Deutsches Institut für Bautechnik

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Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment ETA-08/0113 of 19 June 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	VBT - Unbonded Post-tensioning System with 1 to 6 strands
Product family to which the construction product belongs	PAC 16, Post-Tensioning kits (internal unbonded for strands)
Manufacturer	VBT Vorspann- und Brückentechnologie GmbH Nierenburger Straße 18 49497 Mettingen DEUTSCHLAND
Manufacturing plant	VBT Vorspann- und Brückentechnologie GmbH Nierenburger Straße 18 49497 Mettingen DEUTSCHLAND
This European Technical Assessment contains	30 pages including 23 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

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Specific Part

1 Technical description of the product

1.1 Definition of the construction product

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

VBT – Internal Unbonded Strand Post-Tensioning System

consisting of 1 to 6 strands with a nominal tensile strength 1770 N/mm² or 1860 N/mm² (Y1770 S7 or Y1860 S7 in according with prEN 10138-3, table 4), nominal diameter 15.7 mm (0.62" - 150 mm²), factory-equipped with a corrosion protection system consisting of corrosion-protection grease and extruded PE-sheathing with a 1.5 mm wall thickness, which are used in normal-weight concrete with the following anchorages (stressing and fixed anchorages and couplers):

1. Stressing (active) anchorage and fixed (passive) anchorage in the shape of multiple plane anchorages for tendons of 1 to 6 strands,
2. Fixed couplers on multiple plane anchorages for tendons with 1 strand,
3. Movable couplers for tendons with 1 strand.

Additional components of the present Post-tensioning system are:

4. Bursting reinforcement (helixes and additional reinforcement/stirrups),
5. Corrosion protection.

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

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

1.2 Strands

Only 7-wire strands shall be used in accordance with national provisions and with the characteristics 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 (strand)	d_p	mm	15.7
Nominal cross section (strand)	A_p	mm²	150
Nominal mass (strand)	M	g/m	1172
Individual wires			
External wire diameter	D	mm	5.2 ± 0.04
Core wire diameter	d'	mm	1.02 to 1.04 d

Only strands stranded in the same direction shall be used in a tendon. Further characteristic values of the strands see Annex A13.

1.3 Ring wedges

Ring wedges (see Annex A11) consisting of three parts are used. Single parts are fixed together by a spring ring.

1.4 Anchor heads and coupling heads

The anchor heads of stressing and fixed anchorages and couplers are identical. Differentiation is only needed due to execution of construction works.

The conical bores of anchor and coupling heads shall be deburred. For installation, they shall be clean, free from rust and provided with corrosion protection grease. The anchor and coupling heads have to comply with Annexes A2, A5 and A7.

1.5 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 B2, section 3.4.

Each end of the helix shall be welded to a closed ring. The welding of inner end of helix may be omitted if the length of helix is increased by 1½ additional turns.

1.6 Corrosion protection

The strand is provided in the factory of prestressing steel with a corrosion protection consisting of corrosion protection grease and extruded HDPE sheathing (see section 1.1).

1.7 Corrosion protection in anchorage and coupling zones

Application of corrosion protection in the anchorage and coupling zone shall comply with the assembly instructions in Annex 12. The cavity in the anchorage and coupling zone shall be completely filled with an corrosion protection grease. For this, the same grease as used for the employed prestressing steel strands shall be used.

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.

Specific details for installation and use are given in Annexes B1 and B2.

The test and assessment methods underlying this ETA lead to the assumption of a useful life of least 100 years. This useful life information cannot be construed as a warranty of the manufacturer, but it is an aid in selecting the right products for the expected economically reasonably life of the work.

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

No.	Essential characteristic	Performance (NPA = No Performance Assessed)
BWR 1: Mechanical restistance and stability		
1	Resistance to static load	The acceptance criterion to EAD 160004-00-0301 clause 2.2.1 is fulfilled, see Annex B
2	Resistance to fatigue	The acceptance criterion to EAD 160004-00-0301 clause 2.2.2 is fulfilled, see Annex B
3	Load transfer to structure	The acceptance criterion to EAD 160004-00-0301 clause 2.2.3 is fulfilled, see Annex B
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 160004-00-0301 clause 2.2.5 is fulfilled, see Annex B
6	Deviation/ deflection (limits) for external tendon	NPA
7	Assessment of assembly	The acceptance criterion to EAD 160004-00-0301 clause 2.2.7 is fulfilled
8	Resistance to static load under cryogenic conditions for applications with anchorage/coupling outside the possible cryogenic zone	NPA
9	Resistance to static load under cryogenic conditions for applications with anchorage/coupling inside the possible cryogenic zone	NPA
10	Material properties, component performance, system performance of plastic duct	NPA
11	Material properties, component performance, system performance of plastic duct to provide an encapsulated tendon	NPA
12	Material properties, component performance, system performance of plastic duct to provide an electrically isolated tendon	NPA
13	Corrosion protection	NPA

Monostrand, sheating base material		
14	Melt index	NPA
15	Density	NPA
16	Carbon black	NPA
17	Tensile strenght	NPA
18	Elongation	NPA
19	Thermal stability	NPA
Monostrand, manufactured sheating		
20	Tensile strenght	NPA
21	Elongation	NPA
22	Surface of sheating	NPA
23	Environtal stress cracking	NPA
24	Temperatur resistance	NPA
25	Resistance to externally applied agents (mineral oil, acid, base, solvents and salt water)	NPA
26	Sheating minimum thickness	NPA
Monostrand, manufactured monostrand		
27	External diameter of sheating	NPA
28	Mass of sheating per metre	NPA
29	Mass of filling material per metre	NPA
30	Alteration of dropping point caused by monostrand manufacturing	NPA
31	Alteration of oil separation caused by monostrand facturing	NPA
32	Impact resistance	NPA
33	Reibung zwischen Ummantelung und Litze	NPA
34	Leak tightness	NPA
BWR 2: Safety in case of fire		
35	Reaction to fire	NPA
BWR 3: Hygiene, health and the environment		
36	Content, emmission and/or release of dangerous substances	NPA

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 19 June 2018 by Deutsches Institut für Bautechnik

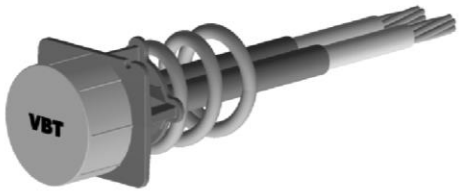
BD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Sultani

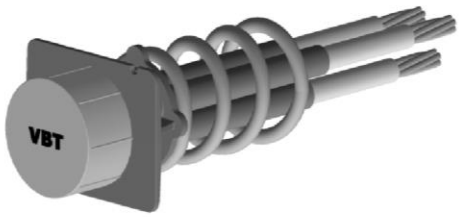
Deutsches Institut für Bautechnik DIBt

Stressing- / Fixed Anchorage VBT01

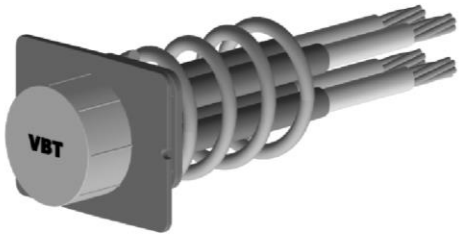
Stressing- / Fixed Anchorage VBT02



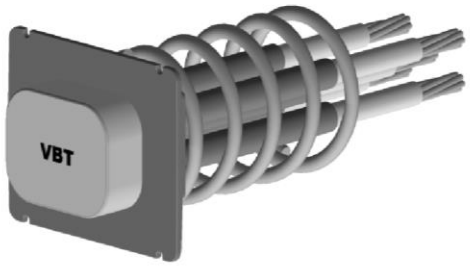
Stressing- / Fixed Anchorage VBT03



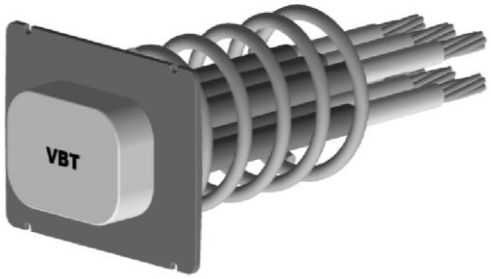
Stressing- / Fixed Anchorage VBT04



Stressing- / Fixed Anchorage VBT05



Stressing- / Fixed Anchorage VBT06



VBT - Unbonded Post-tensioning System with 1 to 6 strands

Description of the product
Overview - Types of Tendon

Annex A1

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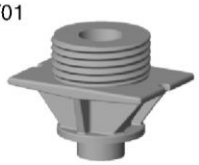
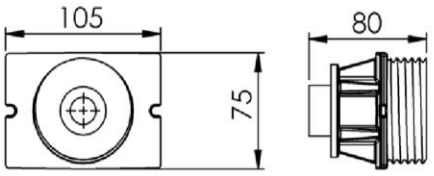
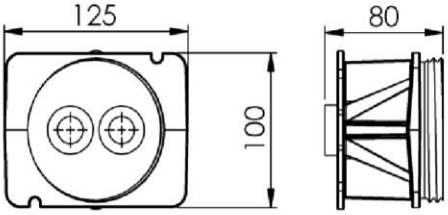
Stressing- / Fixed Anchorage VBT01

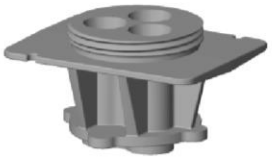


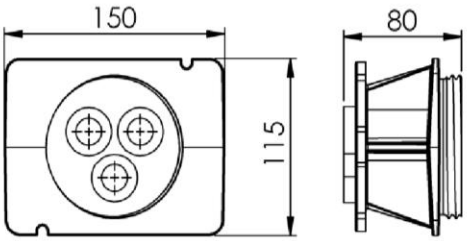


Stressing- / Fixed Anchorage VBT02

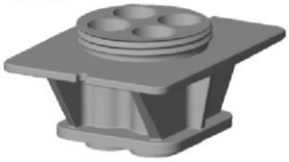


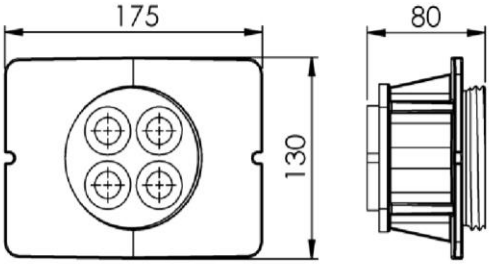
Stressing- / Fixed Anchorage VBT03



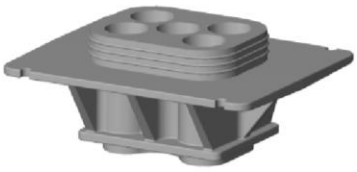


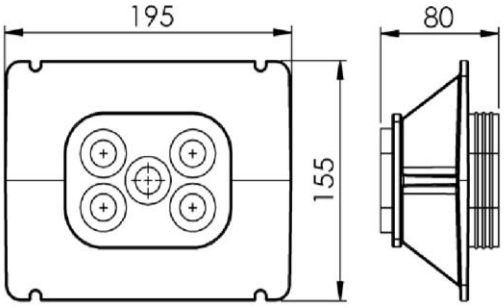
Stressing- / Fixed Anchorage VBT04



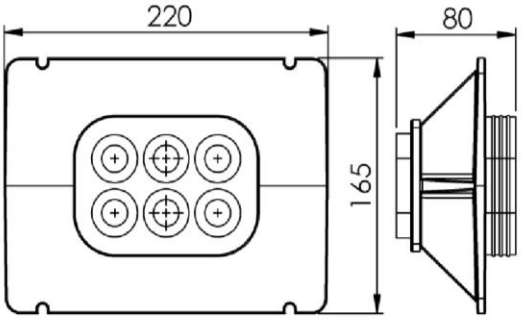


Stressing- / Fixed Anchorage VBT05





Stressing- / Fixed Anchorage VBT06



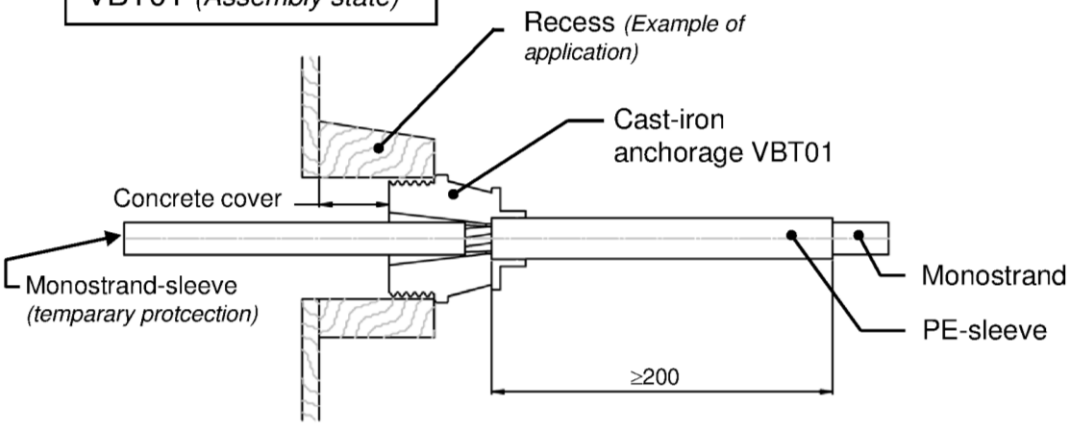
VBT - Unbonded Post-tensioning System with 1 to 6 strands

Annex A2

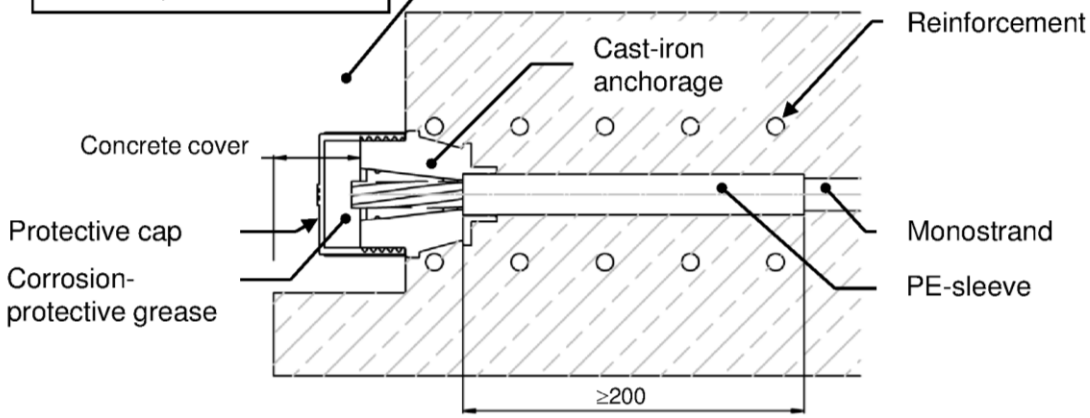
Description of the product
Overview - Anchorages

Deutsches Institut für Bautechnik DIBt

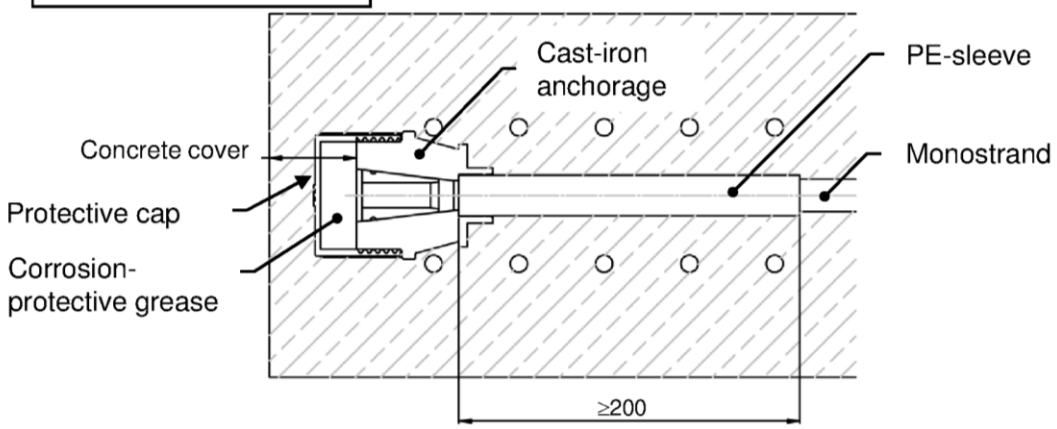
Stressing anchorage VBT01 *(Assembly state)*



Stressing anchorage VBT01 *(Prestressed condition)*



Fixed anchorage VBT01



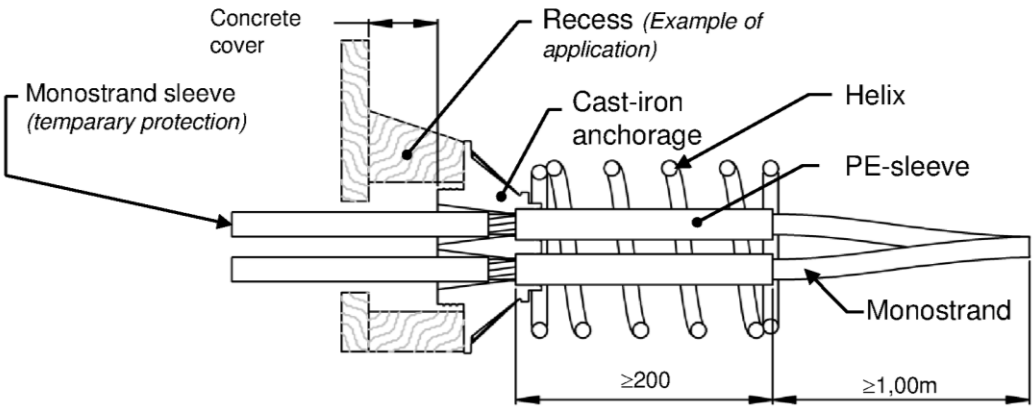
VBT - Unbonded Post-tensioning System with 1 to 6 strands

Description of the product
Stressing anchorage VBT01 and Fixed anchorage VBT01

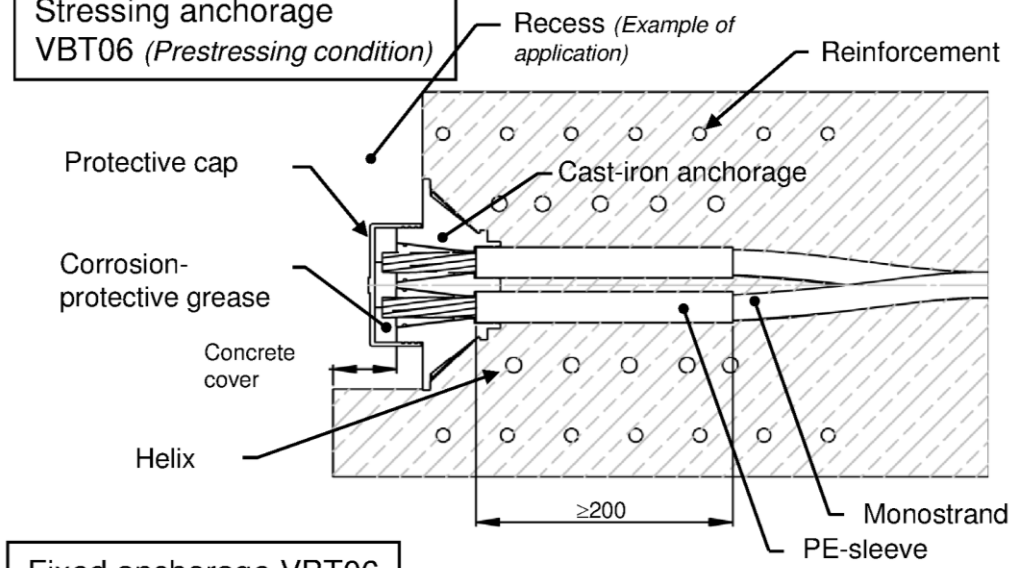
Annex A3

Deutsches Institut für Bautechnik DIBt

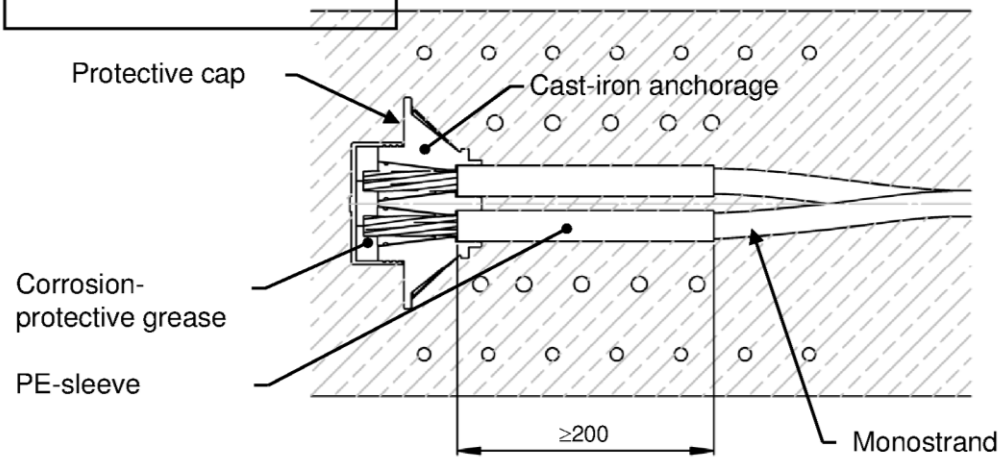
Stressing anchorage VBT06 *(Assembly state)*



Stressing anchorage VBT06 *(Prestressing condition)*



Fixed anchorage VBT06



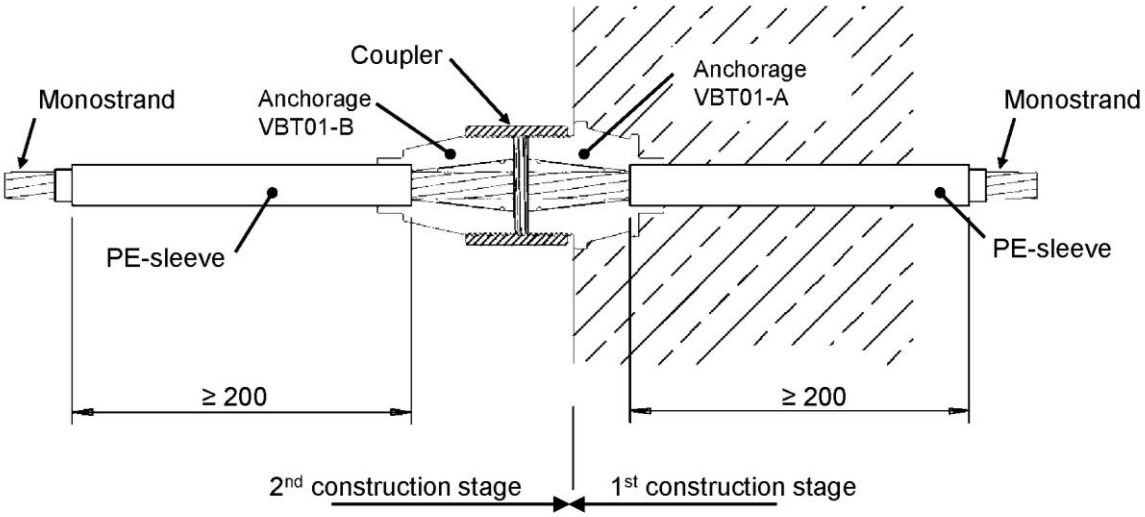
VBT - Unbonded Post-tensioning System with 1 to 6 strands

Description of the product
Stressing Anchorage VBT06 and Fixed Anchorage VBT06

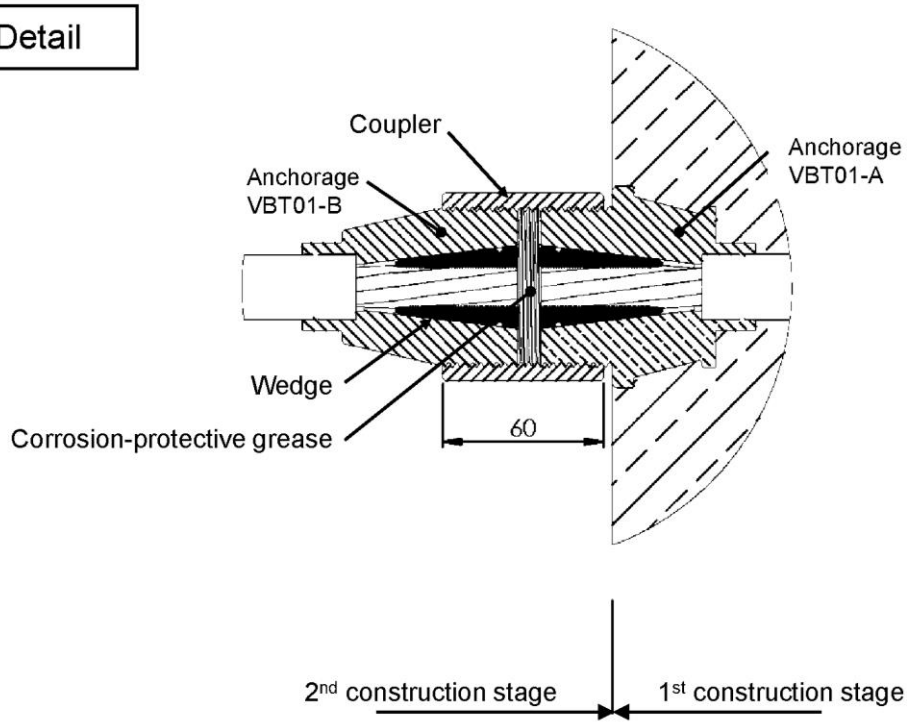
Annex A4

Deutsches Institut für Bautechnik DIBt

Fixed coupler VBT01



Detail



VBT - Unbonded Post-tensioning System with 1 to 6 strands

Description of the product
Fixed coupler VBT01

Annex A5

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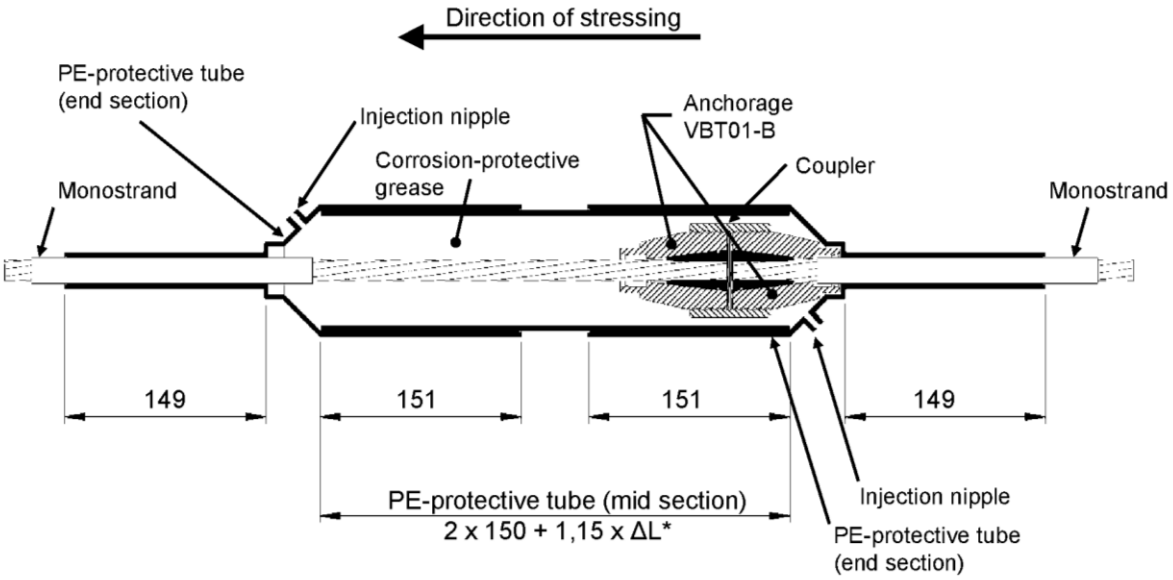
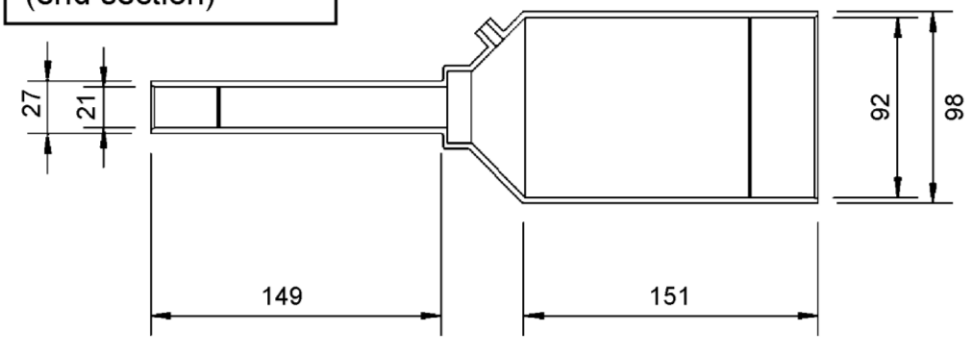
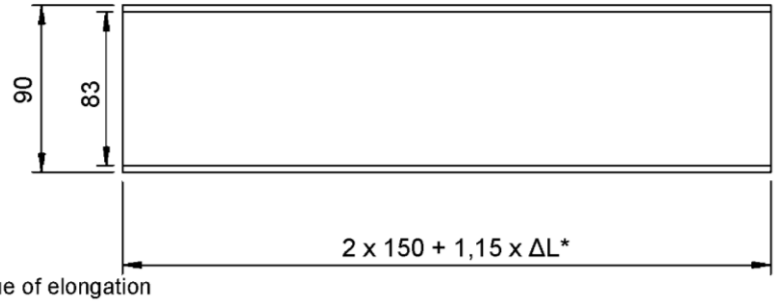
Movable coupler VBT01



PE-protective tube (end section)



PE-protective tube (mid section)

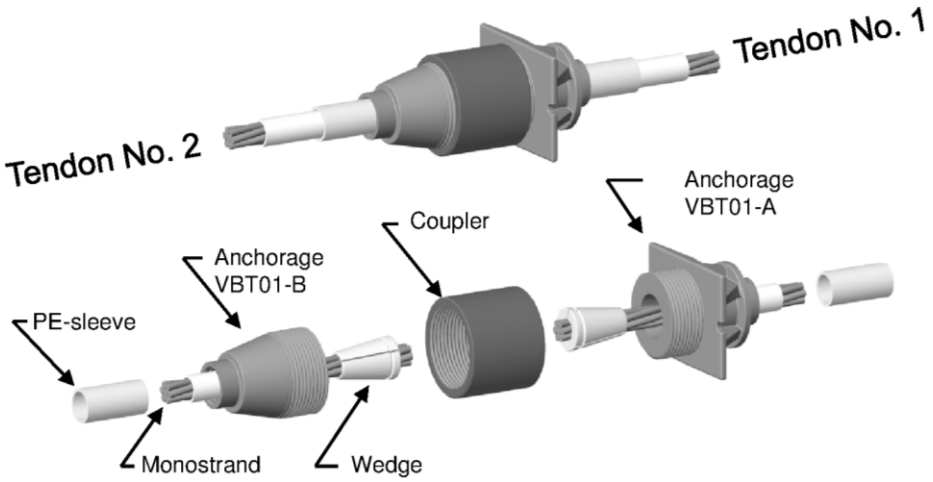


* ΔL = calculated value of elongation

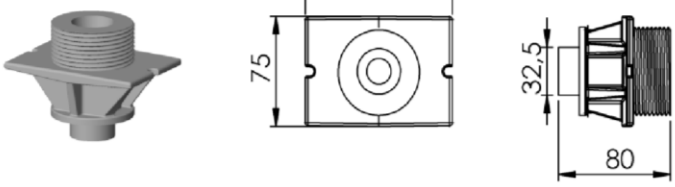
VBT - Unbonded Post-tensioning System with 1 to 6 strands	Annex A6
Description of the product Movable coupler VBT01	

Deutsches Institut für Bautechnik DIBt

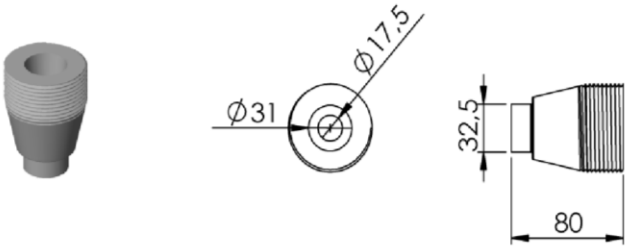
Fixed coupler VBT01



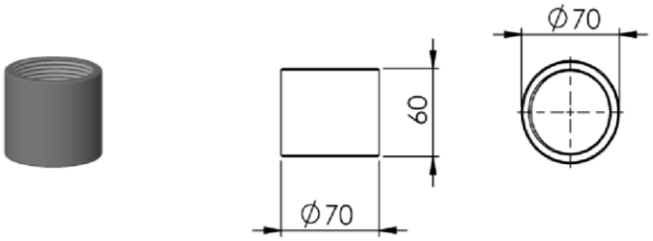
Anchorage VBT01-A



Anchorage VBT01-B



Coupler



All other Components
see Annex 11 und 13

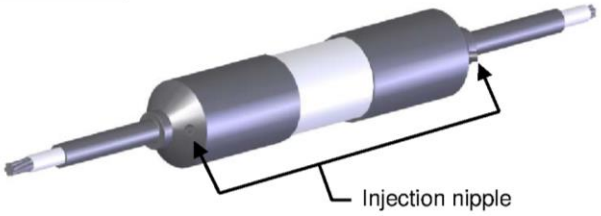
VBT - Unbonded Post-tensioning System with 1 to 6 strands

Description of the product
Fixed Coupler

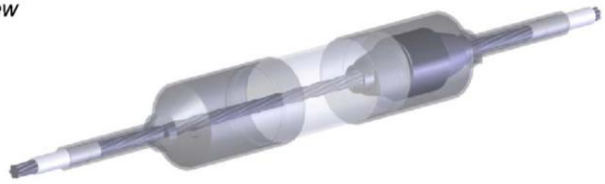
Annex A7

Deutsches Institut für Bautechnik DIBt

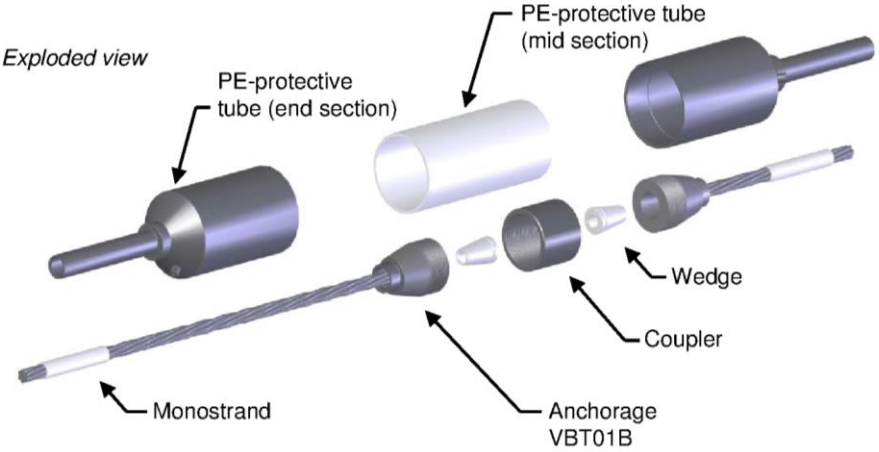
Movable coupler VBT01



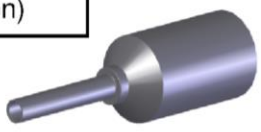
Transparent view

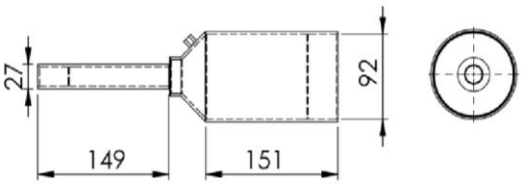


Exploded view

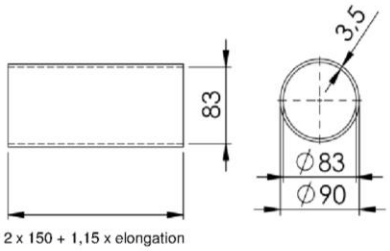


PE-protective tube (end section)





PE-protective tube (mid section)



All other components see Annex 11 und 13

VBT - Unbonded Post-tensioning System with 1 to 6 strands

Description of the product
Movable Coupler

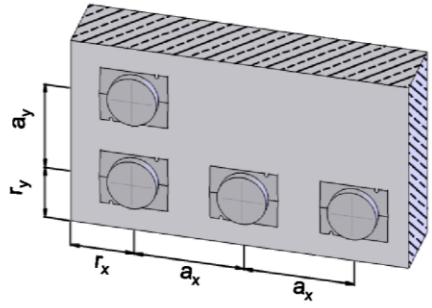
Annex A8

Deutsches Institut für Bautechnik DIBt

Tendon type		VBT01	VBT02	VBT03	VBT04	VBT05	VBT06
Anchor head	a	105	125	150	175	195	220
(see Annex 2)	b	75	100	115	130	155	165
	h	80	80	80	80	80	80
Concrete strength $f_{cm,0}$ at the time of stressing (cube 150)		for all concrete strength					
Helix	External-diameter		100	100	110	130	138
	Bar-diameter		14	14	14	14	14
	Max. lead		40	45	45	45	45
	No. of turns		3+1	4+1	4+1	5+1	5+1
Concrete strength $f_{cm,0}$ at the time of stressing (cube 150)		30 Mpa					
Center distance (min.)	a_x	160	195	225	270	280	320
	a_y	100	150	175	185	230	235
Additional reinforcement $f_{yk} \geq 500$ MPa	No. of layers *n*	5	6	6	7	8	9
	Bar-diameter	10	10	12	12	12	12
	Spacing *e*	50	45	50	45	45	45
Concrete strength $f_{cm,0}$ at the time of stressing (cube 150)		36 Mpa					
Center distance (min.)	a_x	150	180	220	250	280	310
	a_y	110	145	160	170	195	220
Additional reinforcement $f_{yk} \geq 500$ MPa	No. of layers *n*	4	6	6	7	8	8
	Bar-diameter	10	10	12	12	12	12
	Spacing *e*	50	40	50	45	45	45
Concrete strength $f_{cm,0}$ at the time of stressing (cube 150)		55 Mpa					
Center distance (min.)	a_x	135	155	200	220	230	250
	a_y	95	140	150	175	195	185
Additional reinforcement $f_{yk} \geq 500$ MPa	No. of layers *n*	4	5	6	6	7	7
	Bar-diameter	10	10	12	12	12	12
	Spacing *e*	50	45	45	45	45	45
Edge distances (min.)	r_x / r_y	0,5 x min. center distance + concrete cover - 10 mm					

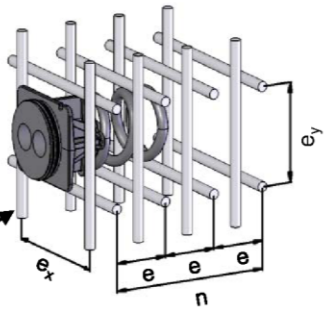
[mm]

Center- and Edge Distances



Additional Reinforcement

$e_x = a_x - 20$
$e_y = a_y - 20$



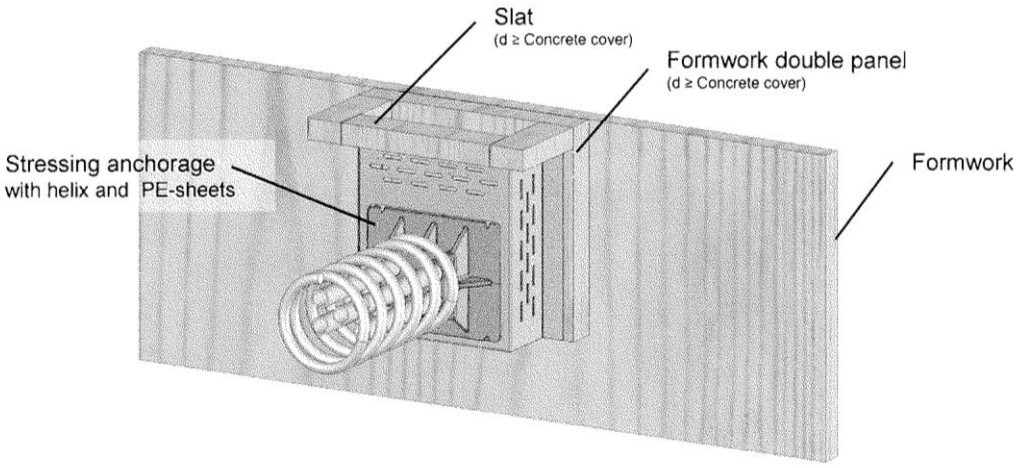
Stirrups or orthogonal reinforcement

VBT - Unbonded Post-tensioning System with 1 to 6 strands

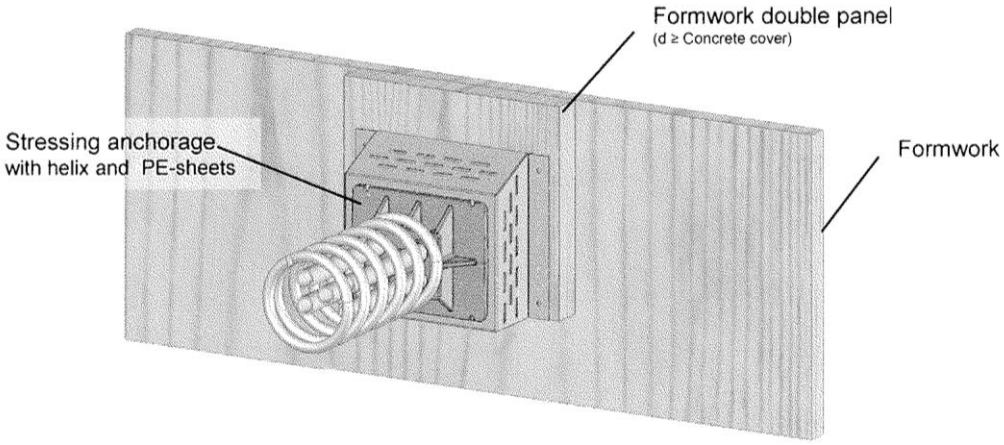
Description of the product
Technical Specification

Annex A9

Example No.1 of application:



Example No. 2 of application:



Material of recess plate: sloted steel plate t ≥ 2 mm

Recess plate, stressing anchorage and helix are connected by VBT and can be completely mounted on site.

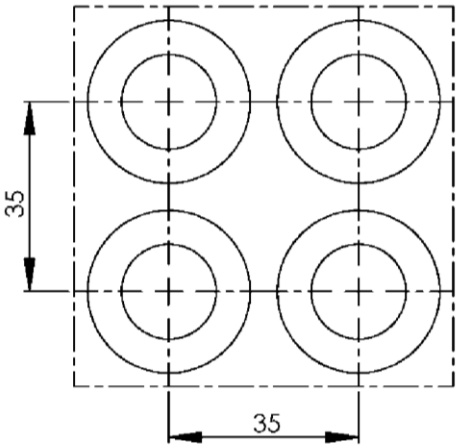
The dimensions of the recess plate cannot be smaller than the dimensions (a x b) of the stressing anchorage (s. Annex 2 and 9). The total depth of the recess amounts to at least 50 mm.

Alternatively the recess could be manufactured on site in the conventional method.

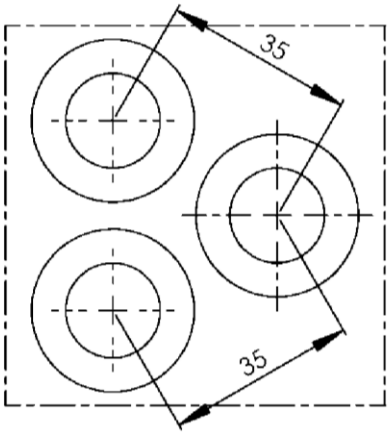
VBT - Unbonded Post-tensioning System with 1 to 6 strands	Annex A10
Description of the product Examples of application	

Deutsches Institut für Bautechnik DIBt

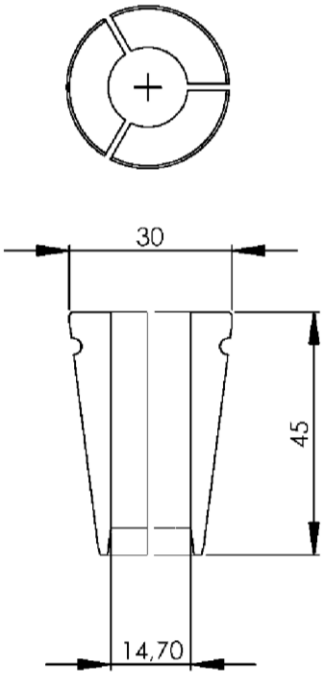
Cone image
VBT02, VBT04, VBT05, VBT06



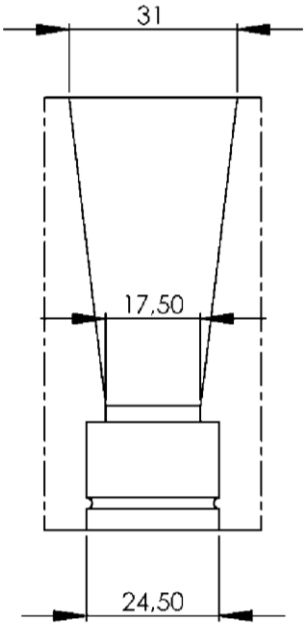
Cone image
VBT03, VBT05



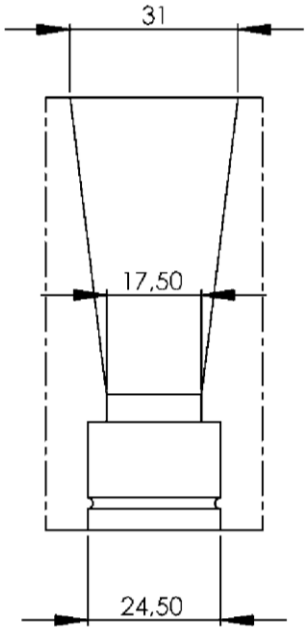
Wedge



Cone geometry



VBT01



VBT02 bis VBT06

The complete geometry is deposited at the DIBT.

VBT - Unbonded Post-tensioning System with 1 to 6 strands

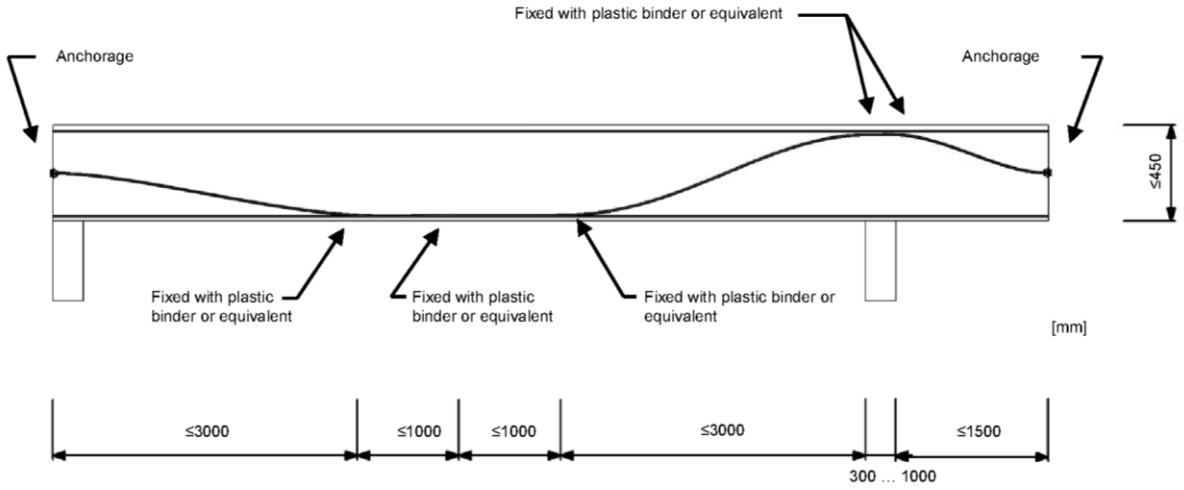
Description of the product
Geometrical Specifications

Annex A11

Deutsches Institut für Bautechnik DIBt

Tendon installation instructions

Free tendon layout, plate thickness ≤ 450mm



1. Installing the tendon anchorages (fasting onto the framework)
2. Installing the reinforcement (bottom layer) on spacers (and the spacers for tendon top layer)
3. Placing the tendons on the lower reinforcement (and on the spacers for tendon top layer)
4. Cutting the PE-sheathing to the required length
5. Inserting the tendons through the anchorages
6. Temparary protection of the strand protrusion with the cutted PE-sheatings
7. Connecting the tendons with the lower reinforcement
8. Installing the upper reinforcement
9. Lifting up and connecting the tendons to the upper reinforcement, if no spacers for tendons are installed
10. Supervising the correct seat of the anchors and of the PE-sleeves before concreting

VBT - Unbonded Post-tensioning System with 1 to 6 strands	Annex A12
Description of the product Tendon installation instructions - Free tendon layout	

Deutsches Institut für Bautechnik DIBt

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

* If admissible in the place of use, strands with higher characteristic yield stresses might be used, but not more than $f_{p0,1k} \geq 1560$ MPa (Y1770S7) or 1640 MPa (Y1860S7).

As long as prEN 10138-3:2009-08 has not been adopted 7-wire strands in accordance with national provisions and with the characteristics given in the table above shall be used.

1 Intended use

The Post-Tensioning System is intended to be used for the prestressing of structures of normal-weight concrete with internal unbonded tendons.

Categories of use according to type of tendon and material of structure:

- Internal unbonded tendon for concrete and composite structures.
- For special structures according to EN 1992.

The structural members are to be designed in accordance with national regulations.

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.

2 Methods of verification

2.1 General

The structural members prestressed by means the VBT Internal Unbonded Strand Post-Tensioning System 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). 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).

Overstressing is permitted if the force in the prestressing jack can be measured to an accuracy of ± 5% of the final value of the prestressing force. The maximum overstressing force P_{max} applied to a tendon shall not exceed the force $P_{max} = 0.95\ A_p\ f_{p0,1k}$ (see Table B 1).

Table B1: Maximum prestressing forces[1] for tendons with A_p = 150 mm²

Tendon Designation	Number of strands	Cross section area A_p [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²			Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²		
			$P_{m0}(x)$ [kN]	P_{max} [kN]	P_{max} (overs.) [kN]	$P_{m0}(x)$ [kN]	P_{max} [kN]	P_{max} (overs.) [kN]
VBT 01	1	150	194	205	217	204	216	228
VBT 02	2	300	388	410	433	408	432	456
VBT 03	3	450	581	616	650	612	648	684
VBT 04	4	600	775	821	866	816	864	912
VBT 05	5	750	969	1026	1083	1020	1080	1140
VBT 06	6	900	1163	1231	1300	1224	1296	1368

[1] The forces stated are maximum values. The actual values are to be found in national regulations valid on place of use. Compliance with the stabilisation and crack width criteria in the load transfer test was verified to a load level of 0.80 F_{pk}.

2.3 Radius of curvature of the tendons in the structure

The smallest admissible radius of curvature of the tendons is 2.6 m.

If this radius is adhered to, verification of prestressing steel outer fibre stresses in curvatures is not required.

2.4 Concrete strength

Concrete complying with EN 206-1:2000, EN 206-1/A1:2004 and EN 206-1/A2:2005 shall be used.
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 2. The mean concrete strength shall be verified by means of tests at least three specimens (cylinder or cube with the edge length of 150 mm or cylinder with diameter of 15 mm and height of 300 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 B2: Necessary mean concrete strength f_{cmj} of the specimens at time of prestressing

$f_{cmj,cube}$ [N/mm²]	$f_{cmj,cyl}$ [N/mm²]
30	25
36	29
55	45

For partial prestressing with 30 % of the full prestressing the minimum value of the concrete compressive strength to be proven is 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 centre and edge distances of the tendon anchorages shall not be less than the values given in the Annex 9 depending on the actual mean concrete strength.

The values of the centre or edge distances of the anchorages given in the Annex 9 may be reduced in one direction up to 15 %, however, not to a lesser value than the minimal distance between the additional reinforcing bars or the external diameter of the helix plus 2 cm. In this case the centre or edge distances of the anchorages in the other direction shall be increased for keeping the same concrete area in the anchorage zone. The dimensions of the additional reinforcement shall be adjusted accordingly.

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

The concrete cover may under no circumstance be less than 20 mm nor smaller than the concrete cover of the reinforcement installed in the same cross section. The concrete cover of the anchorage should be at least 20 mm. Standards and regulations on concrete cover valid in place of use shall be considered.

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 the helix and the additional reinforcement 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 Annex A9. From the given amount of additional reinforcement 50 kg reinforcement steel/m³ concrete may be taken into account as part of the statically required reinforcement. Existing reinforcement in the area under consideration in excess to the reinforcement required by design may be taken into account as additional reinforcement. The additional reinforcement shall consist of closed stirrups (stirrups closed by means of bends or hooks or an equivalent method) or of orthogonal reinforcement properly anchored. The stirrups locks (bends or hooks) shall be placed staggered.

In the anchorage zone vertically led gaps shall be provided for proper concreting and compacting. If in exceptional cases[2] – 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 calculated influence of the wedge slip at the anchorages is 4 mm and shall be taken into account in the static calculation and the determination of the tendon elongation.

2.8 Fatigue resistance

With the fatigue tests for the anchors and couplers carried out in accordance with EAD 160004-00-0301, the stress range of 80 N/mm² of the stands at the maximum stress of 0.65 f_{pk} at 2 x 10^6 load cycles was verified.

2.9 Stressing recess and safeguard against bursting out

The stressing recess shall be designed to ensure a concrete cover of at least 20 mm at protective caps in the final state. Prevention of bursting out of prestressing steels in case of failure shall be ensured.

Sufficient protection shall be provided by e.g. a cover of reinforced concrete or equivalent measures.

2.10 Couplers

Under the possible load combinations the prestressing force acting on the couplers (see Annexes A5 and A7) in the second installation stage may at no time be greater than the prestressing force acting on the coupler in the first installation phase either during installation or in the final state.

2.11 Verification of load capacity for sectional forces in construction transverse

Verification has to made according to EN 1992-1-1:2011, clause 6.2.3 (6) with a reduced width of installation part whereby ϕ in equation (6.17) corresponds to the sum of the diameter of monostrands lying side by side.

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

3. Installation

3.1 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 the VBT-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 and CWA 14646:2003 shall be considered.

The manufacturer is responsible for informing all parties involved about the use of the VBT Post-tensioning system. Supplementary technical documents are issued by the manufacturer if required.

The tendons and the components shall be handled carefully.

3.2 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 the central position the helix may be attached to the anchor body by welding.

c) The recess plate may be attached to the anchor body by welding for the manufacturing of a recess in due form.

Each end of the helix may be welded to a closed ring. Welding of the helix's final turn can be omitted on the inner ends if the helix is extended by 1½ additional turns, on the outer ends if the end turns are welded to anchor body.

After mounting the tendons no more welding shall be performed at the anchorages and in the immediate vicinity of the tendons.

3.3 Support and fixing of the tendon

The tendons have to be supported every 1 m at maximum and be fixed with plastic bands.

By free tendon layout the mounting distances according Annex A12 are valid. Prestressing forces due to free tendon layout may be considered for the evidence of serviceability limit states. The evidence of ultimate limit states shall be carried out without consideration of prestressing forces due to this kind of prestressing.

3.4 Installation of the tendon

The central position of the helix or stirrups shall be ensured by appropriate mountings. The anchor bodies shall be in direction perpendicular to the axis of the tendon.

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

The wedges of fixed anchorages and couplers part B of fixed and movable couplers shall be secured by means of pre-wedging with special hydraulic jacks with a force of 0.9 f_{pk} A_p and be closed with PE protective caps that are filled with the same corrosion protective grease as the strands. In the case of pre-wedging no slip shall be taken into account for the determination of elongation.

At stressing anchorages and couplers part A of fixed couplers the slip is 4 mm and shall be taken into account for the determination of elongation.

During installation of the wedges into the cones all relevant surfaces and gaps shall be greased with corrosion protection grease. The corrosion protection grease shall comply with EAD 160027-00-0301.

The protective caps for the tendon ends that are filled with corrosion protective grease have to be screwed on and fitted to the fixed anchorages before concreting and to the stressing anchorages before closing the stressing recess. Before connecting the coupler part B the cavity between two coupling heads has to be filled with corrosion protective grease (see Annexes A5, A6 and B3).

3.6 Tensioning and stressing records

3.6.1 Tensioning

At time of stressing the minimum mean concrete strength shall comply with the values given in Annex B1, section 2.4.

It is admissible to re-stress the tendons by releasing and re-using the wedges. After re-stressing and anchoring, wedge marks on 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) depends on the jack which is used on site.

3.6.2 Stressing record

All stressing operations shall be recorded for each tendon. In general, the required prestressing force shall be achieved. The elongation is measured and compared with the calculated value.

If during tensioning the difference between measured and calculated elongation or tensioning force is more than 5 % for the sum of all tendons at the cross or 10 % for a single tendon of the calculated value then the engineer responsible for the prestressing process shall be informed and the causes for the deviation shall be found.

Local standards and national regulations valid in place of use shall be considered.

3.6.3 Prestressing jacks and space requirements, safety-at-work

For prestressing, hydraulic jacks are used. Information about the stressing equipment has been submitted to Deutsches Institut für Bautechnik.

To stress the tendons, a minimal clearance according from the system holder given dimensions shall be considered directly behind the anchorages.

The safety-at-work and health protection regulations shall be complied with.

3.7 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 tendons may be wand to a coil with a minimum internat of 1.50 m or as specified by the manufacturer of the monostrand.

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4 Description of the VBT – Unbonded Monostrand System

4.1 Prestressing steel

The prestressing steel of the tendons consists of 7-wire prestressing steel strands 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. These are factory provided with a corrosion protection system consisting of corrosion protective grease and PE - sheath.

4.2 Manufacturing

The tendons are produced in the VBT-factory and rolled up or supplied rectilinearly to the construction site. If the stressed from one side, than the fixed anchor is mounted onto the strand at the VBT-factory und wedged hydraulically.

4.3 Anchorages

Anchorages are made in the VBT-factory with PE-sleeves and helixes.

4.3.1 Stressing- and fixed anchors VBT01 to VBT06

The stressing anchor VBT01-A can be combined with the anchor VBT01-B to a coupling (see Annex A5, A6, A7 and A8).

The stressing anchorages VBT01, VBT02, VBT03, VBT04, VBT05, or VBT06 are fortified to the roof boards and connected with the monostrand.

Construction site arrangement consists of the following operation steps:

The stressing anchor is fixed at the roof boards. The monostrand is laid down at the anchoring and marked at the dismantling point. The interface is to be marked in a way that the PE-sheathing extends at least 10 cm into the PE- sleeve. The PE-sheathing is then cut at the marking and removed. The monostrand is passed through the PE - sleeve and the cast lever and the cutted PE-sheathing is shifted to the temporary protection onto the surviving braid.

The stressing act requires the following operation steps:

After hardening of the concrete construction of the provisional PE sheathing are removed from the strand protrusion. The cavities in the anchoring are filled with corrosion protective grease. The wedges are shifted into the cone openings of the anchoring and after the stressing act pressed in hydraulically. The cutting of the strand protrusion is done by a separating-device. Finally, the PE-protective cap filled with corrosion protective grease is mounted or a direct protection of the monostrand cross-section and the wedge back is made with duration-elastic corrosion reduction mass.

4.3.2 Fixed coupling VBT01-A and VBT01-B

Fixed couplings are used for joining non-stressed tendons to stressed tendons (Annex A5 and A 7).

Site assembly comprises the followings steps:

Removing the protection from the thread of the stressing anchor VBT01-A. The anchor VBT01-B with the screwed coupler is placed at the stressing anchor VBT01-A and screwed down the coupler 15 mm of the lever VBT01-B. The space in the coupler is filled with corrosion protective grease. The coupler of the lever VBT01-B is screwed to completely onto the thread of the pre biased stressing anchor VBT01-A.

4.3.3 Movable coupling VBT01-A and VBT01-B

The movable coupling is used for joining non-stressed tendons (Annex A6 and A8).

Site assembly comprises the followings steps:

Preliminary operation steps at the tendon no. 1:

Removing approx. 10 cm of the monostrand PE-sheathing and placing the PE protective tube on the monostrand. The anchor VBT01-B is mounted onto the monostrand and the wedge is pressed hydraulically into the anchorage VBT01-B (compressive force 110 kN). The previously mentioned operation steps can be factory assembled.

Preliminary operation steps at the tendon no. 2:

At tendon 2 follow same procedure as for tendon 1.

Coupling of the tendons 1 and 2:

The coupler is screwed complete onto the anchor VBT01 -B of the tendon no. 1, then the coupler is screwed back around 15 mm. The resulting gap in the coupler is then filled with protective grease. The PE protective tube (mid section) is shifted onto tendon no. 2 and the coupler of the anchor VBT01-B at tendon no. 1 is completely screwed onto the thread of the stressing anchor VBTO1-B at the tendon no. 2.

Corrosion protection:

Connecting both PE protective tubes (end section) with the PE central protective tube. The connected PE protective tubes are shifted in the direction of the stressing anchoring (stressing jack) up to the anchor VBT01-B at the tendon no. 1, so that the anchoring components can move during the stressing process in same measure as the extension at the coupling region.

Corrosion protective grease is pressed into the injection nipples of the PE protective tubes until it emerges from the circular gap between the monostrand and the PE protective tube. Finally, the PE protective tubes are cleaned and the transition regions of monostrand – PE protective tube is covered with adhesive tape of least 5 cm width.

If PE protective tubes with a length of more than 1.50 m are installed with the movable couplers, handling tests for injection of the corrosion protective grease have to be carried out.

4.4 Stressing operation and Stressing records

4.4.1 Stressing operation

Full stressing can be applied with a mean concrete cub strength in the anchorage zone of $f_{cm,0}$ in accordance with Annex A9. Restressing of tendons before final cutting of the strand protrusions in combination with release and reuse of wedges is allowed. After restressing and anchoring, wege marks on the strand, resulting from the preceding stressing operation. Shall be located at least 15 mm from the wedges in the outward direction.

4.4.2 Stressing records

All stressing operations have to be recorded for each tendon. Primarily, prestressing is performed up to the required force. For checking, the elongation is measured and comparing by confirming it with the calculated value.

4.5 Prestressing jacks and space requierments

Handy hydraulic prestressing jacks are used. For prestressing of single or multistrand anchores a free space of approx.. 1.00 m is required behind the ancorages. The dimension of the instep niches must allow the possibility of cutting the strand protrusion after stressing.

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1. Losses due to friction and wobble effects

For design shall be considered EN 1992-1-1, clause 5.10.5.2.

The losses of the prestressing force due to friction and wobble effects may normally be determined in the calculation by using the friction coefficients $\mu = 0.06$ and the unintentional angular displacement $k = 0.5°/m$ (wobble coefficient).

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Material of Components

Components	**Norm**
Wedge	deposited at Deutsches Institut für Bautechnik
Stressing- and fixed anchorages VBT01 - VBT06	EN 1563:2012-03
Coupling anchorages VBT01-A and VBT01-B	EN 1563:2012-03
Coupler	EN 10210-1:2006-07
Helix	EN 10025-1:2005-02
Additional reinforcement	DIN 488-1:2009-08 DIN 488-2:2009-08
PE-sleeve	EN ISO 17855-1:2014-10 EN ISO 17855-2:2016-06
PE-protective tube	DIN EN ISO 17855-1:2015-02 DIN EN ISO 17855-2:2016-06
Corrosion protective grease	EAD 160027-00-0301

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

Deutsches Institut für Bautechnik DIBt

Codes and References

prEN 10138-3:2009-08	Prestressing Steels – Part 3: Strand
EAD 160004-00-0301:2016-09	European Assessment Document - Post-Tensioning Kits for Prestressing of Structures
EAD 160027-00-0301:2016-09	European Assessment Document – Special Filling Products for Post-Tensioning Kits
EN 206-1:2001-07	Concrete – Part 1: Specification, Performance, Production an Conformity
EN 206-1/A1:2004-10	Concrete – Part 1: Specification, Performance, Production an Conformity; German Version EN 206-1:200/A1:2004
EN 206-1/A2:2005-09	Concrete – Part 1: Specification, Performance, Production an Conformity; German Version EN 206-1:200/A2:2005
CWA 14646:2003-01	Requirements for the installation of post-tensioning kits for prestressing of structures and qualification of the specialist company and its personnel
EN 1992-1-1:2011-01+A1	Eurocode 2: Design of concrete structures – Part 1-1: Gereral rules for buildings; German version EN 1992-1-1:2004/A1:2014
EN 1563:2011-12	Founding – Spheroidal graphite cast irons; German version EN 1563:2011
EN 10210-1:2006-07	Hot finished structural hollow sections of non-alloy and fine grain steels – Part 1: Technical delivery conditions; German version EN 10210-1:2006
EN 10025-1:2005-02	Hot rolled products of structural steel – Part 1: General technical delivery conditions; German version EN 10025-1:2004
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