable couplers. In the case of hydraulic pre-wedging with 1.1 $P_{m0}(x)$ no slip shall be taken into account for the determination of the elongations, except for couplers (4 mm).

The wedges of all anchorages (fixed anchors and couplers) which are no more accessible during tensioning shall be secured by means of securing plates and bolts. The wedging area of fixed anchors to be cast in concrete and of inner part of movable couplers shall be filled with corrosion protection mass (Denso-Jet, Vaseline FC 284 or Nontribos MP-2) and provided with a sealing cap filled with corrosion protection mass.The anticorrosion compound must comply with EAD 160027-00-0301.

Compositions of the different types of these masses have been deposited with the Deutsches Institut für Bautechnik by the manufacturer. In the case of couplers the voids of the outer coupler tendon shall be filled with corrosion protection mass.

The wedges of the stressing anchors shall be wedged after tensioning with at least 0.1 $P_{m0}(x)$. In this case the slip is 3 mm. If the wedges are not compressed, the slip shall be about 6 mm (a reset plate shall be used to fix the wedges).

### 3.6 Tensioning and tensioning protocol

#### 3.6.1 Tensioning

Before tensioning the minimum mean concrete strength shall comply with the recommended values.

It is admissible to restress the tendons by releasing and re-using the wedges. After restressing and anchoring, wedge marks on the strands resulting from first stressing shall be moved to the outside by at least 15 mm.

All strands of a tendon shall be stressed simultaneously. This can be done by centrally controlled individual jacks or by a bundle jack.

#### 3.6.2 tensioning protocoll

All actions during the clamping process are to be recorded for each tendon. As a rule, the required preload force must be achieved. The measured tension travel must be compared with the calculated value.
If, during pre-stressing, there is a difference between the measured and calculated tension travel or the preload force of more than 5% for the sum of all tendons or 10% for a single tendon, the tensioning engineer shall be informed and the causes identified. National regulations must be observed.

### 3.7 Grouting

The grouting procedure is to be carried out in accordance with EN 446. As a rule, the tendons should not be rinsed with water. The insertion speed must be in the range between 3 m/min and 12 m/min.
The length of a press-in section must not exceed 120 m. If this tendon length is exceeded, additional injection openings are provided.
Vents are provided at both ends of the cladding and points where air or water may accumulate. In the case of cladding tubes of considerable length, injection and ventilation openings may be required at intermediate points.
A monitoring according to EN 446 is to be carried out.
National regulations must be observed.

#### 3.7.1 Press-in sections and re-pressing

The length of a pressfit section must not exceed 120 m for BBV L3 to L22, 80 m for BBV L27 and 80 m for BBV L31. If these tendon lengths are exceeded, additional injection openings are provided. For prestressing tendons with pronounced high points, repressions must be made to avoid defects. For the re-pressing measures are required, which must be taken into account already in the planning.

## 4 Packaging, transport and storage

The components and the tendons shall be protected against moisture and staining. The tendons shall be kept away from areas where welding procedures are performed. The accessories and tendons must be protected from moisture and dirt. The tendons shall be kept away from areas where welding is carried out. The tendons without casing shall be transported in such a way that the details of the approvals of the prestressing steel strands used are fully complied with. The tendons with cladding tube are to be transported in such a way that the permissible bend diameters according to DIN EN 523 Table 1 for the cladding tubes are maintained. Whereby also the specifications of the approvals of the used prestressing steel strands are to be considered.

# Description of BBV Post-Tensioning System

## 1 Tendons

The tendons consist of 7-wire strands with a nominal diameter of 0.60” (15,3 mm) and a nominal cross section of 140 mm² or with a nominal diameter of 0.62” (15,7 mm) and a nominal cross section of 150 mm². Steel grades Y1770S7 or Y1860S7 are allowed. Anchorages depending on the tendon sizes are identically for both steel grades.
The number of strands in a tendon can be reduced by omitting single strands always maintaining

a symmetrical pattern, see Annex B1, section 2.2, Table B3

The strands of tendons are combined in a duct without spacer. They are stressed simultaneously and anchored individually in the anchor head by means of wedges.

Round or oval profiled corrugated ducts are used according to EN 523:2003-11 and connected by threaded couplers. For tendons BBV L 3 and BBV L 4 oval ducts can also be used. All duct connections are sealed carefully by PVC sealing tape.

## 2 Anchor and coupling devices

The anchoring with anchor plate or castiron anchor (cast anchor body) and anchor head is usually used as a active anchor or accessible fixed anchor. But it can also be used with attached to the anchor plate / multi-surface anchor perforated disc and sealing as a cast-anchor anchor. In the anchoring area, a diameter-enlarging transition pipe (PE or steel) is connected to the cladding tube.

If a steel transition pipe is used, it must be made with a 4mm PE insert tube. This is followed by the anchor plate / multi-surface anchor and the perforated disc with depending on the tendon size 3 to 31 conical holes in which the strands are anchored with a three-piece round wedge. To anchor strands with a diameter of 0.62 ", wedges with an imprint „0.62″ on the top must be used, and the wedges of cast-in fixed anchors are sealed and held in place with a lock washer.

The splitting tensile forces, which are caused by the transfer of the clamping force to the concrete, are absorbed by the filament made of ribbed steel. In addition, an additional reinforcement of straight bars or ironing is required.

The tendons can be coupled by means of fixed or movable coupling. The coupling consists of a coupling plate in which the strands of the incoming tendon are held in conical bores, as in the tension anchor. The stranded ends of the outgoing tendon are anchored in radially arranged conical bores with three-piece wedges. These wedges are held by a spring and a spring retaining plate in the cone. The coupling is preassembled and consists of the coupling plate, the spring retaining plate and the cap of the cone opening, which is removed only immediately prior to installation of the tendon to be coupled. The cones are filled with corrosion proteczing grease

Proper seating of the strands in the coupling is controlled by a mark on the strand.

## 3 preparation

The strand tendons can be manufactured in the factory or on the construction site. The prestressing steel strand is generally delivered to the construction site by prestressing steel manufacturers in long lengths as disembodied coils. Here they are cut to the required length and inserted into the cladding tube. The prestressing steel strand can also be cut and delivered to the required length at the factory.

## 4 ducts

Steel ducts according to EN 523: 2003 or corrugated plastic pipes meeting the requirements of EAD 16004-00-0301 Section 2.2.10 and conforming to the applicable regulations at the point of use are used as the cladding. Plastic sheaths and the associated boundary conditions are not regulated by this ETA. All connections and joints are carefully sealed with sealing tape.

## 5 Stressing

A hydraulic pump unit and a special jack are used for the stressing of tendons. All strands of a tendon are stressed simultaneously. Stressing in load steps and resetting of the jacks is possible. After stressing, the round wedges are power seated by means of a seating device within the jack. A wedge slip of approx. 3 mm remains after the wedge seating procedure.

Straight tendons strands can be stressed individually by mono jacks.

The tensionforce is read from the respective clamping device taking into account the calibration. The values must be entered in the clamping report and compared with the calculated values.

## 6 grouting

To produce the internal subsequently bond and to protect the prestressing steel strands against corrosion, the duct is pressed out with grout after prestressing. The pressing is done by a special injecting inlet or cap.

The venting of the tendons takes place at the ends by attached vent pipes or special injecting inlets. For long tendons intermediate vents are required. At couplings always vents are arranged. The injecting work must be carried out in accordance with the applicable regulations and standards.

The grout is injected through the injection openings until it emerges again at the other end of the bundle in the same consistency. Decisive for the injection of cement mortar in chip channels are EN 445: 2007, EN 446: 2007 and EN 447: 2007. The injection results are recorded in the injection protocol.

# Time-independent clamping force losses

**Tensioning force losses due to friction and unintentional deflection**

The force losses due to friction and unintentional deflection in the static calculation may be determined using the friction coefficients $\mu$ and unwanted deflection angles k given in Appendix A2. The values $\mu$ and k apply to the specified cladding diameter and support distances of the tendons.

The values given for k only apply if the prestressing steel strands are already in the ducts at the time of concreting.

If the prestressing steel strands are installed only after concreting, the given values for $\mu$ apply only if the stiffening of the ducts during concreting, e. q. as by PE - pipes or when using reinforced ducts in conjunction with smaller distances between the tendon supports.

When determining the clamping paths and the clamping force present in the tendon, the displacement obstruction $\Delta P_{\mu S}$ in the area of the clamping anchor and $\Delta P_{\mu ÜK}$ in the area of the movable overlap coupling must be taken into account (see Appendix A2).

**Codes and References**

| | |
|---|---|
| prEN 10138-3: 2009 | Prestressing Steels - Part 3: Strand |
| EAD 160004-00-0301: 2016 | Post-tensioning kits for prestressing of structures |
| EAD 160027-00-0301: 2016 | Special filling products for post-tensioning kits |
| EN 10025-2: 2005 | Holt Rolled Products of Structural Steels – Part 2: Technical Delivery Conditions for Non-Alloy Structural Steels |
| EN 10083-1: 2006 | Quenched and Tempered Steels – Part 1: Delivery Conditions for unalloyed steel |
| EN 10083-2: 2006 | Quenched and Tempered Steels – Part 2: Technical Delivery Conditions for unalloyed steel |
| EN 10204: 2005 | Metallic Products – Types of Inspection Documents |
| EN 10277-2: 2008 | Bright steel products –Technical delivery conditions –Part 2: Steels for general engineering purposes |
| EN 1563: 2011 | Founding – Spheroidal graphite cast irons |
| EN 445: 2007 | Grout for Prestressing Tendons – test procedures |
| EN 446: 2007 | Grout for Prestressing Tendons – Grouting procedures |
| EN 447: 2007 | Grout for Prestressing Tendons – Basic Requirements |
| DIN 488-1: 2009 | Reinforcing steels – Part 1: Grades, properties, marking |
| EN 523: 2003 | Steel Strip Sheaths for Prestressing tendons |
| EN ISO 17855-1: 2014 | Plastics – Polyethylene (PE) moulding and extrusion materials – Part 1: Designation system and basis for specifications |
| EN 206-1: 2001 | Concrete – Part 1: Specification, Performance, Production an Conformity |
| EN 206-1/A1: 2004 | Concrete – Part 1: Specification, Performance, Production an Conformity; German Version EN 206-1: 2001/A1: 2004 |
| EN 206-1/A2: 2005 | Concrete – Part 1: Specification, Performance, Production an Conformity; German Version EN 206-1:2001/A2 :2005 |



| | |
|---|---|
| BBV-Internal Bonded Strand Post-tensioning System, type i | Annex D |
| **Codes and references** | |