Deutsches Institut für Bautechnik

Zulassungsstelle für Bauprodukte und Bauarten

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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-08/0113

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Handelsbezeichnung *Trade name*	VBT - Monolitzenspannverfahren intern ohne Verbund mit 1 bis 6 Monolitzen *VBT - Unbonded Post-tensioning System with 1 to 6 strands*
Zulassungsinhaber *Holder of approval*	VBT Vorspann- und Brückentechnologie GmbH Nierenburger Straße 18 49497 Mettingen DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	VBT - Monolitzenspannverfahren intern ohne Verbund mit 1 bis 6 Monolitzen zur Vorspannung von Tragwerken *VBT - Post-tensioning kit for prestressing of structures with internal unbonded 1 to 6 strands*
Geltungsdauer: vom *from*	23 June 2008
bis *to*	23 June 2013
verlängert vom *extended from*	18 June 2013
bis *to*	18 June 2018
Herstellwerk *Manufacturing plant*	VBT Vorspann- und Brückentechnologie GmbH Nierenburger Straße 18 49497 Mettingen DEUTSCHLAND

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

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 Article 2 of the law of 8 November 2011[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.

4 This European technical approval may be withdrawn by Deutsches Institut für Bautechnik, in particular pursuant to information by the Commission according to Article 5(1) of Council Directive 89/106/EEC.

5 Reproduction of this European technical approval including transmission by electronic means shall be in full. However, partial reproduction can be made with the written consent of Deutsches Institut für Bautechnik. In this case partial reproduction has to be designated as such. Texts and drawings of advertising brochures shall not contradict or misuse the European technical approval.

6 The European technical approval is issued by the approval body in its official language. This version corresponds fully to the version circulated within EOTA. Translations into other languages have to be designated as such.

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 2011*, p. 2178
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:

VBT – Internal Unbonded Strand Post-Tensioning System

consisting of 1 to 6 strands with a nominal tensile strength of 1770 MPa or 1860 MPa (Y1770 S7 or Y1860 S7), with a 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, which are used in normal-weight concrete with the following anchorages (stressing and fixed anchorages and couplers; see Annexes 1, 7 and 8):

1 Stressing (active) anchorage and fixed (passive) anchorage in the shape of multiple plane anchorages for tendons of 1 to 6 strands (see Annex 1),

2 Fixed couplers on multiple plane anchorages for tendons with 1 strand (see Annex 7),

3 Movable couplers for tendons with 1 strand (see Annex 8),

4 Bursting reinforcement (helixes and additional reinforcement/stirrups),

5 Corrosion protection.

The anchoring of the strands in anchorages and couplers is done by ring wedges.

1.2 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.

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.

[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.

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 Designation

End anchorages can be used as stressing and fixed anchorage, while couplers may be fixed or movable couplers.

e.g. VBT06 – 150 – 1860

The first number of the designation of components of anchorages and couplings (06) identifies the number of strands. The nominal cross section area of single strand is given by the following number (e.g. "150" for 150 mm²) and the strength of strands is given by the last number (e.g. "1860" for Y1860 S7).

2.1.3 Strands

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

Table 1 Characteristic of 7-wire strands in accordance with prEN 10138-3:2004-03

Designation of strand			**Y1770S7**	**Y1860S7**
Tensile strength	R_m	MPa	1770	1860
Diameter	d	mm	15.7	
Nominal cross section area	A_p	mm²	150	
Nominal mass per metre	M	g/m	1,172	
Permitted deviation from nominal mass		%	± 2	
Characteristic value of maximum force	F_{pk}	kN	266	279
Maximum value of maximum force	$F_{m,max}$	kN	305	321
Characteristic value of 0.1% proof force	$F_{p0.1k}$	kN	228	240
Minimum elongation at maximum force with $L_0 \geq 500$ mm	A_{gt}	%	3,5	
Relaxation after 1000 h				
at 0.7 f_{pk}		%	2,5	
at 0.8 f_{pk}		%	4,5	
Modulus of elasticity	E_p	MPa	195,000	

If the use of strands with $R_m = 1860$ MPa is intended on site, these shall be used there exclusively.

2.1.4 Ring wedges

Ring wedges (see Annex 11) consisting of three parts are used. Single parts are fixed together by a spring ring.

2.1.5 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 2, 5 and 7.

2.1.6 Helixes and additional reinforcement / stirrups

The steel grades and dimensions of the helixes and of the additional reinforcement shall comply with the values given in the Annexes. The central position in the structural concrete member on site shall be ensured according the section 4.2.4.

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.

2.1.7 Corrosion protection

The strand is provided in the factory of prestressing steel with a corrosion protection consisting of corrosion protection grease and extruded HDPE sheating (see section 2.1.2).

2.1.8 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 14. 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.

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.

2.2 Methods of verification

2.2.1 General

The assessment of the fitness of the VBT Internal Unbonded Strand Post-Tensioning System for the intended use in the 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 kit 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 VBT Internal Unbonded Strand Post-Tensioning System used to be designed in accordance with national regulations.

2.2.2 Tendons

Prestressing and over-tensioning forces are specified in the respective provisions.

The maximum force P_0 in accordance with EN 1992-1-1:2005, clause 5.10.2.1, equation 5.41 applied to a tendon shall not exceed the force $P_{0,max}$ laid down in Table 2. The value of the initial prestressing force P_{m0} immediately after tensioning and anchoring in accordance with EN 1992-1-1:2005, clause 5.10.3, equation 5.43 shall not exceed the force $P_{m0,max}$ laid down in Table 2.

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. In such case the value of maximum prestressing force P_{max} in accordance with EN 1992-1-1:2005, clause 5.10.2.1(2) shall not exceed the force P_{max} laid down in Table 2.

Table 2: Maximum prestressing forces[8] 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		
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	P_{max} [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	P_{max} [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

2.2.3 Losses of the prestressing force due to friction and wobble effects

For design shall be considered EN 1992-1-1:2004, 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 μ = 0.06 and the unintentional angular displacement k = 0.5°/m (wobble coefficient).

2.2.4 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.

2.2.5 Concrete strength

Concrete complying with EN 206-1 shall be used.

At the time of transmission of the full prestressing force to the concrete member the mean concrete strength in the anchorage zone shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Table 3. The mean concrete strength ($f_{cmj,cube}$ or $f_{cmj,cyl}$) shall be verified by means of at least three specimens (cube with the edge length of 150 mm or cylinder with diameter of 150 mm and height of 300 mm), which shall be stored under the same conditions as the concrete member, with the individual values of specimens not differ no more than 5 %.

Table 3: Necessary mean concrete strength f_{cmj} of the specimens at time of prestressing for anchorages

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

[8] 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}.

For partial prestressing with 30 % of the full prestressing force the actual mean value of the concrete compressive strength to be proved is 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values may be interpolated linearly.

2.2.6 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.

2.2.7 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 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 Annexes. 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[9] – 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 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.

2.2.9 Resistance to fatigue of the anchorages and couplers

With the fatigue tests carried out in accordance with ETAG 013, the stress range of 80 MPa of the anchorages and couplers at the maximum load of 0.65 f_{pk} at 2 x 10^6 load cycles was verified.

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

2.2.10 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.

2.2.11 Couplers

Under the possible load combinations the prestressing force acting on the couplers (see Annexes 5 and 7) 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.

2.2.12 Verification of load capacity for sectional forces in construction transverse

Verification has to made according to EN 1992-1-1:2005, 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.

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[10] system 1+ of the attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 1+: Certification of the conformity of the product by an 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 for the manufacturer

3.2.1.1 Factory production control

The kit manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the kit 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 kit manufacturer may only use initial materials stated in the technical documentation of this European technical approval.

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

The factory production control shall be in accordance with the "control plan of 23 June 2008 relating to the European technical approval ETA-08/0113 issued on 23 June 2008 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 with Deutsches Institut für Bautechnik.[11]

The basic elements of the Control Plan comply with ETAG 013, Annex E1 (see Annex 15).

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 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
- results of controls and tests and, where specified, comparison with the requirements
- name and signature of person responsible for the factory production control.

The records shall be kept for at least ten years and on request they shall be presented to Deutsches Institut für Bautechnik.

If the test result is not satisfactory, the kit manufacturer shall take immediate measures to eliminate the deficiency. Construction products and components which do not comply with the requirements shall be handled such 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 is technically possible and necessary for verifying the deficiency elimination.

3.2.1.2 Other tasks for the manufacturer

The kit 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 kit manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European technical approval ETA-08/0113 issued on 23 June 2008.

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

At least once a year, each components manufacturer shall be audited by the kit manufacturer (see ETAG 013, 8.2.1.1)

3.2.2 Tasks for the approved bodies

3.2.2.1 General

The approved body shall perform the measures according the section 3.2.2.2 to 3.2.2.5 and in accordance with the provisions laid down in the "Control Plan of 23 June 2008 relating to the European Technical Approval ETA-08/0113 issued on 23 June 2008".

[11] 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.

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

The approved certification body involved by the kit manufacturer (VBT Vorspann- und Brückentechnologie 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 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 be 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 kit manufacturer at least once a year. Each factory of the components listed in Annex 15 shall be audited at least once in five years. 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 kit manufacturer

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 16 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 16).

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 or identifying mark of the kit manufacturer and of the production plant (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).

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 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 Deutsches Institut für Bautechnik before the changes are introduced. Deutsches Institut für Bautechnik will decide whether or not such changes affect the approval and consequently the validity of the CE marking on the basis of the approval and if so whether further assessment or alterations to the approval shall be necessary.

The tendon may be manufactured on 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 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. National standards and regulations valid on site shall be considered.

The ETA holder is responsible to inform anyone concerned about the use of this 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 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.

4.2.3 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 12 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.

4.2.4 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.

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

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 material specification of these greases is deposited at Deutsches Institut für Bautechnik.

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 5, 6 and 14).

4.2.6 Tensioning and stressing records

4.2.6.1 Tensioning

At time of stressing the minimum mean concrete strength shall comply with the values given in section 2.2.5.
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.

4.2.6.2 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.

4.2.6.3 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.

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.

Andreas Kummerow
p. p. Head of Department

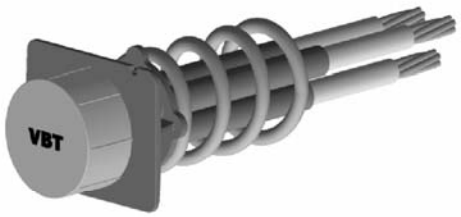
beglaubigt:
Häusler

Deutsches Institut für Bautechnik DIBt

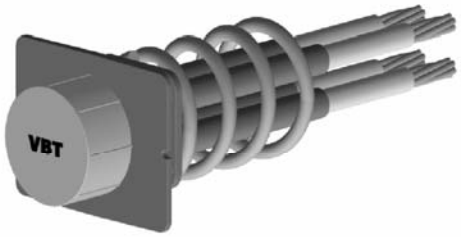
Stressing- / Fixed Anchorage VBT01

Stressing- / Fixed Anchorage VBT02

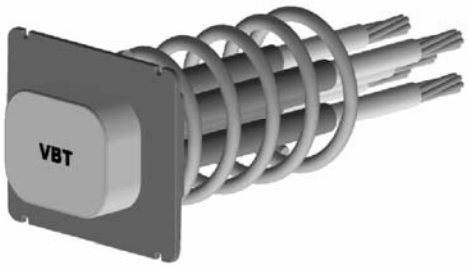
Stressing- / Fixed Anchorage VBT03



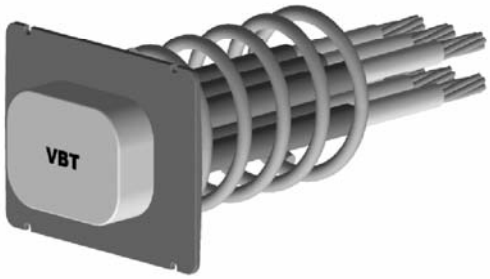
Stressing- / Fixed Anchorage VBT04



Stressing- / Fixed Anchorage VBT05



Stressing- / Fixed Anchorage VBT06



VBT Unbonded Monostrand System	Annex 1
Types of Tendon	

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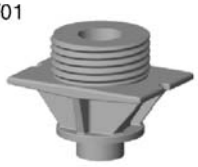
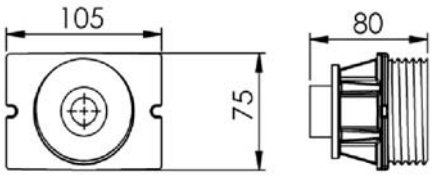
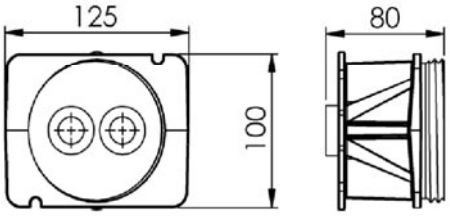
Stressing- / Fixed Anchorage VBT01

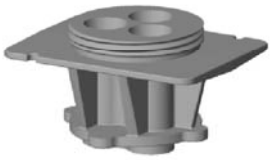


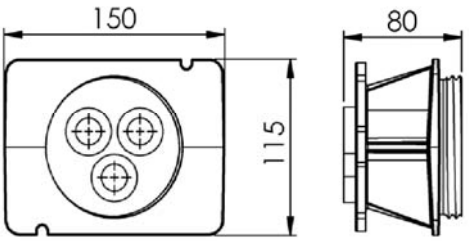


Stressing- / Fixed Anchorage VBT02

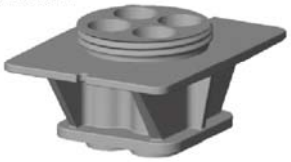


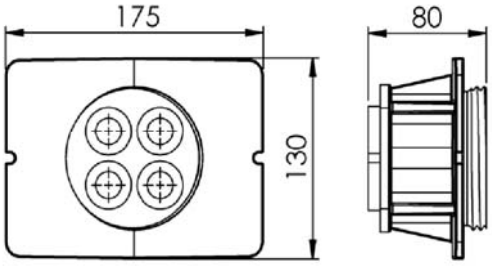
Stressing- / Fixed Anchorage VBT03



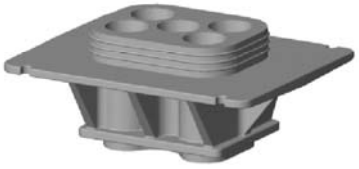


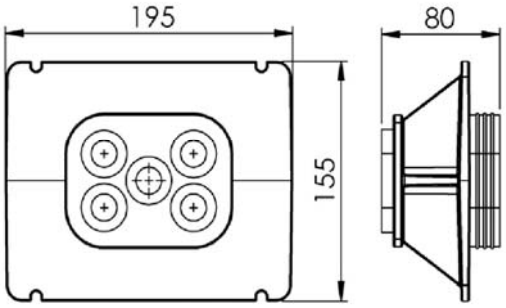
Stressing- / Fixed Anchorage VBT04



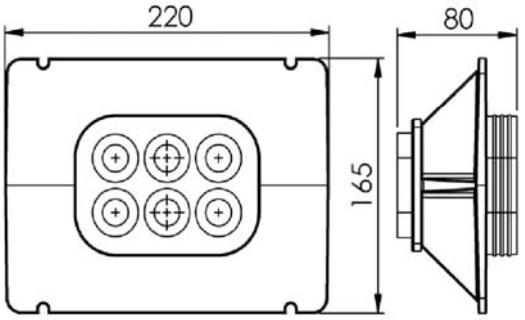


Stressing- / Fixed Anchorage VBT05





Stressing- / Fixed Anchorage VBT06



VBT Unbonded Monostrand System	Annex 2
Anchorages	

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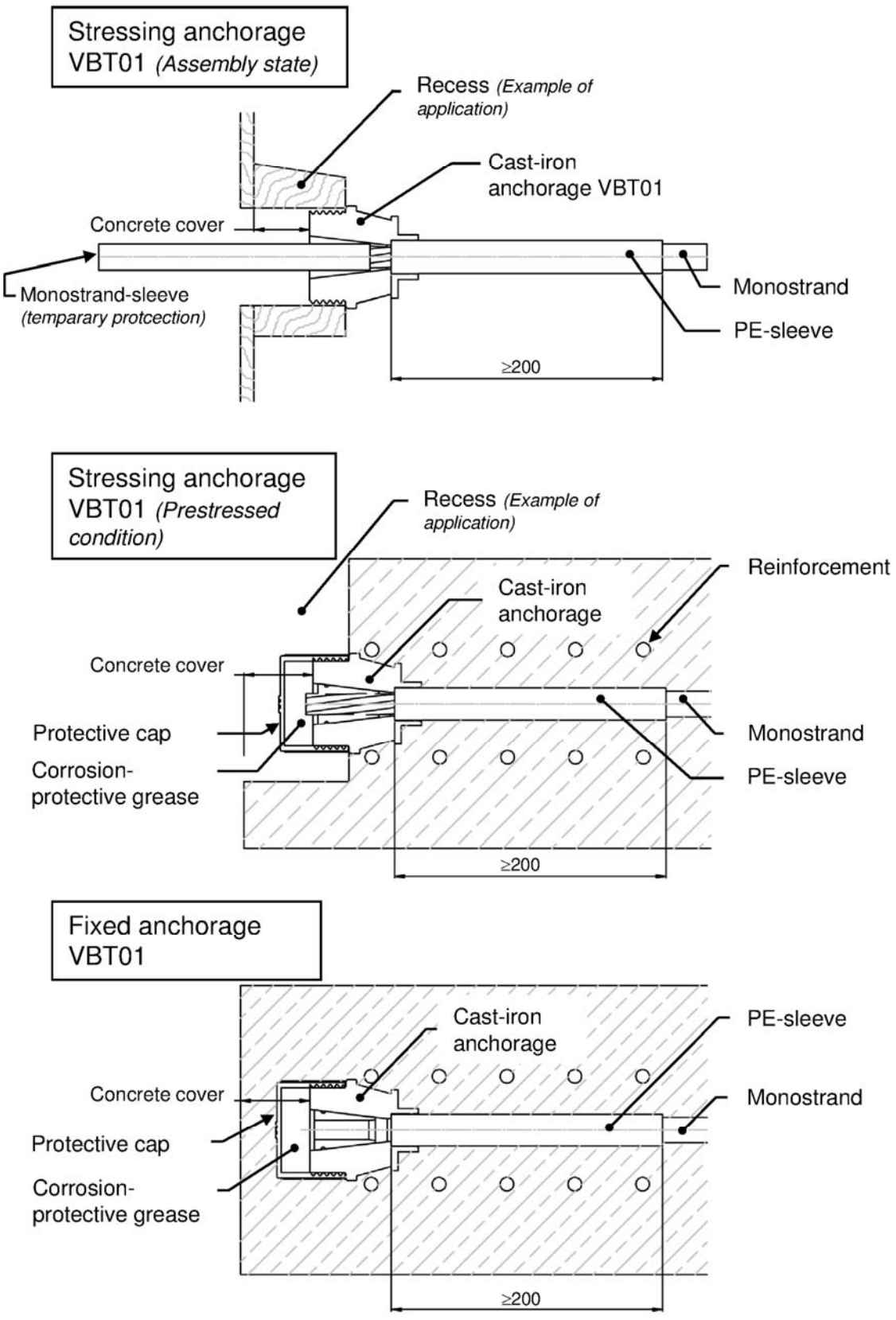

VBT Unbonded Monostrand System	Annex 3
Stressing anchorage VBT01 and Fixed anchorage VBT01	

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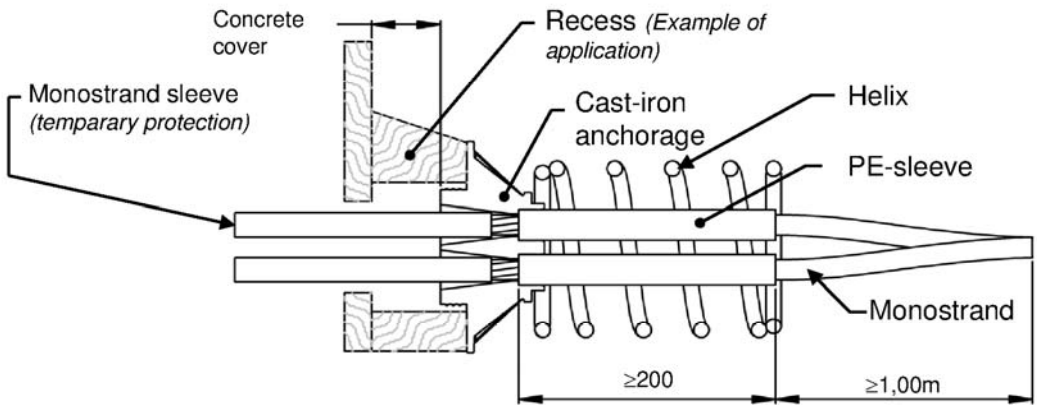
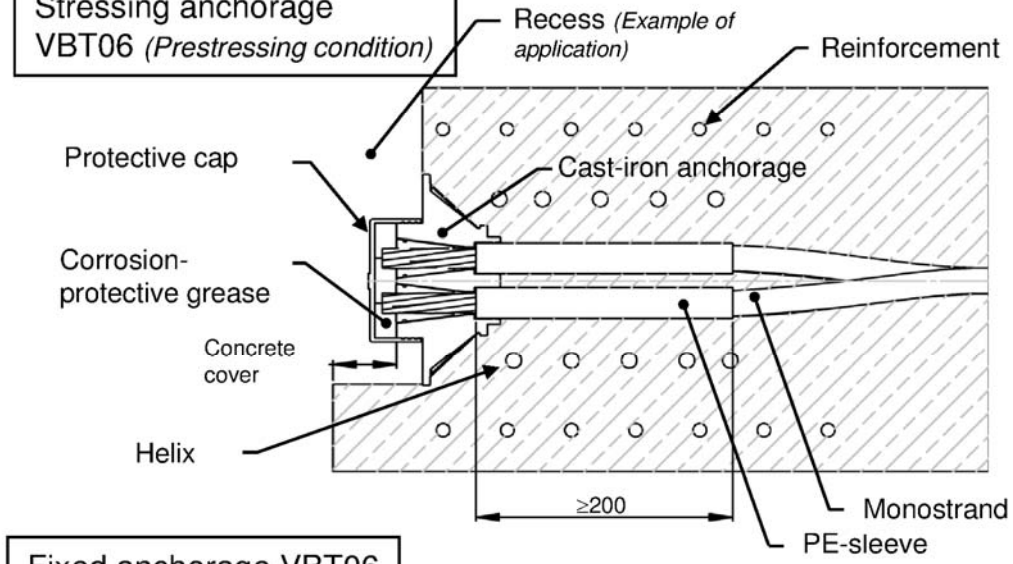
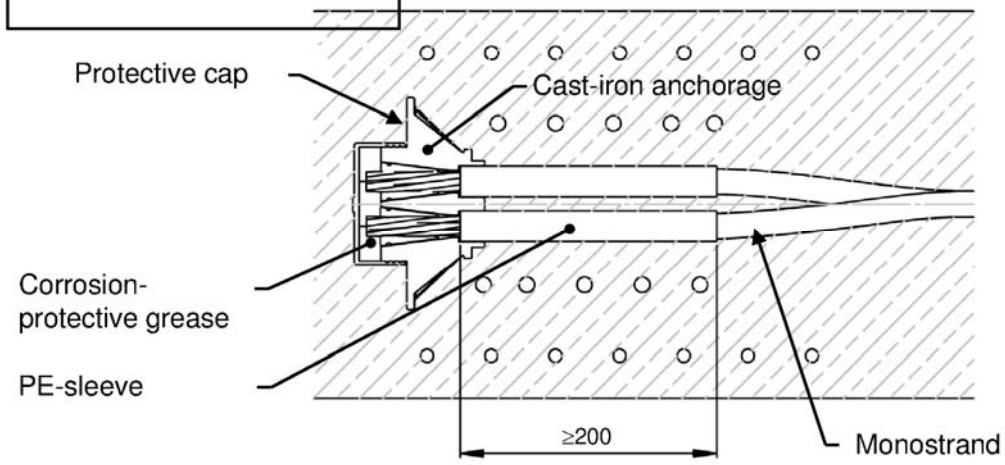
Stressing anchorage VBT06 *(Assembly state)*



Stressing anchorage VBT06 *(Prestressing condition)*



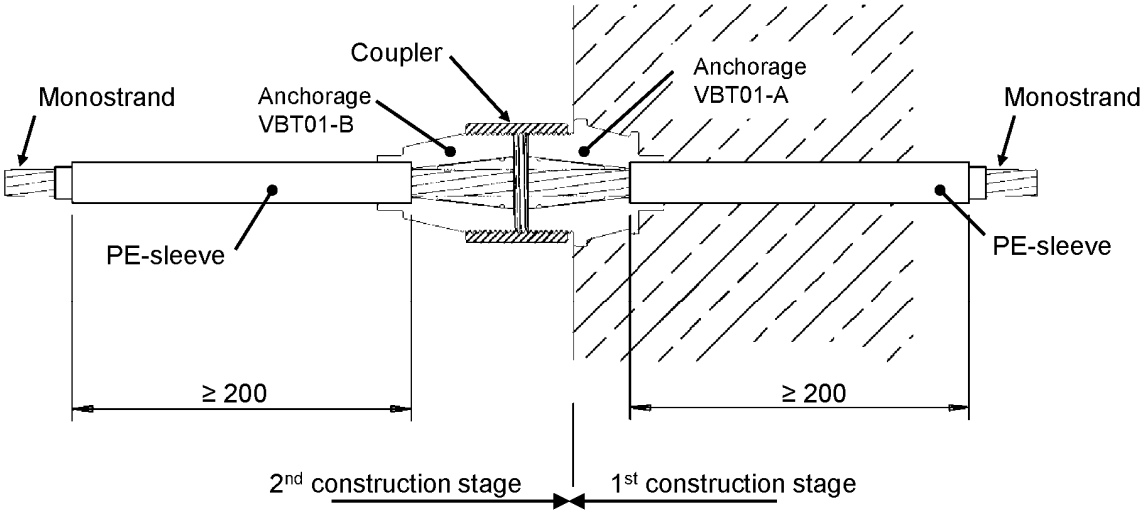
Fixed anchorage VBT06



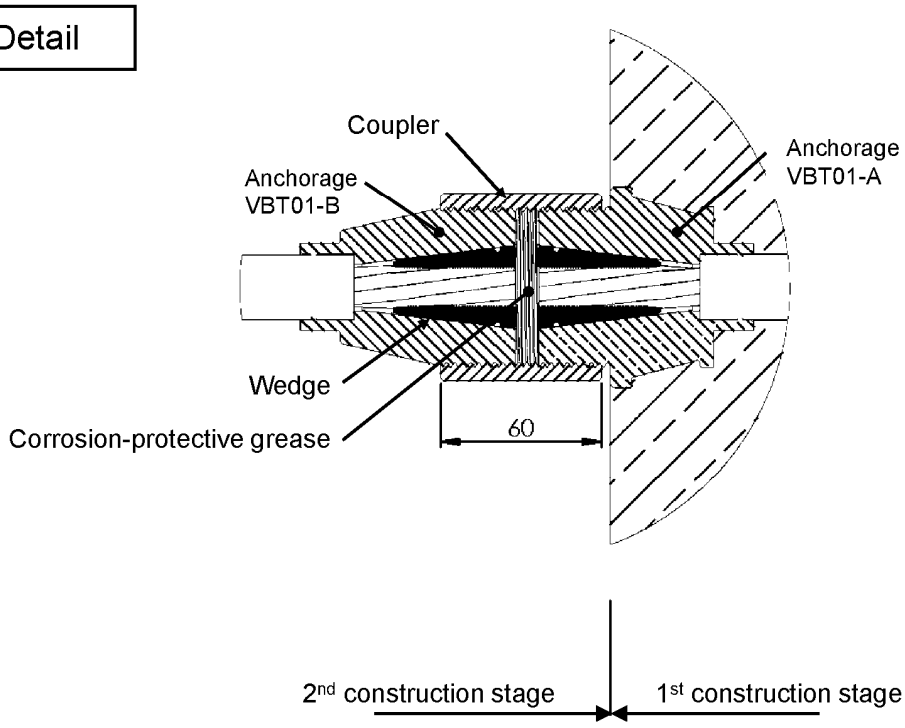
VBT Unbonded Monostrand System	Annex 4
Stressing Anchorage VBT06 and Fixed Anchorage VBT06	

Deutsches Institut für Bautechnik DIBt

Fixed coupler VBT01



Detail



VBT Unbonded Monostrand System	Annex 5
Fixed coupler VBT01	

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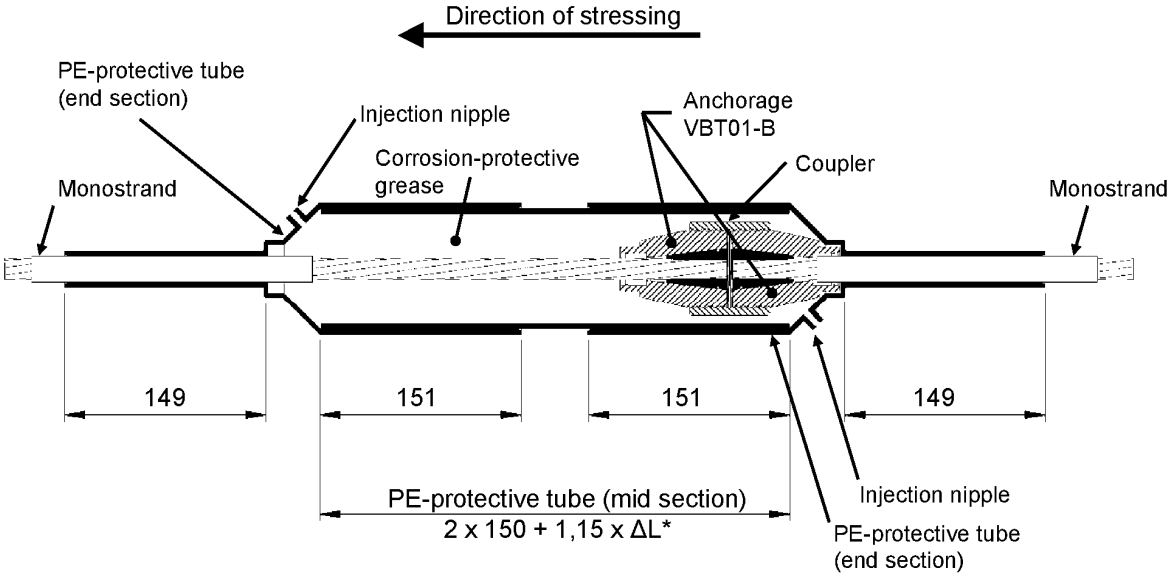
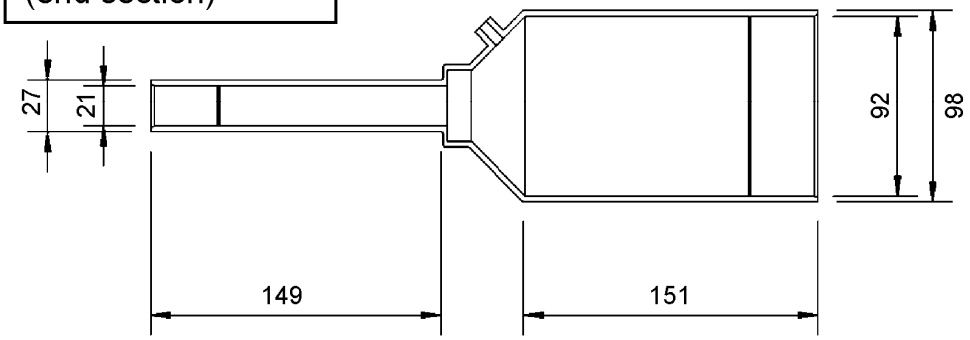
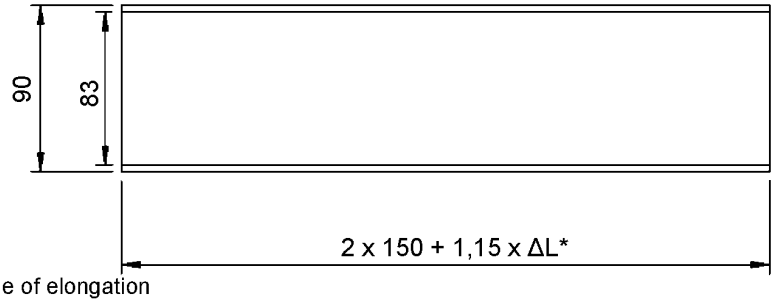
Movable coupler VBT01



PE-protective tube (end section)



PE-protective tube (mid section)



* ΔL = calculated value of elongation

VBT Unbonded Monostrand System	Annex 6
Movable coupler VBT01	

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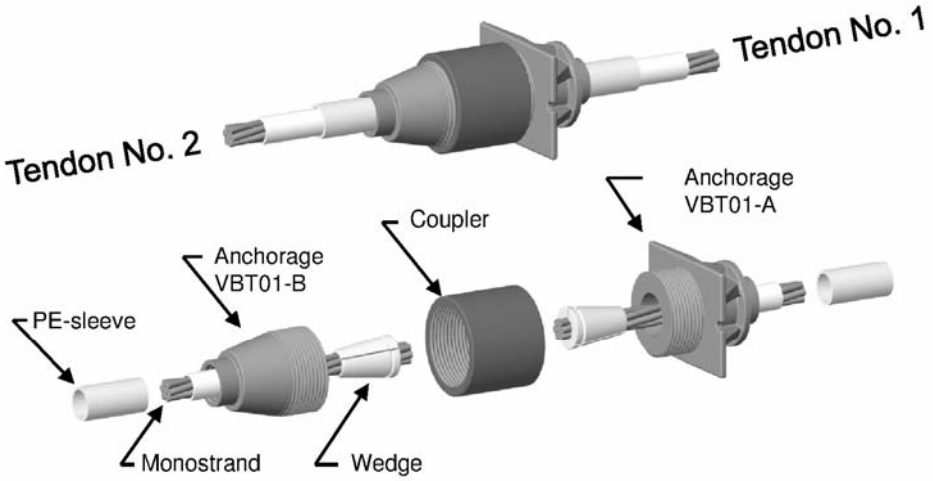
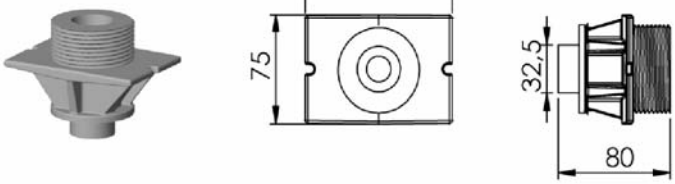
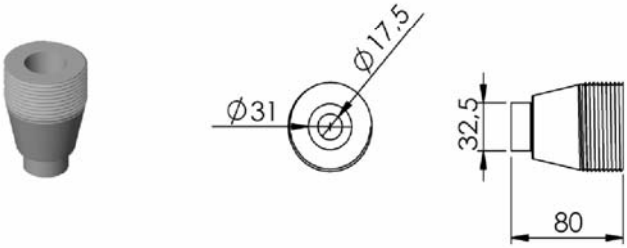
Fixed coupler VBT01



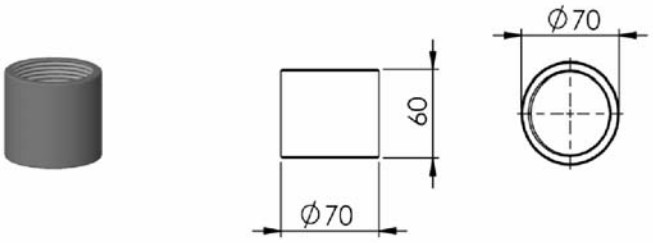
Anchorage VBT01-A



Anchorage VBT01-B



Coupler

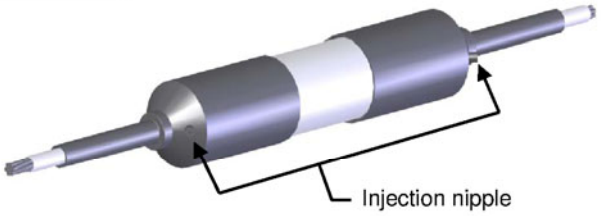


All other Components
see Annex 11 und 13

VBT Unbonded Monostrand System	Annex 7
Fixed Coupler	

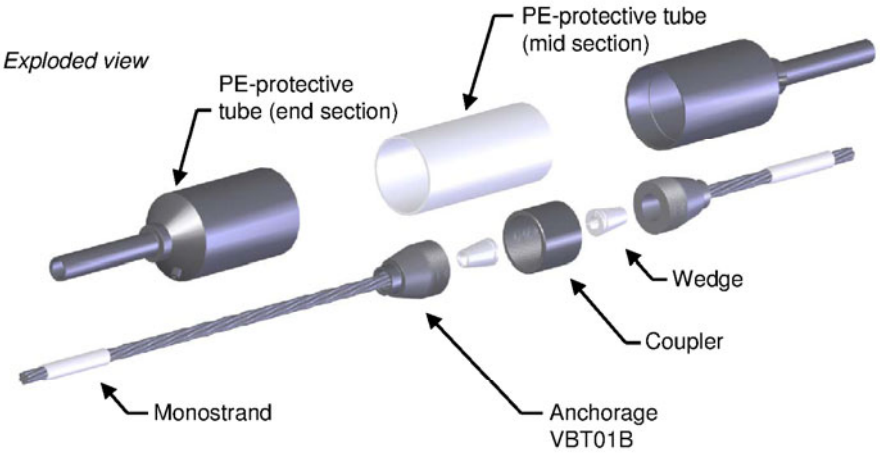
Deutsches Institut für Bautechnik DIBt

Movable coupler VBT01

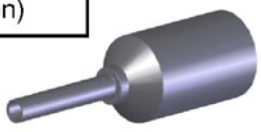


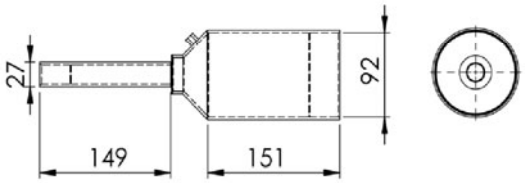
Transparent view

Exploded view

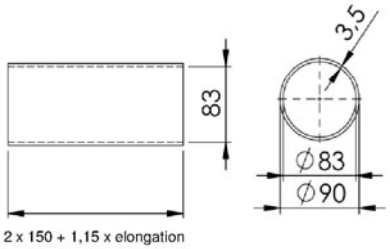


PE-protective tube (end section)





PE-protective tube (mid section)



All other components see Annex 11 und 13

VBT Unbonded Monostrand System	Annex 8
Movable Coupler	

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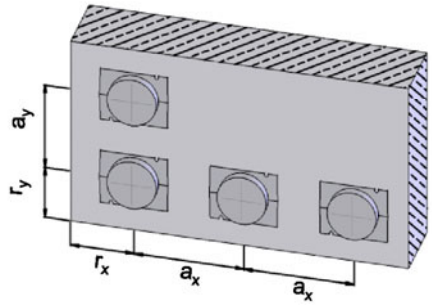
Tendon type		VBT01	VBT02	VBT03	VBT04	VBT05	VBT06
Anchor head	**a**	105	125	150	175	195	220
(see Annex 2)	**b**	75	100	115	130	155	165
	h	80	80	80	80	80	80
Concrete strength $f_{cm,0}$ at the time of stressing (cube 150)		**for all concrete strength**					
Helix	**External-diameter**		100	100	110	130	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**					

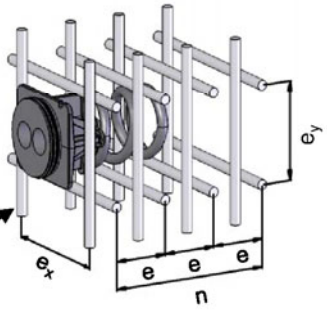
[mm]

Center- and Edge Distances



Additional Reinforcement

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



Stirrups or orthogonal reinforcement

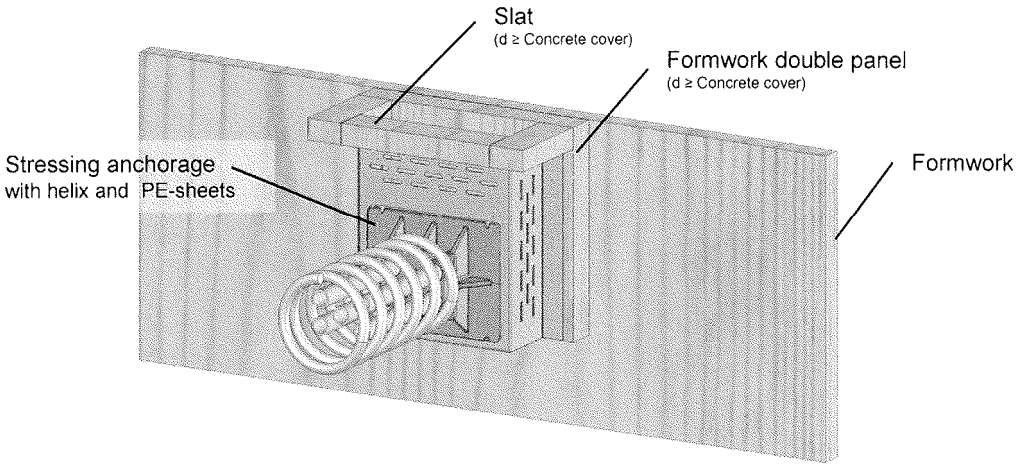
VBT Unbonded Monostrand System

Technical Specification

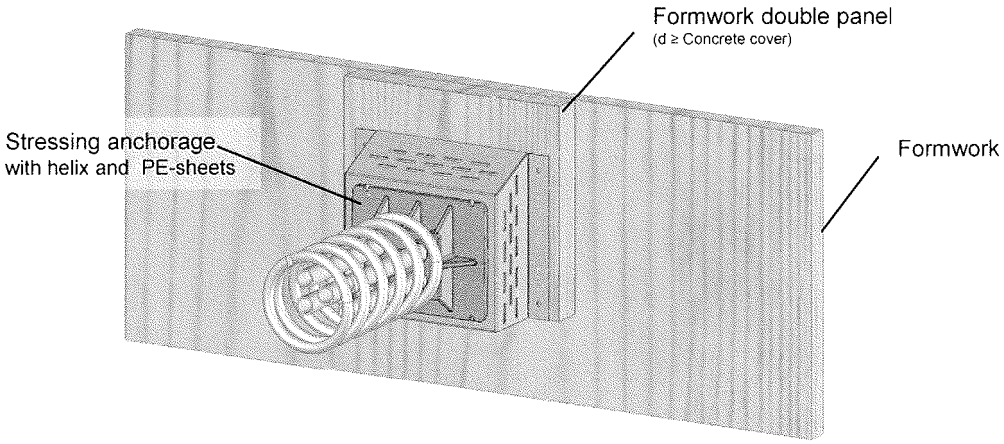
Annex 9

Deutsches Institut für Bautechnik DIBt

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.

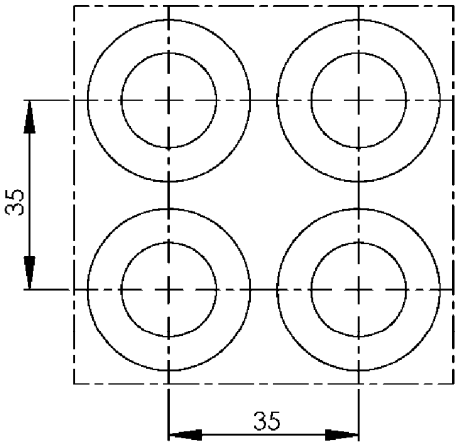
The dimensions of the recess plate cannot be smaller than the dimensions (a x b) of the stressing anchorage (s. Annex 2 and 9). The total depth of the recess amounts to at least 50 mm.

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

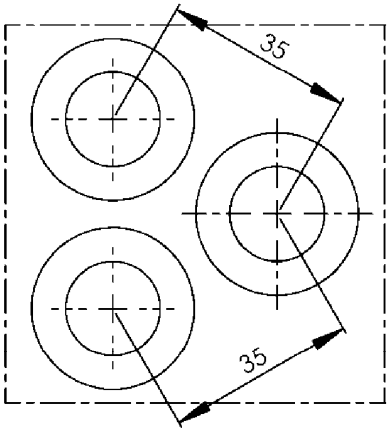
VBT Unbonded Monostrand System	Annex 10
Recess plate Examples of application	

Deutsches Institut für Bautechnik DIBt

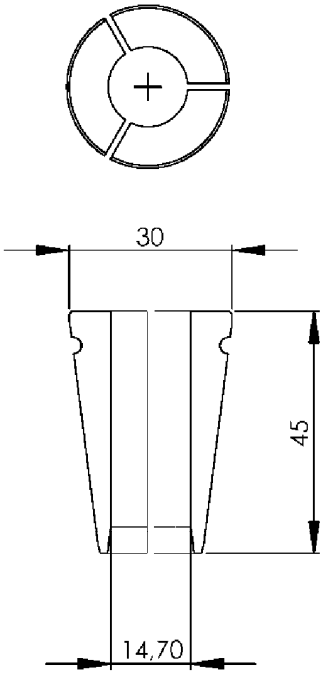
Cone image
VBT02, VBT04, VBT05, VBT06



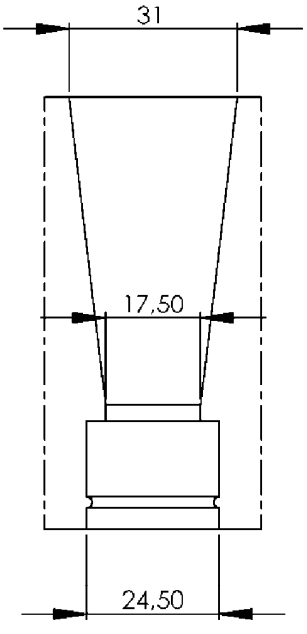
Cone image
VBT03, VBT05



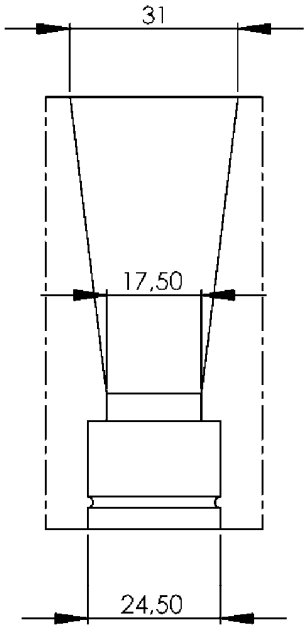
Wedge



Cone geometry



VBT01



VBT02 bis VBT06

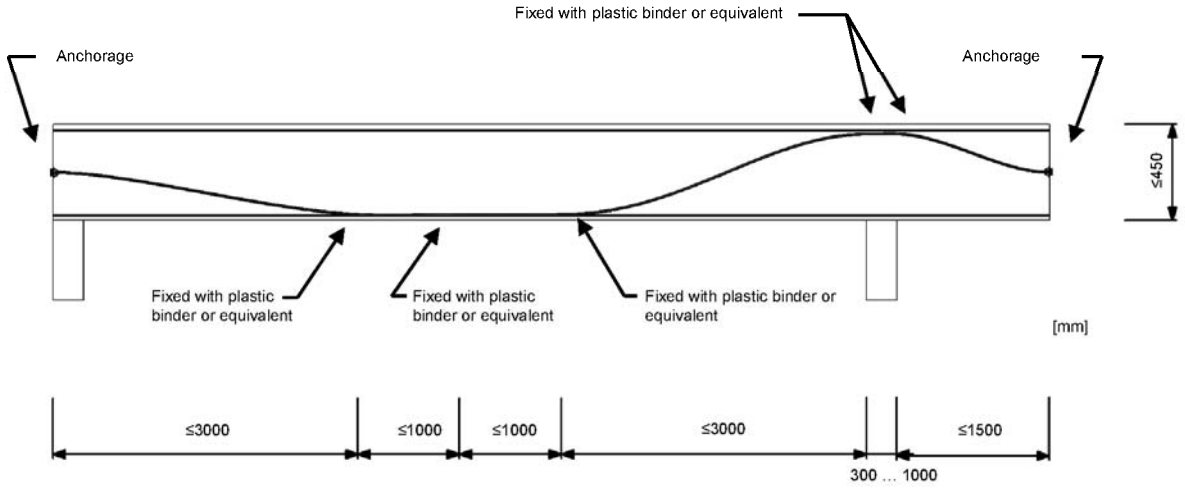
The complete geometry is deposited at the DIBT.

VBT Unbonded Monostrand System	Annex 11
Geometrical Specifications	

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 Monostrand System	Annex 12
Tendon installation instructions Free tendon layout	

Deutsches Institut für Bautechnik DIBt

Components and specification of material

Components	Norm
Wedge	DIN EN 10277-2:1999-10
Stressing- and fixed anchorages VBT01 - VBT06	DIN EN 1563:2003-02
Coupling anchorages VBT01A und VBT01B	DIN EN 1563:2003-02
Coupler	DIN EN 10210-1:2006-07
Helix	DIN EN 10 025:2005-02
Additional reinforcement	DIN 488-1:1984-09 DIN 488-2 bis -6:1986-06
PE-sleeve	DIN-EN ISO 1872
PE-protective tubes	DIN-EN ISO 1872
Corrosion protective grease	according to ETAG 013, Table C.4.1.1or national regulations

The detailed specifications has been deposited at the „Deutschen Institut für Bautechnik".

VBT Unbonded Monostrand System	Annex 13
Components and specification of materials	

Deutsches Institut für Bautechnik DIBt

Description of the VBT – Unbonded Monostrand System

1 Prestressing steel

The prestressing steel of the tendons consists of 7-wire prestressing steel strands with a nominal diameter of 15,7 mm (0,62“) and a nominal tensile strength of either 1.860 MPa or 1.770 MPa. These are factory provided with a corrosion protection system consisting of corrosion protective grease and PE-sheathing.

2 Manufacturing and transportation

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

During transport, the tendons may be wand to a coil with a minimum internal diameter of 1.50 m or as specified by the manufacturer of the monostrand.

3 Anchorages

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

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 5,6,7 and 8).

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.

Description of the VBT – Unbonded Monostrand System

The stressing act requires the following operation steps:

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.

3.2 Fixed coupling VBT01-A and VBT01-B

Fixed couplings are used for joining non-stressed tendons to stressed tendons (Annex 5 and 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.

3.3 Movable coupling VBT01-A and VBT01-B

The movable coupling is used for joining non-stressed tendons (Annex 6 and 8).

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.

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Description of the VBT – Unbonded Monostrand System

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 VBT01-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) upto 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 at least 5 cm width.

4 Stressing operation and Stressing records

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 9. Restressing of tendons before final cutting of the strand protrusions in combination with release and reuse of wedges is allowed. After restressing and anchoring, wedge marks on the strand, resulting from the preceding stressing operation, shall be located at least 15 mm from the wedges in the outward direction.

Stressing record

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.

5 Prestressing jacks and space requirements

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 anchorages. The dimension of the instep niches must allow the possibility of cutting the strand protrusions after stressing.

Control Plan

Component	item	test/ check	traceability	minimum frequency	documentation
Anchorage VBT01 to VBT06 Anchorage VBT01 Typ A + B Coupler	material	check	full	100%	3.1B [1]
	detailed dimensions [2]	test		5% ≥ 2 specimen	yes
	visual inspection [3,4]	check		100%	no
Wedge	material	check	full	100%	3.1B [1]
	treatment, hardness [5,6]	test		0,5% ≥ 2 specimen	yes
	detailed dimensions [5]			5% ≥ 2 specimen	yes
	visual inspection [1,7]	check		100%	no
Monostrand	prestressing steel [9]	check	full	100%	yes
	diameter of strand			each Coil	no
	material [8,10]	test		ETAG 013, C.1.4	yes
	visual inspection [3]	check		each Coil	no
PE sleeve	material [8]	check	full	100%	yes
PE_protective tubes	material [8]	check	full	100%	yes
corrosion-protective grease	material [8]	check	full	100%	yes

according to ETAG 013, Tab. E1

1 Inspection certificate - 3.1.B according to EN 10204
2 Other dimensions than [4]
3 Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labeling, appropiate performance, surface, fins, kinks, smoothness, corrosion, coating etc.
4 Dimensions: cones regarding angle, diameter and surface condition, thread dimensions of all anchorages and couplers.
5 Test report type - 2.2 according to EN 10204
6 Surface hardness
7 Teeth, cone surface
8 Suppliers certificate
9 As long as the basis for CE-marking of prestressing steel is not available, an approval/certificate according to the rules valid in place of use has to accompany each delivery.
10 According to ETAG 013, Annex C.1.4

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Audit testing

Audit testing - Minimum procedures to be performed			
component	item	test/ check	Sampling - number of components per visit
Anchorage	material according to specifacation	check, test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Wedge	material according to specifacation	check, test	2
	treatment	test	2
	detailed dimensions	test	1
	mains dimensions, surface hardness	test	5
	visual inspection [1]	check	5
Single tensile element test	single tensile element test according to ETAG 013, Anhang E.3	test	1 series

according to ETAG 013, Tab. E2

[1] Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labeling, appropiate performance, surface, fins, kinks, smoothness, corrosion, coating etc.