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Authorised and notified according to Article 10 of the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products (89/106/EEC)

Deutsches Institut für Bautechnik DIBt

Mitglied der EOTA
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European Technical Approval ETA-05/0202

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Handelsbezeichnung *Trade name*	BBV-Litzenspannverfahren *BBV-Internal Bonded Strand Post-tensioning System*
Zulassungsinhaber *Holder of approval*	BBV Systems GmbH Industriestraße 98 67240 Bobenheim-Roxheim DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	BBV-Litzenspannverfahren mit 3 bis 31 Litzen (140 und 150 mm²) zur Vorspannung mit nachträglichem Verbund *BBV-Internal Bonded Post-tensioning System for 3 to 31 Strands (140 and 150 mm²)*
Geltungsdauer: vom *Validity: from*	27 June 2011
bis *to*	4 January 2016
Herstellwerk *Manufacturing plant*	BBV Systems GmbH Industriestraße 98 67240 Bobenheim-Roxheim DEUTSCHLAND

Diese Zulassung umfasst *This Approval contains*	31 Seiten einschließlich 16 Anhänge *31 pages including 16 annexes*
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EOTA

Europäische Organisation für Technische Zulassungen
European Organisation for Technical Approvals

I LEGAL BASES AND GENERAL CONDITIONS

1 This European technical approval is issued by Deutsches Institut für Bautechnik in accordance with:

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1], modified by Council Directive 93/68/EEC[2] and Regulation (EC) N° 1882/2003 of the European Parliament and of the Council[3];
- Gesetz über das In-Verkehr-Bringen von und den freien Warenverkehr mit Bauprodukten zur Umsetzung der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte und anderer Rechtsakte der Europäischen Gemeinschaften (Bauproduktengesetz - BauPG) vom 28. April 1998[4], as amended by law of 31 October 2006[5];
- Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex to Commission Decision 94/23/EC[6];
- Guideline for European technical approval of "Post-tensioning kits for prestressing of structures", ETAG 013.

2 Deutsches Institut für Bautechnik is authorized to check whether the provisions of this European technical approval are met. Checking may take place in the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European technical approval and for their fitness for the intended use remains with the holder of the European technical approval.

3 This European technical approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on page 1, or manufacturing plants other than those indicated on page 1 of this European technical approval.

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1 Official Journal of the European Communities L 40, 11 February 1989, p. 12
2 Official Journal of the European Communities L 220, 30 August 1993, p. 1
3 Official Journal of the European Union L 284, 31 October 2003, p. 25
4 *Bundesgesetzblatt Teil I 1998*, p. 812
5 *Bundesgesetzblatt Teil I 2006*, p. 2407, 2416
6 Official Journal of the European Communities L 17, 20 January 1994, p. 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of product/ products and intended use

1.1 Definition of the construction product

The present European Technical Approval applies to a kit:

BBV-Internal Bonded Strand Post-Tensioning System

consisting of 3 to 31 strands with a nominal tensile strength 1770 N/mm² or 1860 N/mm² (Y1770 S7 or Y1860 S7), 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; see Annex 1):

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 Bursting reinforcement (helixes and stirrups),

5 Sheathing (ducts),

6 Corrosion protection.

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

1.2 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.

The couplers shall only be used if the calculated stressing force at the coupler is at least 0.7 $P_{m0,max}$ (see Section 2.2.2).

The provisions made in this European Technical Approval are based on an assumed working life of the PT-System of 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer (or the Approval Body), 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.

2 Characteristics of product and methods of verification

2.1 Characteristics of product

2.1.1 General

The components correspond to the drawings and provisions given in this European Technical Approval including the Annexes. The characteristic material values, dimensions and tolerances of the components not indicated in the Annexes shall correspond to the respective values laid down in the technical documentation[7] of this European Technical Approval. The arrangement of the tendons, the design of the anchorage zones, the anchorage components and the diameters of the ducts shall correspond to the attached description and drawings; the dimensions and materials shall comply with the values given therein.

2.1.2 Strands

Only 7-wire strands shall be used in accordance with nationally provisions with the characteristics given in Table 1:

Table 1: Dimensions and properties of 7-wire strands

Designation	Symbol	Unit	Value	
Tensile strength	Rm	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 used 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 10.

2.1.3 Wedges

Wedges type 30, smooth or knurled, (see Annex 6) are approved. 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".

2.1.4 Anchor heads and couplers

The conical drills of the anchor heads and couplers shall be clean and stainless and provided with a corrosion protection grease.

2.1.5 Bearing plates

For 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 Annexes 2, 4 and 7).

2.1.6 Cast-iron anchor bodies

For 12 to 31 strands multi-surfaced cast-iron anchor bodies shall be used (see Annex 7).

[7] The technical documentation of this European Technical Approval is deposited at the Deutsches Institut für Bautechnik and, as far as relevant for the tasks of the approved bodies involved in the attestation of conformity procedure, is handed over to the approved bodies.

2.1.7 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 section 4.2.3.

2.1.8 Ducts

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 Annexes 2 to 5. The trumpets at stressing and fixed anchors (see Annexes 6, 7) are manufactured from 3.5 mm thick PE material (BBV L12 to L31). The other trumpets (see Annexes 6, 7 and 9) are manufactured from steel. In the area of possible contact between strands and steel trumpet (point of deviation) PE pipes of at least 4 mm thickness and a length of 120.0 mm shall be provided for avoiding any contact between strands and steel. The PE pipes shall be fixed in the right position. It shall be made sure that at anchors and couplers for 3 to 22 and 31 strands (1.part, Annex 9) 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°. The deflection at couplers (2.part, Annex 9) is 7° (at the deviation point between trumpet and duct). At the end of the wedge normally there is no deflection.

Also plastic ducts which meet the requirements according to ETAG 013, Annex C.3 and in accordance with regulations valid at the place of use can be used. Plastic ducts or the accompanying boundary conditions are not covered by ETA-05/0202.

2.1.9 Grout

Grout shall be used according to EN 447:1996.

2.2 Methods of verification

2.2.1 General

The assessment of the fitness of the BBV-Internal Bonded Strand Post-Tensioning System for the intended use in relation to the requirements for mechanical resistance and stability in the sense of Essential Requirement 1 has been made in accordance with the "Guideline for European Technical Approval of Post-tensioning kits for Prestressing of structures, ETAG 013".

The release of dangerous substances (Essential Requirement 3) is determined according to ETAG 013, clause 5.3.1. A declaration was made by the manufacturer, that the product does not contain any dangerous substances.
In addition to the specific clauses relating to dangerous substances contained in this European Technical Approval, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Directive, these requirements need also to be complied with, when and where they apply.
The structural members (normal-weight concrete) prestressed by means of the BBV-Internal Bonded Strand Post-Tensioning System used to be designed in accordance with national regulations.

2.2.2 Tendons

Prestressing and overtensioning forces are specified in the respective national provisions.
The maximum force P_0 applied to a tendon shall not exceed the force $P_{0.max} = 0.9\ A_p\ f_{p0,1k}$ (see Table 2 (140 mm²) or Table 3 (150 mm²) for $f_{p0,1k}$ = 1520 N/mm² or 1600 N/mm²).

The value of the prestressing initial prestress force P_{m0} applied to the concrete after tensioning and anchoring shall not exceed the force $P_{m0,max} = 0.85\ A_p\ f_{p0,1k}$ (see Table 2 (140 mm²) or Table 3 (150 mm²) for $f_{p0,1k}$ = 1520 N/mm² or 1600 N/mm²).

Table 2: Maximal prestressing forces[8] for tendons with A_p = 140 mm²

Tendon Designation	Number of strands	Cross section A_p [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
BBV L3	3	420	543	575	571	605
BBV L4	4	560	724	766	762	806
BBV L5	5	700	904	958	952	1008
BBV L7	7	980	1266	1341	1333	1411
BBV L9	9	1260	1628	1724	1714	1814
BBV L12	12	1680	2171	2298	2285	2419
BBV L15	15	2100	2713	2873	2856	3024
BBV L19	19	2660	3437	3639	3618	3830
BBV L22	22	3080	3979	4213	4189	4435
BBV L27	27	3780	4884	5171	5141	5443
BBV L31	31	4340	5607	5937	5902	6250

Table 3: Maximal prestressing forces[8] for tendons with A_p = 150 mm²

Tendon Designation	Number of strands	Cross section A_p [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
BBV L3	3	450	581	616	612	648
BBV L4	4	600	775	821	816	864
BBV L5	5	750	969	1026	1020	1080
BBV L7	7	1050	1357	1436	1428	1512
BBV L9	9	1350	1744	1847	1836	1944
BBV L12	12	1800	2326	2462	2448	2592
BBV L15	15	2250	2907	3078	3060	3240
BBV L19	19	2850	3682	3899	3876	4104
BBV L22	22	3300	4264	4514	4488	4752
BBV L27	27	4050	5233	5540	5508	5832
BBV L31	31	4650	6008	6361	6324	6696

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 provisions for tendons with anchors (basic types) completely filled also apply to tendons with anchor heads only partly filled. Into the free drills in the anchor head the short pieces of strands with wedges have to be pressed to prevent slipping out. The admissible prestressing force is reduced per strand left out as shown in Table 4.

8 The forces stated in Tables 2 to 4 are maximum values referring on $f_{p0,1k}$ = 1520 N/mm² or 1600 N/mm². The actual prestressing forces are to be found in national regulations valid in the place of use. If admissible in the place of use, strands with higher characteristic yield stresses might be used, but not more than $f_{p0,1k}$ = 1560 N/mm² (Y1770 S7) or 1640 N/mm² (Y1860 S7). In this case the prestressing forces of Tables 2 to 4 can be linearly increased by multiplying them with the factor ($f_{p0,1k}$ / 1520) or ($f_{p0,1k}$ / 1600).
Compliance with the stabilisation and crack width criteria in the load transfer test was verified to a load level of 0,80*F_{pk}.

Table 4: Reduction of the prestressing force[8] when leaving out a strand

A_p	Y1770 S7		Y1860 S7	
	ΔP_{m0} [kN]	ΔP_0 [kN]	ΔP_{m0} [kN]	ΔP_0 [kN]
140 mm²	181	192	190	201
150 mm²	194	205	204	216

Further characteristic values of the tendons (mass per meter, ultimate stressing force F_{pk}) see Annexes 2 to 5.

2.2.3 Losses due to friction and wobble effects

The losses due to friction may usually be determined in the calculation by using the friction coefficients μ and the unintentional angular displacement k (wobble coefficient) given in the Annexes 2 to 5. The values μ and k depend on the given duct dimensions and distances between tendon supports.

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

If the strands are arranged after concreting, the given values μ shall only be used in the calculation if the ducts are adequately stiffened during concreting, e.g. by means of PE and/or PVC pipes, or if reinforced ducts are used in connection with smaller distances between tendon supports.

For the determination of strains and forces of prestressing steel friction losses $\Delta P_{\mu S}$ in the stressing anchor zone and $\Delta P_{\mu ÜK}$ in the movable coupling zone (see Annexes 2 to 5) shall be taken into account.

2.2.4 Radius of curvature of the tendons in the structure

The smallest admissible radius of curvature of the tendons with circular duct depending on the strand strength, the cross section of the strand and the diameter of the duct is given in Table 5 to 8.

Table 5: Smallest radius of curvatur[9] (circular duct) for strands Y1770 S7 with A_p = 140 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])		
BBV L 3	3.50 (40)		
BBV L 4	4.20 (45)	4.10 (50)	3.90 (55)
BBV L 5	4.70 (50)	4.40 (55)	4.20 (60)
BBV L 7	4.80 (55)	4.50 (60)	4.40 (65)
BBV L 9	5.30 (65)	5.10 (70)	4.90 (75)
BBV L 12	6.10 (75)	5.90 (80)	
BBV L 15	6.70 (85)	6.50 (90)	
BBV L 19	7.90 (90)	7.60 (95)	
BBV L 22	8.20 (100)	7.80 (110)	
BBV L 27	9.20 (110)	8.90 (115)	
BBV L 31	10.00 (115)	9.50 (125)	

9 The given smallest admissible radii of curvature refer on the maximum presstressing forces $P_{m0,max}$ according to Tables 2 or 3. If admissible in the place of use, and if strands with higher characteristic yield stressed will be used, the given radii of curvature shall be linearly increased by multiplying them with the factor ($f_{p0,1k}$ / 1520) or ($f_{p0,1k}$ / 1600) and rounded up in steps of 0.1m. See also section 2.2.2 and footnote 8.

Table 6: Smallest radius of curvatur[9] (circular duct) for strands Y1770 S7 with A_p = 150 mm²

Tendon	**Radius of curvature [m] (Inner diameter of the duct [mm])**		
BBV L 3	3.70 (40)		
BBV L 4	4.50 (45)	4.40 (50)	4.20 (55)
BBV L 5	4.90 (50)	4.60 (55)	4.40 (60)
BBV L 7	5.10 (55)	4.80 (60)	4.60 (65)
BBV L 9	5.60 (65)	5.30 (70)	5.20 (75)
BBV L 12	6.50 (75)	6.10 (80)	
BBV L 15	7.10 (85)	6.80 (90)	
BBV L 19	8.50 (90)	8.00 (95)	
BBV L 22	8.90 (100)	8.20 (110)	
BBV L 27	9.90 (110)	9.40 (115)	
BBV L 31	10.80 (115)	10.00 (125)	

Table 7: Smallest radius of curvatur[9] (circular duct) for strands Y1860 S7 with A_p = 140 mm²

Tendon	**Radius of curvature [m] (Inner diameter of the duct [mm])**		
BBV L 3	3.70 (40)		
BBV L 4	4.40 (45)	4.30 (50)	4.10 (55)
BBV L 5	4.80 (50)	4.50 (55)	4.40 (60)
BBV L 7	5.00 (55)	4.70 (60)	4.50 (65)
BBV L 9	5.40 (65)	5.20 (70)	5.00 (75)
BBV L 12	6.30 (75)	6.00 (80)	
BBV L 15	6.90 (85)	6.70 (90)	
BBV L 19	8.20 (90)	7.80 (95)	
BBV L 22	8.60 (100)	8.00 (110)	
BBV L 27	9.60 (110)	9.20 (115)	
BBV L 31	10.50 (115)	9.70 (125)	

Table 8: Smallest radius of curvatur[9] (circular duct) for strands Y1860 S7 with A_p = 150 mm²

Tendon	**Radius of curvature [m] (Inner diameter of the duct [mm])**		
BBV L 3	4.00 (40)		
BBV L 4	4.70 (45)	4.60 (50)	4.40 (55)
BBV L 5	5.00 (50)	4.70 (55)	4.50 (60)
BBV L 7	5.50 (55)	5.00 (60)	4.70 (65)
BBV L 9	6.00 (65)	5.50 (70)	5.30 (75)
BBV L 12	6.90 (75)	6.50 (80)	
BBV L 15	7.60 (85)	7.20 (90)	
BBV L 19	9.10 (90)	8.60 (95)	
BBV L 22	9.40 (100)	8.60 (110)	
BBV L 27	10.50 (110)	10,10 (115)	

BBV L 31	11.60 (115)	10.60 (125)	

According to ETAG 013 for tendons with at least five strands and circular ducts the following formula for calculation of the minimal radius of curvature can be used if admissible at the place of use:

$$R_{min} = \frac{2 \cdot P_{m0,max} \cdot d_{strand}}{p_{R,max} \cdot d_{duct}}$$

with

R_{min}	minimum admissible radius of curvature in [m]
$P_{m0,max}$	$P_{m0,max} = 0.85\ A_p\ f_{p0,1k}$ according to section 2.2.2 in [kN]
d_{strand}	diameter of the strands in [mm]
$p_{R,max}$	maximum admissible pressure under a strand ($p_{R,max}$ = 130 to 150 kN/m)
d_{duct}	inner duct diameter in [mm]

R_{min} shall be given with an accuracy of 0.1m (shall be rounded up).

The smallest admissible radius of curvature of the tendons with oval duct depending on the bending axis is given in Table 9. For oval ducts bending only is allowed around one axis (the stiff or the weak).

Table 9: Smallest radius of curvatur[9] (oval duct)

Tendon	**Inner duct dimensions [mm x mm]**	**Radius of curvature [m]**	
		Bending axis	
		stiff	weak
BBV L 3	60 x 21	5.30	2.50
BBV L 4	80 x 21	7.20	2.50

2.2.5 Concrete strength

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 10. 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 10: Necessary mean concrete strength f_{cmj} 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 proved is 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values can be interpolated lineally.

2.2.6 Centre and edge distances of the tendon anchorages, concrete cover

The centre and edge distances of the tendon anchorages must not be smaller than the values given in the Annexes 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 7) shall be installed parallel to the large concrete side (the maximum spacing of concrete axis).

The 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 8). In this case the 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.

2.2.7 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).

The steel grades and 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[10] - 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.

2.2.8 Slip at the anchorages

The slip at the anchorages (see section 4.2.5) shall be taken into account in the static calculation and the determination of the tendon elongation.

2.2.9 Resistance to fatigue of the anchorages and couplers

With the fatigue tests carried out in accordance with ETAG 013, the stress range of 80 N/mm² of the strands at the maximum stress of 0.65 f_{pk} at 2×10^6 load cycles was demonstrated.

2.2.10 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.

2.2.11 Couplers

The couplers shall only be used if the calculated stressing force at the coupler is at least 0.7 $P_{m0,max}$ (see section 2.2.2). 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 $\Delta\lambda$ + 30 mm, where $\Delta\lambda$ is the maximum elongation length at the time of prestressing.

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 9.

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

10 This requires the approval for individual case according to the national regulations and administrative provisions.

3 Evaluation and attestation of conformity and CE marking

3.1 System of attestation of conformity

According to the decision 98/456/EC of the European Commission[11] the system 1+ of attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 1+: Certification of the conformity of the product by a approved certification body on the basis of:

(a) Tasks for the manufacturer:

(1) factory production control;

(2) further testing of samples taken at the factory by the manufacturer in accordance with a prescribed test plan;

(b) Tasks for the approved body:

(3) initial type-testing of the product;

(4) initial inspection of factory and of factory production control;

(5) continuous surveillance, assessment and approval of factory production control;

(6) audit-testing of samples taken at the factory.

3.2 Responsibilities

3.2.1 Tasks of the manufacturer

3.2.1.1 Factory production control

The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. This production control system shall insure that the product is in conformity with this European Technical Approval.

The manufacturer may only use initial materials stated in the technical documentation of this European Technical Approval.

The factory production control shall be in accordance with the "control plan of 25 March 2011 relating to the European Technical Approval ETA-05/0202 issued on 27 June 2011" which is part of the technical documentation of this European Technical Approval. The "control plan" is laid down in the context of the factory production control system operated by the manufacturer and deposited at the Deutsches Institut für Bautechnik.[12]

The basic elements of the "control plan" comply with ETAG 013, Annex E1 (see Annexes 12 and 13)

The results of factory production control shall be recorded and evaluated in accordance with the provisions of the "control plan".

The records shall contain at least the following information:

- designation of the product or of the initial material and the components,
- kind of control or testing,
- date of manufacture and of testing of product or components and of initial material or of the components,
- results of controls and tests and, where relevant, comparison with the requirements,

[11] Official Journal of the European Communities L 201/112 of 3 July 1998

[12] The "control plan" is a confidential part of the European technical approval and only handed over to the approved body involved in the procedure of attestation of conformity. See section 3.2.2.

- signature of person responsible for the factory production control.

The records shall be kept for at least ten years and submitted to the approved body. On request they shall be presented to Deutsches Institut für Bautechnik.

If the test result is not satisfactory, the manufacturer shall take immediate measures to eliminate the deficiency. Construction products and components which do not comply with the requirements shall be handled in such a way that they cannot be mistaken for products complying with the requirements. After elimination of the deficiency the relevant test shall be immediately repeated as far as it is technically possible and necessary for verifying the deficiency elimination.

3.2.1.2 Other tasks of manufacturer

The manufacturer shall, on the basis of a contract, involve a body which is approved for the tasks referred to in section 3.1 in the field of Post-Tensioning Kits for Prestressing of Structures in order to undertake the actions laid down in section 3.2.2. For this purpose, the "control plan" referred to in sections 3.2.1.1 and 3.2.2 shall be handed over by the manufacturer to the approved body involved.

The manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European Technical Approval ETA-05/0202 issued on 27 June 2011.

At least once a year specimens shall be taken from one job site and one series of single tensile element test shall be performed according to ETAG 013, Annex E3 (see Annex 14). The results of these test series shall be made available to the approved body.

3.2.2 Tasks of approved body

3.2.2.1 General

The approved body shall perform the measures according to sections 3.2.2.2 to 3.2.2.5 and in accordance with the provisions laid down in the "control plan of 25 March 2011 relating to the European Technical Approval ETA-05/0202 issued on 27 June 2011".

The approved body shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in written reports.

The approved certification body involved by the kit manufacturer (BBV Systems GmbH) shall issue an EC certificate of conformity of the product stating the conformity with the provisions of this European Technical Approval.

In cases where the provisions of the European Technical Approval and its "control plan" are no longer fulfilled the certification body shall withdraw the certificate of conformity and inform the Deutsches Institut für Bautechnik without delay.

3.2.2.2 Initial type-testing of the product

For initial type-testing the results of the tests performed as part of the assessment for the European Technical Approval may by used unless there are changes in the production line or plant. In such cases the necessary initial type-testing has to be agreed between the Deutsches Institut für Bautechnik and the approved body involved.

3.2.2.3 Initial inspection of factory and of factory production control

The approved body shall ascertain that, in accordance with the "control plan", the factory, in particular the staff and equipment, and the factory production control are suitable to ensure a continuous and orderly manufacturing of the Post -tensioning system with the specifications mentioned in section 2.1 as well as in the Annexes to the European Technical Approval.

3.2.2.4 Continuous surveillance, assessment and approval of factory production control

The approved body shall visit the factory at least once a year. It has to be verified that the system of factory production control and the specified manufacturing process are maintained taking account of the "control plan".

Continuous surveillance and assessment of factory production control have to be performed according to the "control plan".

The results of product certification and continuous surveillance shall be made available on demand by the approved body to the Deutsches Institut für Bautechnik.

3.2.2.5 Audit-testing of samples taken at the factory

During surveillance inspections the approved body shall take samples of components of the Post-tensioning system for independent testing. For the most important components Annex 14 contains the minimum procedures which have to be performed by the approved body.

The basic elements of the Audit testing comply with ETAG 013, Annex E2 (see Annex 14)

3.3 CE marking

The CE marking shall be affixed on the delivery note. The letters "CE" shall be followed by the identification number of the approved certification body, where relevant, and be accompanied by the following additional information:

- the name and address of the producer (legal entity responsible for the manufacture),
- the last two digits of the year in which the CE marking was affixed,
- the number of the EC certificate of conformity for the product,
- the number of the European Technical Approval,
- the number of the guideline for European Technical Approval,
- the identification of the product (trade name),
- nominal cross section and tensile strength of the strands.

4 Assumptions under which the fitness of the product for the intended use was favourably assessed

4.1 Manufacturing

The European Technical Approval is issued for the product on the basis of agreed data/information, deposited with the Deutsches Institut für Bautechnik, which identifies the product that has been assessed and judged. Changes to the product or production process, which could result in this deposited data/information being incorrect, should be notified to the Deutsches Institut für Bautechnik before the changes are introduced. The Deutsches Institut für Bautechnik will decide whether or not such changes affect the ETA and consequently the validity of the CE marking on the basis of the ETA and if so whether further assessment or alterations to the ETA shall be necessary.

The tendons may be manufactured on the site or in the manufacturing plant (prefabricated tendons).

4.2 Installation

4.2.1 General

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 ETA holder certifying that he is instructed by the ETA holder and has the required knowledge and experience with this post-tensioning system. Standards and regulations valid on side shall be considered.

The ETA holder is responsible to inform anyone concerned about the use of this BBV-Post-tensioning System. Additional information as listed in ETAG 013, Section 9.2 shall be held available at the ETA holder and shall be distributed as needed.

The tendons and the components shall be handled carefully.

4.2.2 Welding

Welding at the anchorages is only permitted 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 or anchor body by tack-welding.

After placing the strands in the ducts, no more welding shall be performed at the anchorages.

4.2.3 Installation of the tendon

The central position of the helix or stirrups shall be ensured by tack-welding to the bearing plate or the anchor body or by means of mounting brackets. The bearing plate or anchor body 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 (see section 2.1.8).

The connection between trumpet and duct shall be sealed carefully by tape in order to prevent the penetrating of concrete.

4.2.4 Coupler

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

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

If the calculated prestressing force is less than 0.7 $P_{m0,max}$ or if knurled wedges type 30 are used, the wedges of fixed anchorages shall be pre-wedged with 1.1 $P_{m0,max}$ (see section 2.2.2).

The wedges of movable couplers in the parallel drills shall be pre-wedged with 1.1 $P_{m0,max}$ (see section 2.2.2), if knurled wedges type 30 are used.

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 $P_{m0,max}$ 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 (see Annex 6 and 9). The types of these masses are deposited with the Deutsches Institut für Bautechnik by the manufacturer. In the case of couplers the voids of the outer coupler tendon (see Annex 9) shall be filled with corrosion protection mass.

The wedges of the stressing anchors shall be pre-wedged after tensioning with at least 0.1 $P_{m0,max}$. In this case the slip is 3 mm.

4.2.6 Tensioning

Before tensioning the minimum mean concrete strength shall comply with the values given in section 2.2.5.

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.

The minimum straight length for tensioning behind the anchorages (strand protrusion) is given in Annexes 2 to 5. All strands of a tendon shall be stressed simultaneously. This can be done by centrally controlled individual jacks or by a collective jack.

4.2.7 Grouting

4.2.7.1 Grout and Grouting procedures

Grout according section 2.1.9 shall be used. Grouting procedures shall be carried out in accordance with EN 446:1996.

4.2.7.2 Water rinse

Normally, tendons shall not be rinsed with water.

4.2.7.3 Grouting speed

The grouting speed shall be in the range between 3m/min and 12m/min.

4.2.7.4 Grouted section and re-grouting

The length of a grouted section shall not exceed 120 m for tendons BBV L3 to L22, 95 m for tendons BBV L27 and 80 m for BBV L31. When exceeding these tendon lengths, additional grouting openings shall be provided. Where the tendon is led via distinct high points, re-groutings shall be performed in order to avoid voids. For re-groutings corresponding measures shall be taken into account already in design.

4.2.7.5 Surveillance

Surveillance according to EN 446:1996 shall be carried out.

5 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.

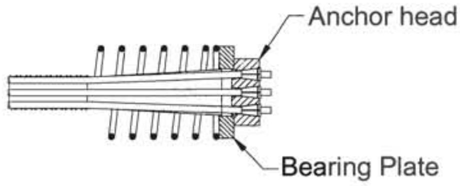
During transport the smallest admissible diameter of curvature of tendons with duct up to 22 strands is 1.65 m and exceeding 22 strands is 2.0 m. For tendons without duct the smallest diameter of curvature during transport is 1.65 m.

Georg Feistel
Head of Department

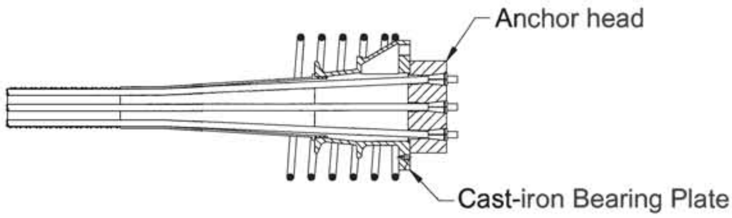
beglaubigt:
Schlack

OVERVIEW ANCHORAGES

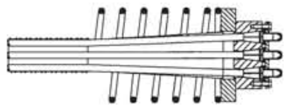
1. Active Anchor (S) and Passive Anchor (F) BBV L3 – BBV L9



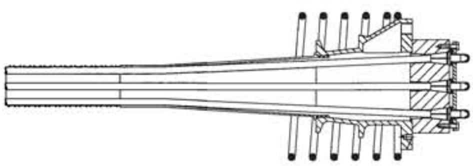
2. Active Anchor (S) and Passive Anchor (F) BBV L12 – BBV L31



3. Embedded Passive Anchor (Fe) BBV L3 – BBV L9

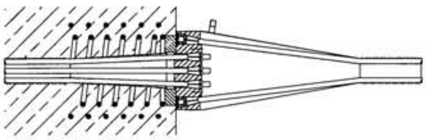


4. Embedded Passive Anchor (Fe) BBV L12 – BBV L31

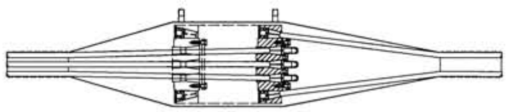


5. Coupler (ÜK) BBV L3 – BBV L9

Fixed Coupler (FÜK)

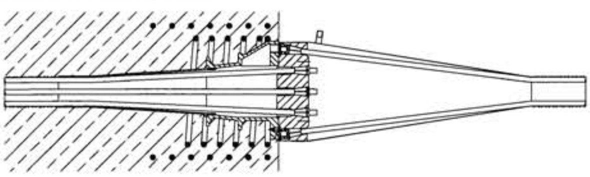


Movable Coupler (BÜK)

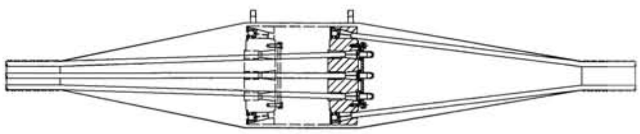


6. Coupler (ÜK) BBV L12 – BBV L31

Fixed Coupler (FÜK)



Movable Coupler (BÜK)



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

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 : Ultimate Force F_{pk}	kN	797	1062	1328	1859	2390
150mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	616	821	1026	1436	1847
150mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	581	775	969	1357	1744
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 : Ultimate Force F_{pk}	kN	743	991	1239	1735	2230
140mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	575	766	958	1341	1724
140mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	543	724	904	1266	1628
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 μ	-	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 $\Delta P_{\mu ÜK}$	%	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	21	79	79	93
Anchors (S), (F), (Fe), Couplers (FÜK),(BÜK)						
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

* Concrete cover shall be taken into account additionally (see section 2.2.6). 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

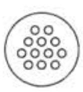
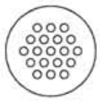
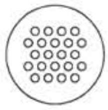
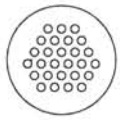
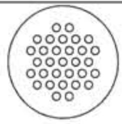
*** Based on $f_{p0,1k}$ = 1520 N/mm² (Grade Y1770)

**** 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 μ to be considered is:	BBV L 3	BBV L 4
Bending round the stiff axis:	μ = 0.23	μ = 0.26
Bending round the weak axis:	μ = 0.15	μ = 0.15

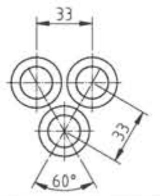
***** Min. edge distance : min. centre distance/2+20 mm (rounding up at 5 mm intervals). Concrete cover shall be taken into account additionally (see section 2.2.6).

TECHNICAL DETAILS BBV L 12 – BBV L 31
Grade Y1770
Anchors (S), (F), (Fe), Couplers, (FÜK), (BÜK)

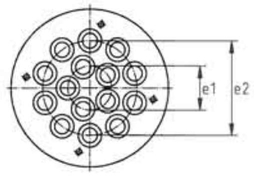
Tendon type		BBV L 12	BBV L 15	BBV L 19	BBV L 22	BBV L 27	BBV L 31
Strand Pattern							
Number of strands	n	12	15	19	22	27	31
150mm² : Nominal Cross Section A_p	mm²	1800	2250	2850	3300	4050	4650
150mm² : Nominal Mass M	kg/m	14.06	17.58	22.27	25.78	31.64	36.58
150mm² : Ultimate Force F_{pk}	kN	3186	3983	5045	5841	7169	8231
150mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2462	3078	3899	4514	5540	6361
150mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2326	2907	3682	4264	5233	6008
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 : Ultimate Force F_{pk}	kN	2974	3717	4708	5452	6691	7682
140mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2298	2873	3639	4213	5171	5937
140mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2171	2713	3437	3979	4884	5607
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	0.20 / 0.19	0.21 / 0.20	0.20 / 0.19	0.20 / 0.20	0.20 / 0.20
Friction Losses							
Active Anchor $\Delta P_{\mu s}$	%	0.8	0.8	0.8	0.6	0.8	0.8
Coupler $\Delta P_{\mu ÜK}$	%	1.2	1.1	1.0	1.2	1.2	1.2
Ducts							
Inner Diameter	mm	75/80	85/90	90/95	100/110	110/115	115/125
Outer Diameter	mm	82/87	92/97	97/102	107/117	117/125	122/135
Eccentricity, 150mm²	mm	10.3/13.9	12.4/15.8	9.9/13.1	13.3/20.1	14.1/17.3	12.1/19.6
140mm²	mm	11.7/14.9	14.0/17.7	10.2/15.8	15.9/22.1	15.7/19.0	14.2/21.5
Strand Protrusion **	cm	93	93	125	125	141	141
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)							
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 2
*** based on $f_{p0,1k}$ = 1520 N/mm² (Grade Y1770)

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).



Example: BBV L15

BBV SYSTEMS Industriesstrasse 98 67240 Bobenheim-Roxheim	**Technical Details** BBV L 12 – BBV L 31 Steel Grade Y1770 BBV Internal Bonded Strand Post-Tensioning System	Annex 3

TECHNICAL DETAILS BBV L 3 – BBV L 9
Steel Grade Y1860
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)

Tendon Type	Unit	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 Ap	mm²	450	600	750	1050	1350
150mm² : Nominal Mass M	kg/m	3.52	4.69	5.86	8.20	10.55
150mm² : Ultimate Force F_{pk}	kN	837	1116	1395	1953	2511
150mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	648	864	1080	1512	1944
150mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	612	816	1020	1428	1836
140mm² : Nominal Cross Section Ap	mm²	420	560	700	980	1260
140mm² : Nominal Mass M	kg/m	3.28	4.37	5.47	7.65	9.84
140mm² : Ultimate Force F_{pk}	kN	781	1042	1302	1823	2344
140mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	605	806	1008	1411	1814
140mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	571	762	952	1333	1714
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 μ	-	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
Coupler $\Delta P_{\mu ÜK}$	%	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	51/56/61	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
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	21	79	79	93
Anchors (S), (F), (Fe), Couplers (FÜK),(BÜK)						
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

* Concrete cover shall be taken into account additionally (see section 2.2.6). 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

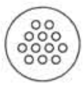
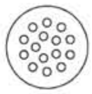
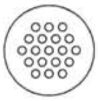
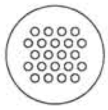
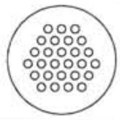
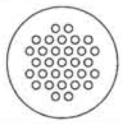
*** Based on $f_{p0,1k}$ = 1600 N/mm² (Grade Y1860)

**** 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 μ to be considered is:	BBV L 3	BBV L 4
Bending round the stiff axis:	μ = 0.23	μ = 0.26
Bending round the weak axis:	μ = 0.15	μ = 0.15

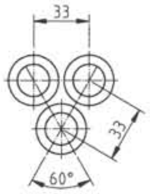
***** Min. edge distance : min. centre distance/2+20 mm (rounding up at 5 mm intervals). Concrete cover shall be taken into account additionally (see section 2.2.6).

TECHNICAL DETAILS BBV L 12 – BBV L 31
Steel Grade Y1860
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)

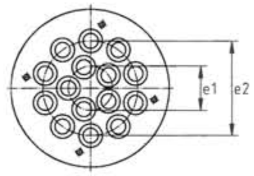
Tendon Type		**BBV L 12**	**BBV L 15**	**BBV L 19**	**BBV L 22**	**BBV L 27**	**BBV L 31**
Strand Pattern							
Number of Strands	n	12	15	19	22	27	31
150mm² : Nominal Cross Section A_p	mm²	1800	2250	2850	3300	4050	4650
150mm² : Nominal Mass M	kg/m	14.06	17.58	22.27	25.78	31.64	36.58
150mm² : Ultimate Force F_{pk}	kN	3348	4185	5301	6138	7533	8649
150mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2592	3240	4104	4752	5832	6696
150mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2448	3060	3876	4488	5508	6324
140mm² : Nominal Cross Section A_p	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 : Ultimate Force F_{pk}	kN	3125	3906	4948	5729	7031	8072
140mm² : $P_0 = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2419	3024	3830	4435	5443	6250
140mm² : $P_{m0} = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2285	2856	3618	4189	5141	5902
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	0.20 / 0.19	0.21 / 0.20	0.20 / 0.19	0.20 / 0.20	0.20 / 0.20
Friction Losses							
Active Anchor $\Delta P_{\mu s}$	%	0.8	0.8	0.8	0.6	0.8	0.8
Coupler $\Delta P_{\mu ÜK}$	%	1.2	1.1	1.0	1.2	1.2	1.2
Ducts							
Inner Diameter	mm	75/80	85/90	90/95	100/110	110/115	115/125
Outer Diameter	mm	82/87	92/97	97/102	107/117	117/125	122/135
Eccentricity, 150mm²	mm	10.3/13.9	12.4/15.8	9.9/13.1	13.3/20.1	14.1/17.3	12.1/19.6
140mm²	mm	11.7/14.9	14.0/17.7	10.2/15.8	15.9/22.1	15.7/19.0	14.2/21.5
Strand Protrusion **)	cm	93	93	125	125	141	141
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)							
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 2
*** based on $f_{p0,1k}$ = 1600 N/mm² (Grade Y1860)

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 e2).



Example: BBV L15

BBV SYSTEMS Industriesstrasse 98 67240 Bobenheim-Roxheim	**Technical Details** BBV L 12 – BBV L 31 Steel Grade Y1860 BBV Internal Bonded Strand Post-Tensioning System	Annex 5

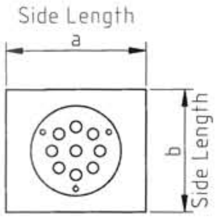
DESCRIPTION OF WEDGE ANCHORAGES

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

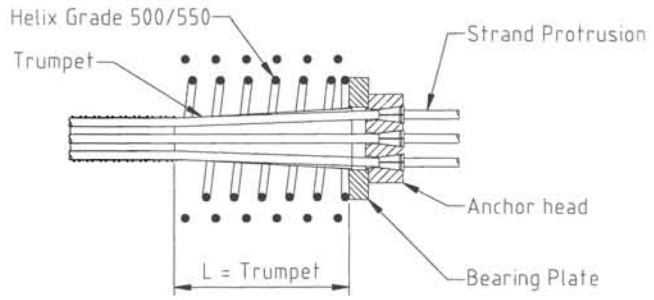
Active anchors (S) with bearing plate and anchor head
Accessible passive anchor (F) with bearing plate and anchor head

For embedded Passive Anchor (Fe) the anchor head is tack-welded 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

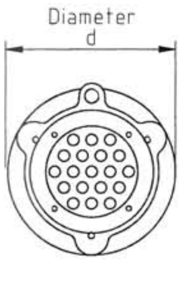


Shown BBV L 9

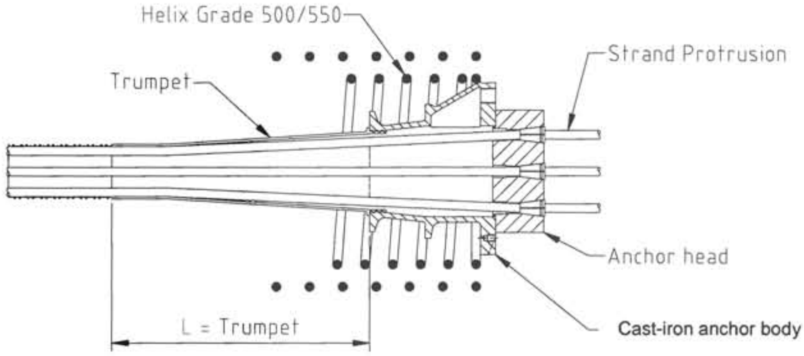


Tendon Type BBV L 3 – L9: active anchor and passive anchor with rectangular bearing plate *a x b* and anchor head.

L 12 – L 31



Shown BBV L 19



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.

BBV SYSTEMS Industriesstrasse 98 67240 Bobenheim-Roxheim	**Description of Wedge Anchorages** BBV Internal Bonded Strand Post-Tensioning System	Annex 6

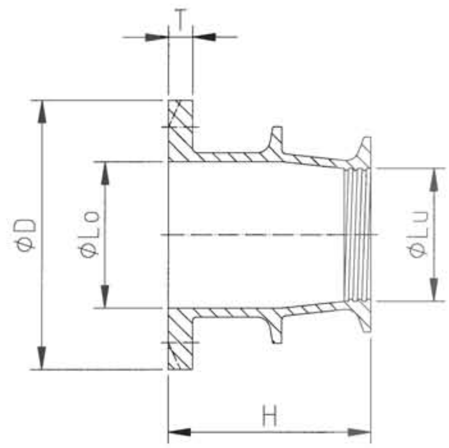
DIMENSIONS OF ANCHOR COMPONENTS

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 body													
Diameter	D	mm						240	270	300	327	360	382
Height	H	mm						182	203	227	248	272	294
Thickness 1st 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
Diameter	A	mm	68	77	79	89	109	127	146	159	179	195	204
Diameter circle e1		mm	45	54	56	66	86	*grid	56	*grid	*grid	*grid	*grid
Diameter circle e2		mm							120				
Trumpet													
Max. outer diameter		mm	70	79	81	91	111	131	147	156	173	184	190
Length		mm	≥200	≥244	≥201	≥247	≥417	≥500	≥553	≥595	≥620	≥544	≥509

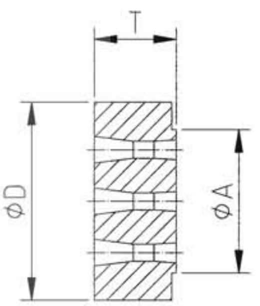
* Grid according to Annex 3

Bearing plate see Annex 6

Cast-iron anchor body



Anchor head



BBV SYSTEMS

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Dimensions of Anchor Components

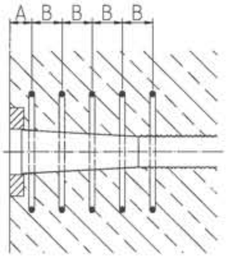
BBV L 3 – BBV L 31

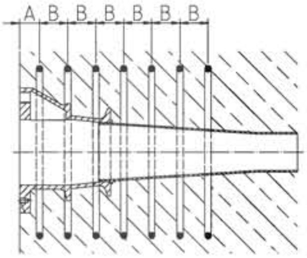
BBV Internal Bonded Strand Post-Tensioning System

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/mm^2	mm	14	14	14	14	14	14	14	16	16	16	16
$f_{cmj,cube}$ =34 N/mm^2	mm	14	14	14	14	14	14	16	16	16	16	16
$f_{cmj,cube}$ =40 N/mm^2	mm	14	14	14	14	14	14	14	16	16	16	16
$f_{cmj,cube}$ =45 N/mm^2	mm	14	14	14	14	14	14	14	16	16	16	16
Outer Diameter												
$f_{cmj,cube}$=28/30 N/mm^2	mm	140	160	180	200	240	300	345	390	430	490	520
$f_{cmj,cube}$ =34 N/mm^2	mm	135	150	170	190	230	300	340	380	410	450	480
$f_{cmj,cube}$ =40 N/mm^2	mm	130	135	160	190	225	285	320	360	380	430	460
$f_{cmj,cube}$ =45 N/mm^2	mm	120	120	140	180	220	270	315	340	365	410	430
Min. Length												
$f_{cmj,cube}$=28/30 N/mm^2	mm	200	230	250	300	350	350	400	450	450	550	550
$f_{cmj,cube}$ =34 N/mm^2	mm	180	210	240	270	310	300	350	400	450	470	470
$f_{cmj,cube}$ =40 N/mm^2	mm	170	200	220	250	290	300	300	350	350	450	450
$f_{cmj,cube}$ =45 N/mm^2	mm	160	180	200	250	275	250	250	300	300	350	350
Pitch												
$f_{cmj,cube}$=28/30 N/mm^2	mm	40	40	40	50	50	50	50	50	50	50	50
$f_{cmj,cube}$ =34 N/mm^2	mm	40	40	40	50	50	50	50	50	50	50	50
$f_{cmj,cube}$ =40 N/mm^2	mm	40	40	40	50	50	50	50	50	50	50	50
$f_{cmj,cube}$ =45 N/mm^2	mm	40	40	40	50	50	50	50	50	50	50	50
Helix Turns												
$f_{cmj,cube}$=28/30 N/mm^2	n	6	7	7.5	7	8	8	9	10	10	12	12
$f_{cmj,cube}$ =34 N/mm^2	n	5.5	6.5	7	6.5	7	7	8	9	10	10.5	10.5
$f_{cmj,cube}$ =40 N/mm^2	n	5.5	6	6.5	6	7	7	7	8	8	10	10
$f_{cmj,cube}$ =45 N/mm^2	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/mm^2	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/mm^2	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/mm^2	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/mm^2	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/mm^2	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/mm^2	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/mm^2	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/mm^2	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

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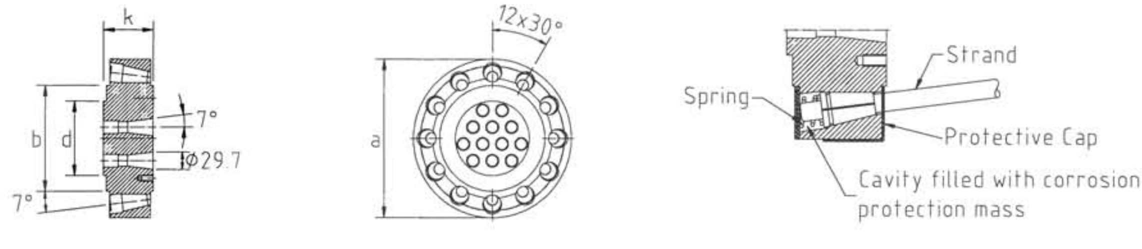
Helix and Reinforcement

BBV L 3 – BBV L 31

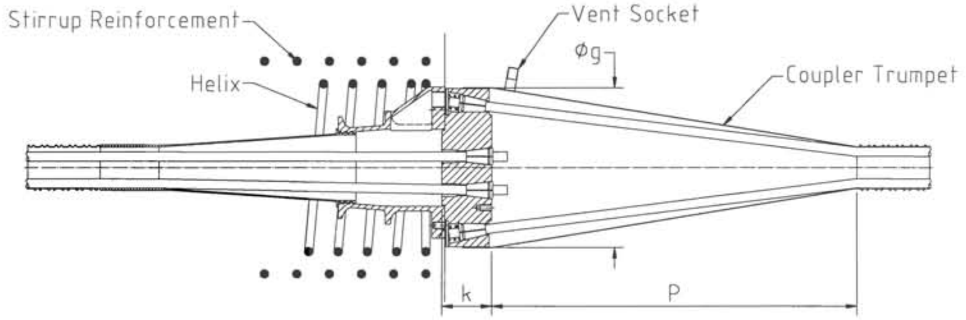
BBV Internal Bonded Strand
Post-Tensioning System

Annex 8

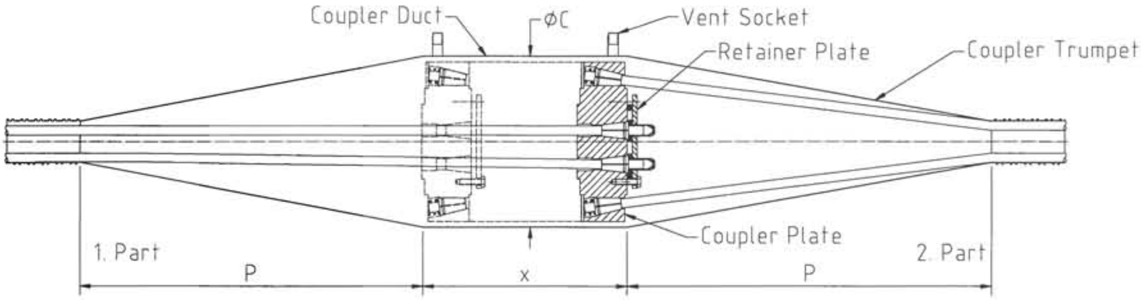
COUPLER (ÜK)



Fixed Coupler (FÜK)



Movable Coupler (BÜK)



Min. length of coupler duct: for one-end stressing $x = k + 1{,}15\,\Delta l + 30\text{mm}$
for both ends stressing $x = k + 1{,}15\,\Delta l + 60\text{ mm}$ (Δl = elongation)

Tendon type		L3	L4	L5	L7	L9	L12	L15	L19	L22	L27	L31
Coupler Plate												
Diameter a	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
Coupler Trumpet												
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

Anchor plate, trumpet, helix and reinforcement see Annexes 7 and 8

DIMENSIONS AND PROPERTIES OF 7-WIRE STRANDS

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	1520 or 1600*	
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

As long as EN 10138 does not exist 7-wire strands in accordance with national provisions and with the characteristics given in the table above shall be used.

* If admissible in the place of use, strands with higher characteristic yield stresses might be used, but not more than $f_{p0,1k}$ = 1560 N/mm² (Y1770 S7) or 1640 N/mm² (Y1860 S7).

MATERIAL OF COMPONENTS AND RELATED STANDARDS

Designation	Material	Material code	Standard
Bearing plates	S235JR	1.0038	EN 10025-2:2004
Cast-iron anchor bodies	deposited at Deutsches Institut für Bautechnik		
Wedges	deposited at Deutsches Institut für Bautechnik		
Anchor heads	C45+N	1.0503	EN 10083-2:2006
Couplers	C45+N	1.0503	EN 10083-2:2006
Springs for couplers	deposited at Deutsches Institut für Bautechnik		
Helixes for S, F, Fe, FÜK [1]	R_e = 500 MPa		EN 10080:2005-08
Additional reinforcement for S, F, Fe, FÜK (stirrups) [1]	R_e = 500 MPa		EN 10080:2005-08
Securing plates for wedges	S235JR	1.0038	EN 10025-2:2004
Trumpets	steel or PE deposited at Deutsches Institut für Bautechnik		
PE pipes and caps	PE deposited at Deutsches Institut für Bautechnik		
Corrosion protection mass Nontribus MP-2 [2] (grease)	deposited at Deutsches Institut für Bautechnik		
Corrosion protection mass Vaseline FC 284 [2] (wax)	deposited at Deutsches Institut für Bautechnik		
Corrosion protection mass Denso - Jet [2] (wax)	deposited at Deutsches Institut für Bautechnik		

The technical documentation of the components of this European Technical Approval is deposited at the Deutsches Institut für Bautechnik

1 deposited at Deutsches Institut für Bautechnik
2 corrosion protection mass (wax or grease) according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.1 or C4.2.

CONTENT OF CONTROL PLAN

Component	Item	Test/ Check	Traceability [4]	Minimum frequency	Documen-tation
Bearing plate for 3 to 9 strands	material	check	bulk	100 %	"2.2" [1]
	detailed dimensions[5]	test		3 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Cast-iron anchor body for 12 to 31 strands	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5% ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Anchor head	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Coupler	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Wedge	material	check	full	100 %	"3.1" [2]
	treatment, hardness	test		0,5 % ≥ 2 specimen	yes
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Duct	material	check	full	100 %	"CE"
	visual inspection[3]	check		100 %	no

Continuation of Control Plan and footnotes see Annex 13

CONTENT OF CONTROL PLAN - CONTINUED -

Component	Item	Test/ Check	Traceability [4]	Minimum frequency	Documentation
Tensile element strand	material [6]	check	full	100 %	yes
	diameter	test		each coil/bundle	no
	visual inspection[3]	check		each coil/bundle	no
Constituents of filling material as per EN 447	cement	check	full	100 %	yes
	admixtures, additions	check	full	100 %	yes
Helix	material	check	full	100 %	yes
	visual inspection[3]	check		100 %	no
Stirrups	material	check	full	100 %	yes
	visual inspection[3]	check		100 %	no
Springs for couplers	material	check	full	100 %	"2.2"[1]
	visual inspection[3]	check		100 %	no
Grease	material[7]	check	full	100 %	"2.2"[1]
Wax	material[8]	check	full	100 %	"2.2"[1]

All samples shall be randomly selected and clearly identified.

1 "2.2" : Test report type "2.2" according to EN 10204
2 "3.1" : Inspection certificate type "3.1" according to EN 10204
3 Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, smoothness, corrosion, coating, etc., as given in the Control Plan
4 full : Full traceability of each component to its raw material.
bulk : Traceability of each delivery of components to a defined point.
5 Detailed dimensions mean measuring of all dimensions and angles according to the specification as given in the Control Plan
6 Characteristic material properties see Annex 10
7 Grease according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.1
8 Wax according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.2

AUDIT TESTING

Component	Item	Test/ Check	Sampling - Number of components per visit
Anchor head	material according to specification	check, test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Cast-iron anchor body	material according to specification	check, test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Coupler	material according to specification	check, test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Wedge	material according to specification	check, test	2
	treatment	test	2
	detailed dimensions	test	1
	main dimensions, surface hardness	test	5
	visual inspection [1]	check	5
Single tensile element	ETAG 013 Annex E.3	test	1 series

1 Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, smoothness, corrosion, etc.

All samples shall be randomly selected and clearly identified.

DESCRIPTION OF THE BBV INTERNAL BONDED STRAND 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 Y1770 S7 or Y1860 S7 are allowed. Anchorages depending on the tendon sizes are identically for both steel grades.

TABLE I: The strands are bundled to the following tendons and stressing forces:

Steel Grade Nominal Diameter		Y1770 0.60"	Y1770 0.62"	Y1860 0.60"	Y1860 0.62"
Tendon Designation	No. of strands	P_{m0} [kN]	P_{m0} [kN]	P_{m0} [kN]	P_{m0} [kN]
BBV L 3	3	543	581	571	612
BBV L 4	4	724	775	762	816
BBV L 5	5	904	969	952	1020
BBV L 7	7	1266	1357	1333	1428
BBV L 9	9	1628	1744	1714	1836
BBV L 12	12	2171	2326	2285	2448
BBV L 15	15	2713	2907	2856	3060
BBV L 19	19	3437	3682	3618	3876
BBV L 22	22	3979	4264	4189	4488
BBV L 27	27	4884	5233	5141	5508
BBV L 31	31	5607	6008	5902	6324

Based on $f_{p0.1k}$ = 1520 N/mm² (Grade Y1770) and 1600 N/mm² (Grade Y1860)
P_{m0} = $0{,}85 \cdot f_{p0.1k} \cdot A_p$

The number of strands in a tendon can be reduced by omitting single strands always maintaining a symmetrical pattern.

TABLE II: Reduction of stressing force if one strand is omitted

ø	Steel Grade Y1770 S7		Steel Grade Y1860 S7	
	ΔP_{m0} [kN]	ΔP_0 [kN]	ΔP_{m0} [kN]	ΔP_0 [kN]
0.60"	181	192	190	201
0.62"	194	205	204	216

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 profiled corrugated ducts are used according to EN 523 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 tape.

DESCRIPTION OF THE BBV INTERNAL BONDED STRAND POST-TENSIONING SYSTEM

2. Anchorages

The anchorage with anchor plate or anchor body and anchor head is used as active anchor or accessible passive anchor. If the anchor head is tack welded to the anchor plate/anchor body and sealed, this type can also be used as an embedded anchorage. Within the anchorage zone the corrugated duct is replaced by a trumpet (PE or steel) with a larger diameter, in which the strands are deflected by a maximum of 2.6 ° or 2.1° respectively (see ETA clause 2.1.8). If using a steel trumpet, this one shall be equipped with a PE-inlet. Consecutive part is the anchor plate /anchor body and anchor head with 3 to 31 conical borings – depending on the tendon size – in which the strands are anchored with round wedges, each consisting of three segments.
For anchorage of dia. 0.62" strands wedges with marking "0.62" on the front face shall be installed. The wedges of the embedded passive anchors have to be sealed and secured by a retainer plate. The bursting forces caused by the load transfer to the concrete member shall be carried by a helix made of ribbed steel. Additional reinforcement such as straight bars or stirrups is required. At the fixed anchors without pre-wedging the slip is 4 mm. At the stressing anchors the slip is 3 mm (see ETA clause 4.2.5).

3. Couplers

Tendons can be coupled with fixed or movable couplers. The coupler consists of a coupler disc in which the strands of the arriving tendon are anchored in the same way as in the active anchor. The strands of the departing tendon are held in a radial pattern of conical borings and anchored by three-segment wedges in the coupler. These wedges are retained by a spring and a lock washer in their seating. The coupler is pre-assembled and consists of a coupler plate, a lock washer and a cover cap for the conical holes which is removed prior for installation of the tendon. The cones are filled with corrosion protection mass.
The correct position of the strands within the coupler is checked by marks on the strands.
During the stressing of the tendon a wedge slip of 4 mm occurs due to the seating of these wedges, if the arriving tendon is pre-wedged. Without pre-wedging the slip of a movable coupler is 8 mm (see ETA clause 4.2.5).

4. 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 easily done. 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.

5. Grouting

For bond and corrosion protection of the strands, the ducts are grouted after stressing. The grout is injected into the grouting cap or through grout pipes.
The ducts are vented at the ends of the tendons by means of venting pipes or grouting caps. Intermediate venting points are necessary in case of long tendons. Couplers are always equipped with vents. Grouting shall be executed in accordance with national regulations and standards.