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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
Member of EOTA

European Technical Approval ETA-06/0022

English translation prepared by DIBt - Original version in German language

Handelsbezeichnung *Trade name*	DYWIDAG-Litzenspannverfahren mit nachträglichem Verbund *DYWIDAG Bonded Strand Post-tensioning System*
Zulassungsinhaber *Holder of approval*	DYWIDAG-Systems International GmbH Destouchesstraße 68 80796 München DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	DYWIDAG-Litzenspannverfahren mit 3 bis 37 Litzen (140 und 150 mm²) zur Vorspannung mit nachträglichem Verbund *Dywidag Bonded Post-tensioning System for 3 to 37 Strands (140 and 150 mm²)*
Geltungsdauer: *Validity:* vom *from*	13 January 2011
bis *to*	13 January 2016
Herstellwerk *Manufacturing plant*	DYWIDAG-Systems International GmbH Max-Planck-Ring 1 40764 Langenfeld DEUTSCHLAND

Diese Zulassung umfasst *This Approval contains*	45 Seiten einschließlich 21 Anhänge *45 pages including 21 annexes*
Diese Zulassung ersetzt *This Approval replaces*	ETA-06/0022 mit Geltungsdauer vom 12.01.2006 bis 12.01.2011 *ETA-06/0022 with validity from 12.01.2006 to 12.01.2011*

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I LEGAL BASES AND GENERAL CONDITIONS

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

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

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

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

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of the construction product

1.1 Definition of the construction product

The present European technical approval applies to a kit:

DYWIDAG- Bonded Strand Post-Tensioning System

consisting of 3 to 37 strands with nominal tensile strength 1770 MPa or 1860 MPa (Y1770 S7 or Y1860 S7), nominal diameter 15.3 mm (0.6" – 140 mm²) or 15.7 mm (0.62" – 150 mm²) which are used in normal-weight concrete with the following anchorages (stressing and fixed anchorages and couplers; see Annex 1):

1 Stressing (active) anchorage and fixed (passive) anchorage type ED with bearing plate and wedge plate for tendons of 3, 4 and 5 strands,

2 Stressing (active) anchorage and fixed (passive) anchorage type MA with cast iron anchor body and wedge plate for tendons of 5, 7, 9, 12, 15, 19, 22, 27, 31 and 37 strands,

3 Couplers R (fixed) for tendons of 5, 7, 9, 12, 15, 19, 22, 27, 31 and 37 strands,

4 Couplers D (movable) for tendons of 3, 4, 5, 7, 9, 12, 15, 19, 22, 27, 31 and 37 strands,

5 Loop anchorage for tendons of 3, 4, 5, 7, 9, 12, 15, 19 and 22 strands.

6 Bursting reinforcement (helixes and stirrups)

7 Sheathing (ducts)

8 Corrosion protection

The strands are anchored in wedge plates and couplers by means of wedges.

1.2 Intended use

The Post-Tensioning System is assumed to be used for the prestressing of structures of normal-weight concrete with internal bonded tendons. No optional use category is intended. The structural members used to be designed in accordance with national regulations.

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

The provisions made in this European technical approval are based on an assumed working life of the PT-System of 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer (or the Approval Body), but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

2 Characteristics of product and methods of verification

2.1 Characteristics of product

2.1.1 General

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

The first digit of the designation of components of anchorages and couplings (6) identifies the nominal strand diameter in tenfold of inches (0.6"/0.62"), the second digit is an internal code and the last two digits refer to the number of strands (size of tendon). The components (except helix and additional reinforcement) fit for tendons with both strand strengths

2.1.2 Strands

Only 7-wire strands shall be used in accordance with national provisions with the characteristics given in Annex 18.

To avoid confusion only strands with one nominal diameter shall be used on one site. If the use of strands with R_m = 1860 MPa is intended on site, these shall solely be used there.

Only strands stranded in the same direction shall be used in a tendon.

2.1.3 Wedges

Wedges (see Annex 2) are approved with 30°-tooth or 45°-tooth. The segments of the wedges for strands ∅ 15.3 mm are 42 mm long and the segments of the wedges for strands ∅ 15.7 mm are 45 mm long.

Wedges of one supplier only may be used at one construction site.

2.1.4 Wedge plates and couplers

The conical drills of the wedge plates and couplers shall be clean, stainless and provided with a corrosion protection grease.

2.1.5 Bearing Plates

For 3 to 5 strands circular bearing plates (type ED) shall be used (see Annexes 3 and 4).

2.1.6 Cast-iron anchor bodies

For 5 to 37 strands multi-plane cast-iron anchor bodies (type MA) shall be used (see Annexes 5 and 6).

2.1.7 Helixes and stirrups

The steel grades and dimensions of the helixes and of the stirrups shall comply with the values given in the Annexes. The central position in the structural concrete member on site shall be ensured according the section 4.2.3.

The outer end of the helix shall be welded to the anchor plate ED or the anchor body MA. This is not necessary if the final turn is welded to form a closed ring.

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

2.1.8 Ducts, tubes and trumpets

Ducts shall be used in according to EN 523:2003. For tendons with 3 to 5 strands oval ducts may be used. For these ducts EN 523:2003 applies accordingly. The dimensions of the ducts shall comply with values given in Annex 2.

In the deviation region of the loop anchorages it is also possible to use smooth steel tubes of a minimum wall thickness of 2 mm according to EN 10216 or EN 10217 (see Annexes 13 and 14).

The trumpets at stressing, fixed anchorages and couplers (see Annexes 2 to 6, 11 and 12a) are manufactured from 3.0 mm thick PE material (see Annex 17).

Also plastic ducts which meet the requirements according to ETAG 013, Annex C.3 and in accordance with regulations valid at the place of use can be used. Plastic ducts or the accompanying boundary conditions are not covered by ETA-06/0022.

2.1.9 Grout

Grout according to EN 447:1996 shall be used.

2.2 Methods of verification

2.2.1 General

The assessment of the fitness of the DYWIDAG-Bonded 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 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 DYWIDAG-Internal Bonded 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 applied to a tendon shall not exceed the force $P_{0,max} = 0.9\ A_p\ f_{p0,1k}$ laid down in Table 1 (140 mm²) or in Table 2 (150 mm²). The value of the initial prestressing force P_{m0} immediately after tensioning and anchoring shall not exceed the force $P_{m0,max} = 0.85\ A_p\ f_{p0,1k}$ laid down in Table 1 (140 mm²) or in Table 2 (150 mm²).

Table 1: Maximum prestressing forces[8] for tendons with Ap = 140 mm²

Tendon Designation	Number of strands	Cross section Ap [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
6803	3	420	543	575	571	605
6804	4	560	724	766	762	806
6805	5	700	904	958	952	1008
6807	7	980	1266	1341	1333	1411
6809	9	1260	1628	1724	1714	1814
6812	12	1680	2171	2298	2285	2419
6815	15	2100	2713	2873	2856	3024
6819	19	2660	3437	3639	3618	3830
6822	22	3080	3979	4213	4189	4435
6827	27	3780	4884	5171	5141	5443
6831	31	4340	5607	5937	5902	6250
6837	37	5180	6693	7086	7045	7459

Table 2: Maximum prestressing forces[8] for tendons with Ap = 150 mm²

Tendon Designation	Number of strands	Cross section Ap [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
6803	3	450	581	616	612	648
6804	4	600	775	821	816	864
6805	5	750	969	1026	1020	1080
6807	7	1050	1357	1436	1428	1512
6809	9	1350	1744	1847	1836	1944
6812	12	1800	2326	2462	2448	2592
6815	15	2250	2907	3078	3060	3240

8 The forces stated are maximum values. The actual values are to be found in national regulations valid in the 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}.

Tendon Desig nation	Number of strands	Cross section Ap [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
6819	19	2850	3682	3899	3876	4104
6822	22	3300	4264	4514	4488	4752
6827	27	4050	5233	5540	5508	5832
6831	31	4650	6008	6361	6324	6696
6837	37	5550	7171	7592	7548	7992

The number of strands in a tendon may be reduced by leaving out strands lying radial-symmetrically in the wedge plate. The provisions for tendons with wedge plates (basic types) completely filled also apply to tendons with only partly filled wedges plates. Into the cones not filled, short pieces of strands with wedges have to be pressed to assure a sufficient bending stiffness of the wedge plates.

The admissible prestressing force is reduced per strand left out as shown in Table 3.

Table 3: Reduction of the prestressing force when leaving out one strand

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

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

The losses of the prestressing force due to friction and wobbling effects may normally be determined in the calculation by using the friction coefficients μ and the unintentional angular displacement k (wobble coefficient) given in Table 4. The values μ and k depend on the given duct dimensions and the maximum distances between the tendon supports.

Table 4: Friction and wobble effects

Tendon size	inner diameter of Duct (mm)	Friction coefficient μ [rad^{-1}]	Wobble coefficient k [rad/m]	distances between tendon supports [m]	Friction Losses $\Delta P_{\mu A}$ (%)
6803	41 50 55/21*)	0.21 0.18 0.15	$7*10^{-3}$ $5*10^{-3}$ $14*10^{-3}$	max 1.8	1
6804	45 55 70/21*)	0.24 0.19 0.15	$5*10^{-3}$ $5*10^{-3}$ $14*10^{-3}$		
6805	50 60 85/21*)	0.20 0.20 0.15	$5*10^{-3}$ $5*10^{-3}$ $14*10^{-3}$		

Tendon size	**inner diameter of Duct (mm)**	**Friction coefficient μ [rad^{-1}]**	**Wobble coefficient k [rad/m]**	**distances between tendon supports [m]**	**Friction Losses $\Delta P_{\mu A}$ (%)**
6806	55 65	0.22 0.19	5*10^{-3} 5*10^{-3}	max 1.8	0.5
6807	60 65	0.22 0.19	5*10^{-3} 5*10^{-3}		
6808	70 75	0.20 0.19	5*10^{-3} 5*10^{-3}		
6809	70 75	0.20 0.19	5*10^{-3} 5*10^{-3}		
6810	75 80	0.19 0.19	5*10^{-3} 5*10^{-3}		
6812	75 80	0.19 0.19	5*10^{-3} 5*10^{-3}		
6815	85 90	0.20 0.19	5*10^{-3} 5*10^{-3}		
6819	90 95	0.21 0.20	5*10^{-3} 5*10^{-3}		
6822	95 100	0.20 0.20	5*10^{-3} 5*10^{-3}		
6827	110	0.20	5*10^{-3}		
6831	120	0.20	5*10^{-3}		
6837	130	0.20	5*10^{-3}		
*) oval ducts					

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

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

For the determination of strains and forces of prestressing steel friction losses $\Delta P_{\mu A}$ in the active anchorage zone shall be taken into account according to Table 4, last column.

2.2.4 Radius of curvature of the tendons in the structure

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

Table 5: Smallest radius of curvature (circular duct) for strands Y1770 S7 with Ap = 140 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])			
6803	3,50	(40)	3,10	(50)
6804	4,20	(45)	3,90	(55)
6805	4,70	(50)	4,20	(60)
6807	4.50	(60)	4,40	(65)
6809	5,10	(70)	4,90	(75)
6812	6,10	(75)	5,90	(80)
6815	6,70	(85)	6,50	(90)
6819	7,90	(90)	7,60	(95)
6822	8,60	(95)	8,20	(100)
6827	--	--	9,20	(110)
6831	--	--	9,60	(120)
6837	--	--	10,60	(130)

Table 6: Smallest radius of curvature (circular duct) for strands Y1770 S7 with Ap = 150 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])			
6803	3,70	(40)	3,30	(50)
6804	4,50	(45)	4,20	(55)
6805	4,90	(50)	4,40	(60)
6807	4,80	(60)	4,60	(65)
6809	5,30	(70)	5,20	(75)
6812	6,50	(75)	6,10	(80)
6815	7,10	(85)	6,80	(90)
6819	8,50	(90)	8,00	(95)
6822	9,30	(95)	8,90	(100)

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])			
6827	--	--	9,90	(110)
6831	--	--	10,40	(120)
6837	--	--	11,40	(130)

Table 7: Smallest radius of curvature (circular duct) for strands Y1860 S7 with Ap = 140 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])			
6803	3,70	(40)	3,30	(50)
6804	4,40	(45)	4,10	(55)
6805	4,80	(50)	4,40	(60)
6807	4,70	(60)	4,50	(65)
6809	5,20	(70)	5,00	(75)
6812	6,30	(75)	6,00	(80)
6815	6,90	(85)	6,70	(90)
6819	8,20	(90)	7,80	(95)
6822	9,00	(95)	8,60	(100)
6827	--	--	9,60	(110)
6831	--	--	10,10	(120)
6837	--	--	11,10	(130)

Table 8: Smallest radius of curvature (circular duct) for strands Y1860 S7 with Ap = 150mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])			
6803	4,00	(40)	3,40	(50)
6804	4,70	(45)	4,40	(55)
6805	5,00	(50)	4,50	(60)
6807	5,00	(60)	4,70	(65)

Tendon	**Radius of curvature [m] (Inner diameter of the duct [mm])**			
6809	5,50	(70)	5,30	(75)
6812	6,90	(75)	6,50	(80)
6815	7,60	(85)	7,20	(90)
6819	9,10	(90)	8,60	(95)
6822	9,90	(95)	9,40	(100)
6827	--	--	10,50	(110)
6831	--	--	11,00	(120)
6837	--	--	12,20	(130)

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

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

with

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

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

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

Table 9: Smallest radius of curvature (oval duct)

Tendon	**Inner duct dimensions [mm x mm]**	**Radius of curvature [m]**	
		Bending axis	
		stiff	weak
6803	55 x 21	5,30	2,50
6804	70 x 21	7,20	2,50
6805	85 x 21	9,00	2,50

2.2.5 Concrete strength

At the time of transmission of the full prestressing force to the concrete member the mean concrete strength of the normal weight concrete in the anchorage zone shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Table 10. 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 more than 5 %.

Table 10: Necessary mean concrete strength fcmj of the specimens at time of prestressing for anchorages ED and MA

Anchorage	fcmj,cube [N/mm²]	fcmj,cyl [N/mm²]
ED	25	20
ED	35	28
ED	45	36
MA	28	23
MA	40	33
MA	52	42

For partial prestressing with 30 % of the full prestressing the minimum value of the concrete compressive strength to be proved is 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values 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 be the values given in the Annexes depending on the actual mean concrete strength.

The values of the centre or edge distances of the anchorages given in the Annexes may be reduced in one direction up to 15 %, however, not to a smaller value than the external diameter of the helix plus 2 cm (see Annexes 3, 4 and 7 to 10). 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 fitted 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. This reinforcement must not be taken into account as part of the statically required reinforcement. However, existing reinforcement in a corresponding position more than the given reinforcement may be taken into account for the additional reinforcement. The additional reinforcement shall be 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. 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 slip at the anchorages (see section 4.2.5) shall be taken into account in the static calculation and the determination of the tendon elongation.

2.2.9 Resistance to fatigue of the anchorages and couplers

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

2.2.10 Increased tension losses at couplers

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

2.2.11 Couplers

The coupler shall only be used if the calculated stressing force at the coupler is at least 0.7 $P_{m0,max}$ (see section 2.2.2). Couplers shall be positioned in straight tendon sections with straight length of at least 1.0 m to each side. For movable couplers the position and length of the coupler duct shall ensure a movement over the length of at least 1.2 Δl or at least Δl + 120mm, respectively, where Δl is the maximum elongation length at the time of prestressing.

2.2.12 Loop anchorages

Tendons with loop anchorages shall only be used in concrete members subject to static action and considering the layouts given in the Annexes 13 and 14. Both straight legs of the loop shall be of the same length, at both ends stressing anchorages shall be applied. They shall generally be simultaneously stressed at both ends.

Prior to the installation the smooth steel tubes and ducts respectively for the area of deflection of the hairpin bars (stirrups) shall be pre-bent with special bending techniques (bending model or bending machine). The minimum admissible radius min R is given in Annexes 13 and 14. The tube or duct wall should not buckle and should still be leak tight. The ducts in the loop area shall be braced, e.g. with fixed, diagonal reinforcement.

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

The minimum concrete thickness h and the required cross-section area of additional reinforcement (hairpin bars) are given in the Annexes 13 and 14. The hairpin bars shall be secured in position with perpendicular reinforcement.

In addition to the hairpin bars at least 40 % of the existing prestressing force from the loop anchor (in the area of deflection) shall be anchored by reinforcing backwards, i.e. beyond the end of the loop. This reinforcement, evenly distributed above and below the loop duct (on the top and bottom side of the plate), shall be arranged in the direction of the leg of the loop (Annexes 13 and 14, direction Y). In the area of deflection this reinforcement shall be arranged vertically with the same cross section (Annexes 13 and 14, direction X). The reinforcement shall be arranged as close as possible to the loop duct and only that part of the reinforcement may be taken into account whose resulting tensile force possibly lies in the axis of the ending loop anchor. It shall be made sure that the force (40 % of the prestressing force) is accepted by the reinforcement and the formation of cracks excluded.

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] the system 1+ of attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 1+: Certification of the conformity of the product by 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 manufacturer.

3.2 Responsibilities

3.2.1 Tasks of the manufacturer

3.2.1.1 Factory production control

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

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

[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 10 December 2010 relating to the European technical approval ETA -06/0022 issued on 13 January 2011" which is part of the technical documentation of this European technical approval. The control plan is laid down in the context of the factory production control system operated by the manufacturer and deposited with Deutsches Institut für Bautechnik.[11]

The basic elements of the Control Plan comply with ETAG 013, Annex E1 (see Annexes 19a and 19b).

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

The manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European technical approval ETA 06/0022 issued on 13 January 2011.

At least once a year specimens shall be taken from one job site and one series of single tensile element test shall be performed according ETAG 013, Annex E3 (see Annex 20). 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 manufacturer (see ETAG 013, 8.2.1.1)

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

3.2.2 Tasks of 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 06 December 2005 relating to the European technical approval ETA – 06/0022 issued on 13 January 2011".

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 reports.

The approved certification body involved by the manufacturer (DYWIDAG-Systems International 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 manufacturer at least once a year. Each factory of the components listed in annex 20 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 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 20 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 20)

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 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)
- nominal cross section and tensile strength of the strands

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

4.1 Manufacturing

The European technical approval is issued for the product on the basis of agreed data/information, deposited with 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 ETA and consequently the validity of the CE marking on the basis of the ETA and if so whether further assessment or alterations to the ETA shall be necessary.

The 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 DYWIDAG-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 DYWIDAG-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 bearing plate or anchor body by welding.

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

4.2.3 Installation of the tendon

The central position of the helix or stirrups shall be ensured by tack-welding to the bearing plate or the anchor body or other appropriate mountings. The bearing plate or anchor body and the anchor head shall be in direction perpendicular to the axis of the tendon.
The tendon shall be placed straightforward the first meter at the anchorage.

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

4.2.4 Coupler

To make it possible to control the depth of pushing in the necessary depth of pushing in shall be colour-marked at the ends of the strands of the second construction phase.

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

If the calculated prestressing force is less than 0.7 $P_{m0,max}$ the wedges of fixed anchorages shall be pre-wedged with $P_{0,max}$ (see section 2.2.2).
The draw-in of the anchorage to be taken into account for the determination of the elongations and at load transfer from the jack onto the anchorage shall be taken from Table 11.
The wedges of all anchorages (fixed anchorages and couplers) which are no more accessible during tensioning shall be secured by means of wedge keeping plates and bolts.

Table 11: Draw-in values for calculation of elongation [mm]

	Draw-in at stressing anchorage		Draw-in at fixed anchorage	Draw-in at coupling R	Draw-in at coupling D
	Draw-in to be considered for calculation of elongation	Draw-in at load transfer from the jack onto the anchorage	Draw-in to be considered for calculation of elongation		
Without pre-wedging or power-seating,	1	8	6	4	8
With power-seating 20 kN per strand at stressing anchorage	1	4	-	-	-
With pre-wedging P0,max at fixed anchorage	-	-	1	-	-

At installation of the wedges into the conical borings of the not accessible fixed anchorages and of second construction phase of coupler R the surfaces and gaps shall be filled with corrosion protection compound (for example Denso-Jet or Petro-Plast). The specifications of these compounds are deposited at the Deutsches Institut für Bautechnik.

Before the pouring of concrete, the wedge plates of the not accessible fixed anchorages shall be sealed with a grout cap.

4.2.6 Stressing and stressing records

4.2.6.1 Stressing

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

It is admissible to restress the tendons by releasing and re-using the wedges. After restressing and anchoring, wedge marks on 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. All strands of a tendon shall be stressed simultaneously. This can be done by centrally controlled individual jacks or by a bundle jack.

Loop tendons shall be stressed at both ends simultaneously.

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 is more than 15 % of the calculated value then the engineer shall be informed and the causes shall be found.

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

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

To stress the tendons, clearance of 1.0 to 1.5 m shall be considered directly behind the anchorages.

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

4.2.7 Grouting

4.2.7.1 Grout and grouting procedures

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

4.2.7.2 Water rinse

Normally, ducts shall not be rinsed with water.

4.2.7.3 Grouting speed

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

4.2.7.4 Grouted section and re-grouting

The length of a grouted section shall not exceed 120 m for tendons with 3 to 22 strands, 95 m for tendons with 23 to 27 strands and 50 m for tendons with 28 to 37 strands. When exceeding these tendon lengths, additional grouting openings shall be provided. Where the tendon is led via distinct high points, re-groutings shall be performed in order to avoid voids. For re-groutings corresponding measures shall be taken into account already in design.

4.2.7.5 Surveillance

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

5 Packaging, transport and storage

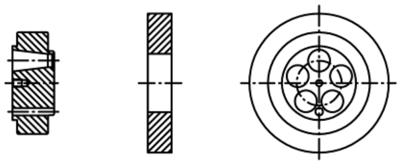
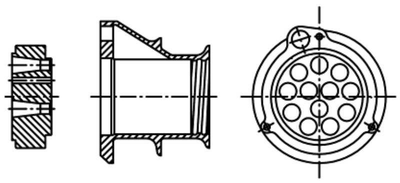
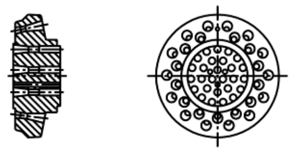
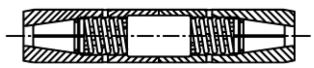
The components and the tendons shall be protected against moisture and staining.

The tendons shall be kept away from areas where welding procedures are performed.

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

Georg Feistel
Head of Department

beglaubigt
Wittig

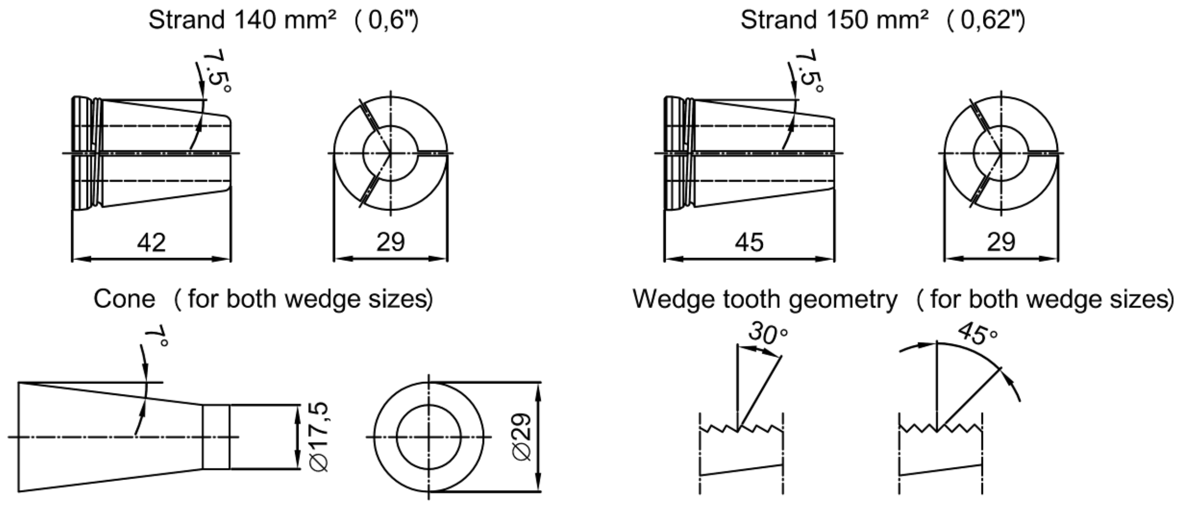
Designation	Figure	Tendon Size	Max. stressing force [kN]	
			Strand 140mm²	Strand 150mm²
Plate anchorage Type ED (Annex 3-4/15)		68 03 68 04 68 05	571 762 952	612 816 1020
Multiplane anchorage Type MA (Annex 5-10/15)		68 05 68 07 68 09 68 12 68 15 68 19 68 22 68 27 68 31 68 37	952 1333 1714 2285 2856 3618 4189 5141 5902 7045	1020 1428 1836 2448 3060 3876 4488 5508 6324 7548
Coupler Type R (Annex 11/16)		68 05 68 07 68 09 68 12 68 15 68 19 68 22 68 27 68 31 68 37	952 1333 1714 2285 2856 3618 4189 5141 5902 7045	1020 1428 1836 2448 3060 3876 4488 5508 6324 7548
Coupler Type D (Annex 12)		68 03 68 04 68 05 68 07 68 09 68 12 68 15 68 19 68 22 68 27 68 31 68 37	571 762 952 1333 1714 2285 2856 3618 4189 5141 5902 7045	612 816 1020 1428 1836 2448 3060 3876 4488 5508 6324 7548

DYWIDAG Bonded Strand Post-tensioning System

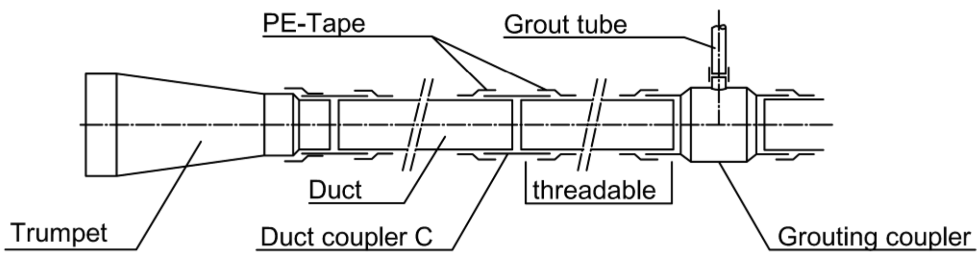
Components - anchorage and coupling

Annex 1

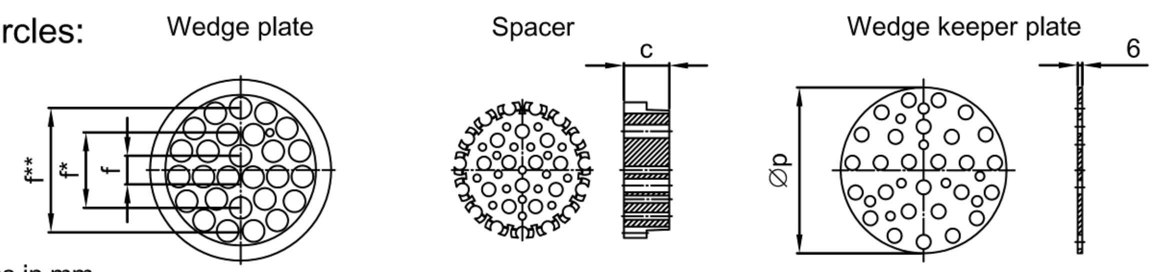
Wedge:



Duct:



Pitch circles:



Dimensions in mm

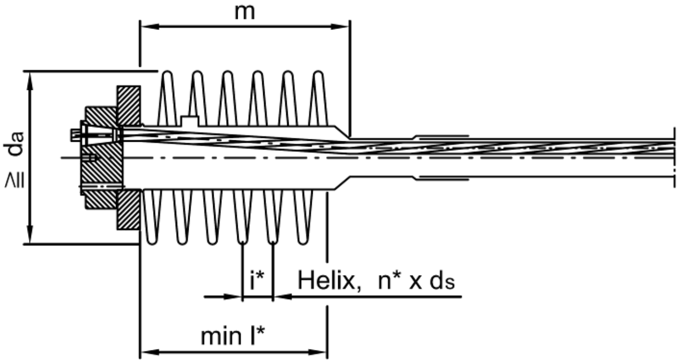
Tendon size		6803	6804	6805	6807	6809	6812	6815	6819	6822	6827	6831	6837
No. of strands		03	04	05	07	09	12	15	19	22	27	31	37
Spacer	c	--	--	40	40	40	40	40	60	60	60	60	60
Wedge keeper plate	Øp	80	80	90	100	115	135	155	170	185	195	215	215
Pitch circles	 f f* f**	-- 44 -- --	-- 50 -- --	-- 60 -- --	0 70 -- --	0 86 -- --	-- 40 105 --	-- 60 125 --	0 70 136 --	-- 86 152 --	-- 38 100 165	0 -- 126 190	0 65 126 190
Duct Type I Ø Type II Ø Type "oval"	 ID ID ID	 41 50 55/21	 45 55 70/21	 50 60 85/21	 60 65 --	 70 75 --	 75 80 --	 85 90 --	 90 95 --	 95 100 --	 -- 110 --	 -- 120 --	 -- 130 --

DYWIDAG Bonded Strand Post-tensioning System

Details: Wedge / Cone / Duct

Annex 2

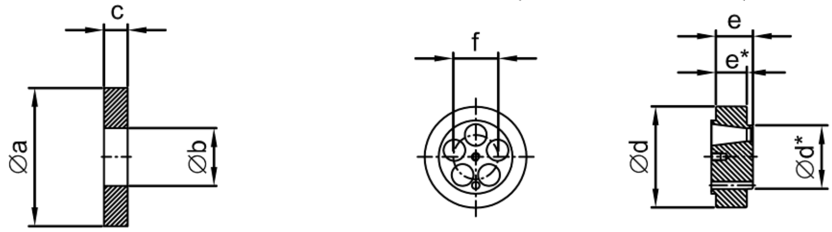
Deutsches Institut für Bautechnik DIBt



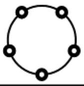
Anchor plate ED

Wedge plate ED

(f acc. to Annex 2)



Dimensions in mm

Tendon size	6803			6804			6805		
Strand	140mm², f_{pk}=1860N/mm² (F_{pk}=260,4kN) and f_{pk}=1770N/mm² (F_{pk}=247,8kN)								
No. of strands	03			04			05		
Cone pattern and position									
Minimum actual concrete strength at stressing $f_{cm,0,cyl}$ [N/mm²]	20	28	36	20	28	36	20	28	36
Center distance A	215	190	175	240	215	195	270	240	220
Edge distance R	0,5 x Center distance + Concrete cover - 10 mm								
Anchor plate Type 2351 / 2352 ∅ a	165			165			190		185
∅ b	72			72			86		86
c	30			30			30		30
Wedge plate Type 1350 ∅ d	110			110			135		
∅ d*	71			71			85		
e	55			55			55		
e*	47			47			47		
Helix (Material see Annex 17) Turns n*	5	5	5	5	5	5	6	5	5
∅ d_s	14	14	14	12	14	14	12	14	14
∅ d_a	180	150	150	205	180	150	230	205	170
i*	45	40	40	40	45	40	40	45	40
min l*	195	175	175	175	195	175	215	195	175
Trumpet Length m	170			170			280		

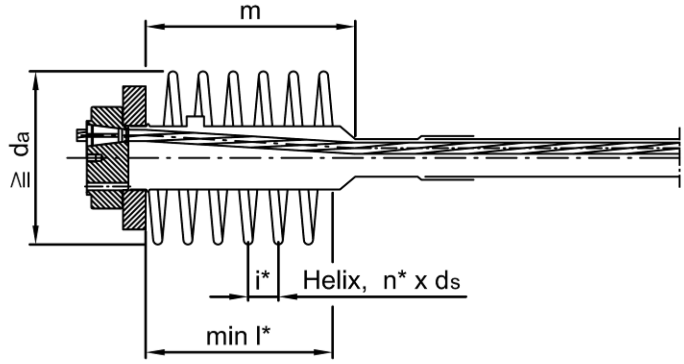
DYWIDAG Bonded Strand Post-tensioning System

Plate anchorage ED

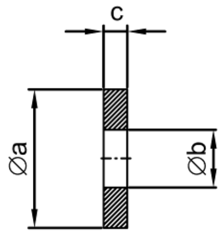
for strand Y1860S7 15,3 and for strand Y1770S7 15,3

Annex 3

Deutsches Institut für Bautechnik DIBt

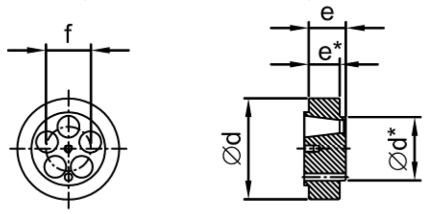


Anchor plate ED

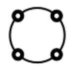
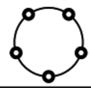


Wedge plate ED

(f acc. to Annex 2)



Dimensions in mm

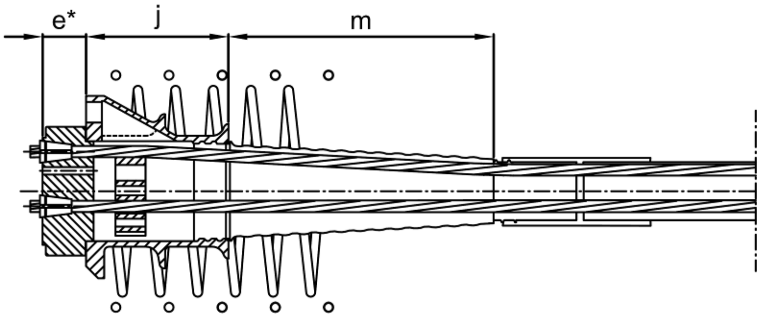
Tendon size	6803			6804			6805		
Strand	150mm², f_{pk}=1860N/mm² (F_{pk}=279kN) and f_{pk}=1770N/mm² (F_{pk}=265,5kN)								
No. of strands	03			04			05		
Cone pattern and position									
Minimum actual concrete strength at stressing $f_{cm,0,cyl}$ [N/mm²]	20	28	36	20	28	36	20	28	36
Center distance A	225	200	185	250	225	210	280	250	235
Edge distance R	0,5 x Center distance + Concrete cover - 10 mm								
Anchor plate Type 2351 / 2352 Ø a	165			165			190		185
Ø b	72			72			86		86
c	30			30			30		30
Wedge plate Type 1350 Ø d	110			110			135		
Ø d*	71			71			85		
e	55			55			55		
e*	47			47			47		
Helix (Material see Annex 17) Turns n*	5	5	5	5	5	5	6	5	5
Ø d s	14	14	14	12	14	14	12	14	14
Ø d a	180	150	150	205	180	150	230	205	170
i*	45	40	40	40	45	40	40	45	40
min l*	195	175	175	175	195	175	215	195	175
Trumpet Length m	170			170			280		

DYWIDAG Bonded Strand Post-tensioning System

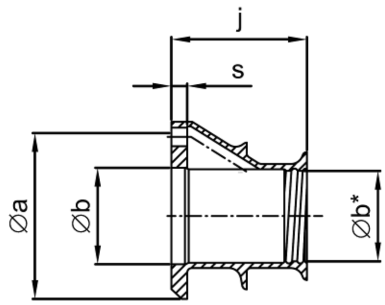
Plate anchorage ED

for strand Y1860S7 15,7 and for strand Y1770S7 15,7

Annex 4

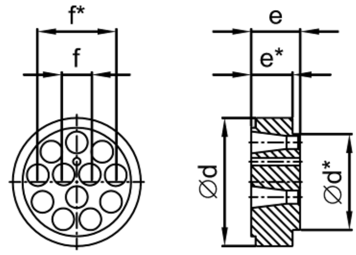


Anchor body MA

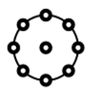
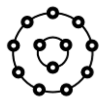
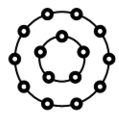


Wedge plate MA

(f, f* acc. to Annex 2)



Dimensions in mm

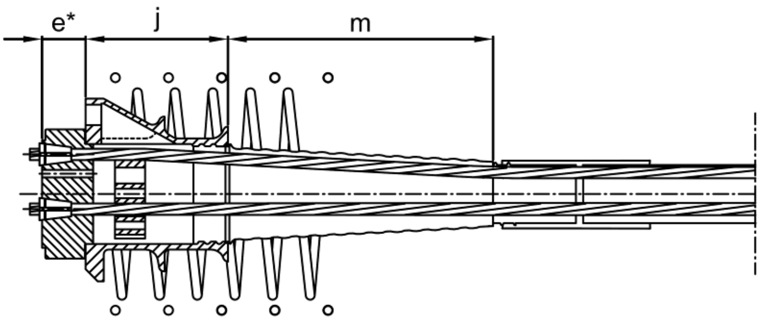
Tendon size				6805	6807	6809	6812	6815
No. of strands				05	07	09	12	15
Cone pattern and position								
Anchor body MA	Ø		a	150	170	190	220	250
Type 2301	Ø		b	90	98	114	130	150
	Ø		b*	80	90	100	120	130
			j	90	100	125	180	200
			s	18	18	18	21	23
Wedge plate	Ø		d	117	130	145	170	190
Type 1362	Ø		d*	88	96	112	128	148
			e	55	60	60	65	70
			e*	47	52	52	55	60
Trumpet		Length	m	190	160	280	350	390

DYWIDAG Bonded Strand Post-tensioning System

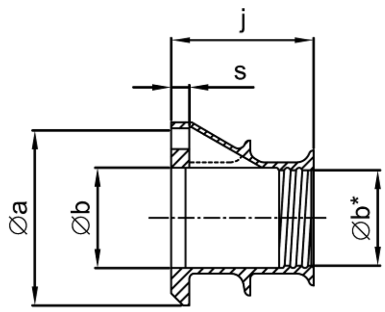
Multiplane anchorage MA

Dimensions of Components for 6805 - 6815

Annex 5

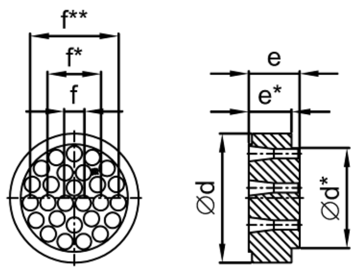


Anchor body MA



Wedge plate MA

(f, f*, f** acc. to Annex 2)



Dimensions in mm

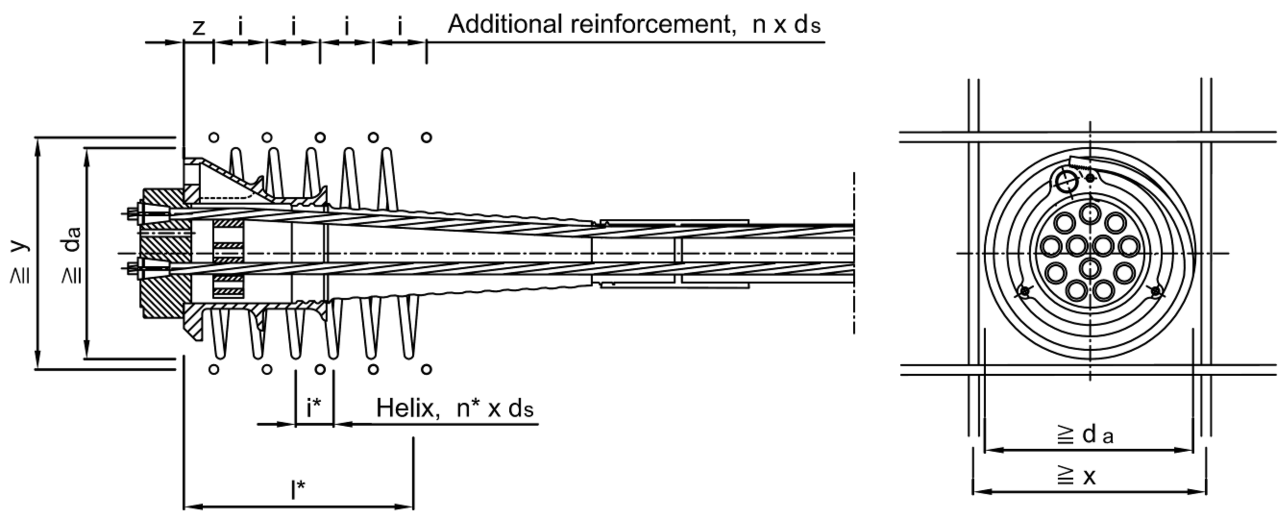
Tendon size			6819	6822	6827	6831	6837
No. of strands			19	22	27	31	37
Cone pattern and position							
Anchor body MA	∅	a	280	310	340	420	420
Type 2301	∅	b	162	179	190	217	217
	∅	b*	145	161	161	196	196
		j	220	220	240	350	350
		s	27	32	38	50	50
Wedge plate	∅	d	210	220	240	270	270
Type 1362	∅	d*	159	176	188	214	214
		e	80	85	95	100	115
		e*	68	73	80	80	95
Trumpet	Length	m	430	550	550	550	550

DYWIDAG Bonded Strand Post-tensioning System

Multiplane anchorage MA

Dimensions of Components for 6819 - 6837

Annex 6



Dimensions in mm

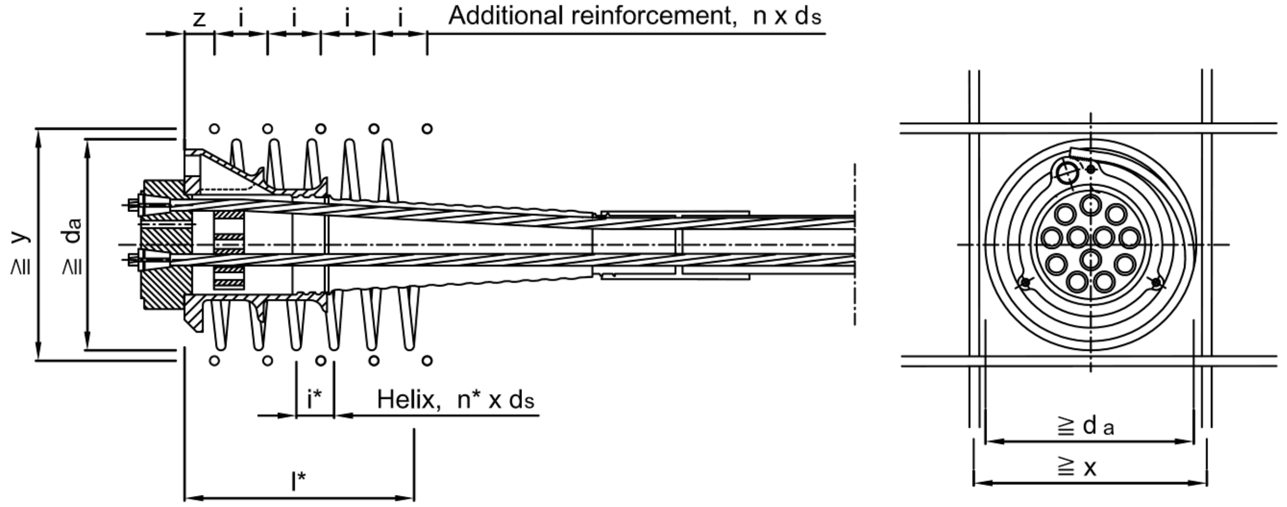
Tendon size	6805			6807			6809			6812			6815		
Strand	140mm²,f_{pk}=1860N/mm² (F_{pk}=260,4kN) and 140mm²,f_{pk}=1770N/mm² (F_{pk}=247,8kN)														
No. of strands	05			07			09			12			15		
Minimum actual concrete strength at stressing $f_{cm,0,cyl}$ [N/mm²]	23	33	42	23	33	42	23	33	42	23	33	42	23	33	42
Center distance A	265	220	200	310	260	235	350	295	270	405	345	310	455	385	345
Edge distance R	0,5 x Center distance + Concrete cover - 10 mm														
Additional reinforcement (Material see Annex 17)															
No. n	6	5	5	6	5	5	6	5	4	7	6	5	7	6	6
Ø d_s	12	12	12	12	12	12	12	12	12	12	12	14	14	14	14
z	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
i	50	50	50	50	55	55	50	60	65	50	60	65	60	65	70
x/y	230	190	170	280	230	205	320	265	240	375	315	275	420	350	310
Helix (Material see Annex 17)															
Turns n*	4,5	4,5	4	5	5	5	6	5,5	5	7	6,5	6	7	7	7
Ø d_s	14	14	14	14	14	14	14	16	16	14	16	16	16	16	16
Ø d_a	220	200	180	255	235	205	290	250	225	345	290	265	380	340	290
i*	45	45	40	45	45	40	45	45	40	45	45	45	45	45	45
min l*	270	270	230	295	295	270	340	320	270	385	365	340	385	385	385

DYWIDAG Bonded Strand Post-tensioning System

Multiplane anchorage MA

Center and edge distances of tendon sizes 6805 - 6815
for strand Y1860S7 15,3 and for strand Y1770S7 15,3

Annex 7



Dimensions in mm

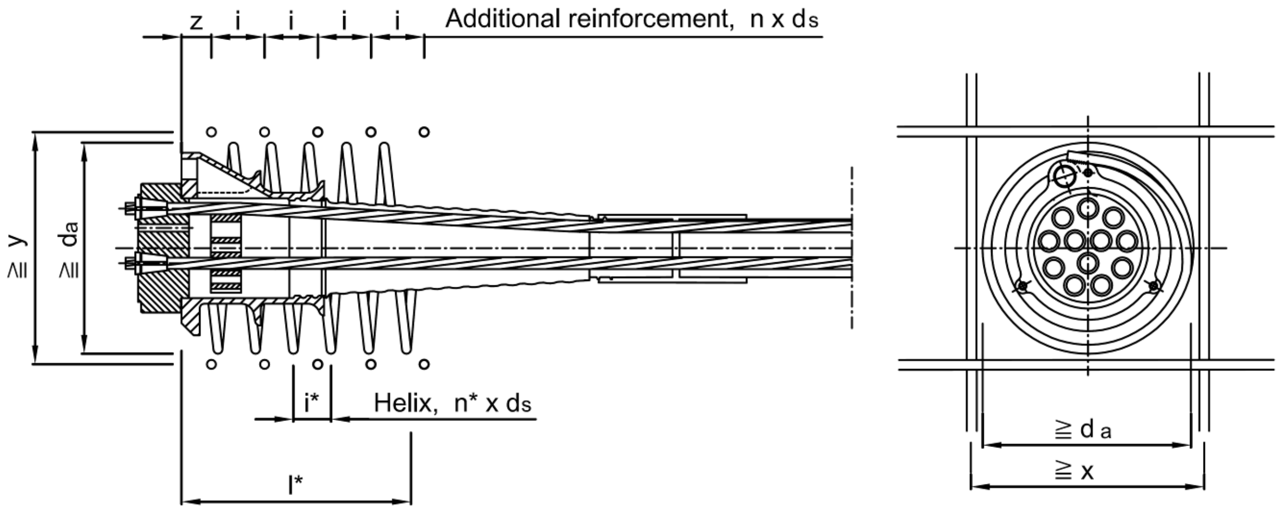
Tendon size	6819			6822			6827			6831			6837		
Strand	140mm², f_{pk}=1860N/mm² (F_{pk}=260,4kN) and 140mm², f_{pk}=1770N/mm² (F_{pk}=247,8kN)														
No. of strands	19			22			27			31			37		
Minimum actual concrete strength at stressing $f_{cm,0,cyl}$ [N/mm²]	23	33	42	23	33	42	23	33	42	23	33	42	23	33	42
Center distance A	515	430	390	555	470	420	615	525	475	665	570	520	730	630	580
Edge distance R	0,5 x Center distance + Concrete cover - 10 mm														
Additional reinforcement (Material see Annex 17)															
No. n	8	7	6	8	8	7	9	8	7	9	8	8	10	9	8
∅ d_s	16	16	16	16	16	16	16	16	16	20	20	20	20	20	20
z	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
i	60	65	70	60	65	65	60	65	70	75	80	80	75	75	85
x/y	480	395	355	520	435	385	580	490	440	625	530	480	690	590	540
Helix (Material see Annex 17)															
Turns n*	7,5	7,5	7,5	8	7,5	7,5	7	7	7	10	9	8	11	9	8
∅ d_s	16	16	16	16	16	16	20	20	20	20	20	20	20	20	20
∅ d_a	445	390	320	485	430	360	535	450	405	590	510	465	630	550	500
i*	45	45	45	45	50	50	55	55	55	55	60	65	50	60	65
min l*	410	410	410	430	445	445	460	460	460	625	615	595	625	615	595

DYWIDAG Bonded Strand Post-tensioning System

Multiplane anchorage MA

Center and edge distances of tendon sizes 6819 - 6837
for strand Y1860S7 15,3 and for strand Y1770S7 15,3

Annex 8



Dimensions in mm

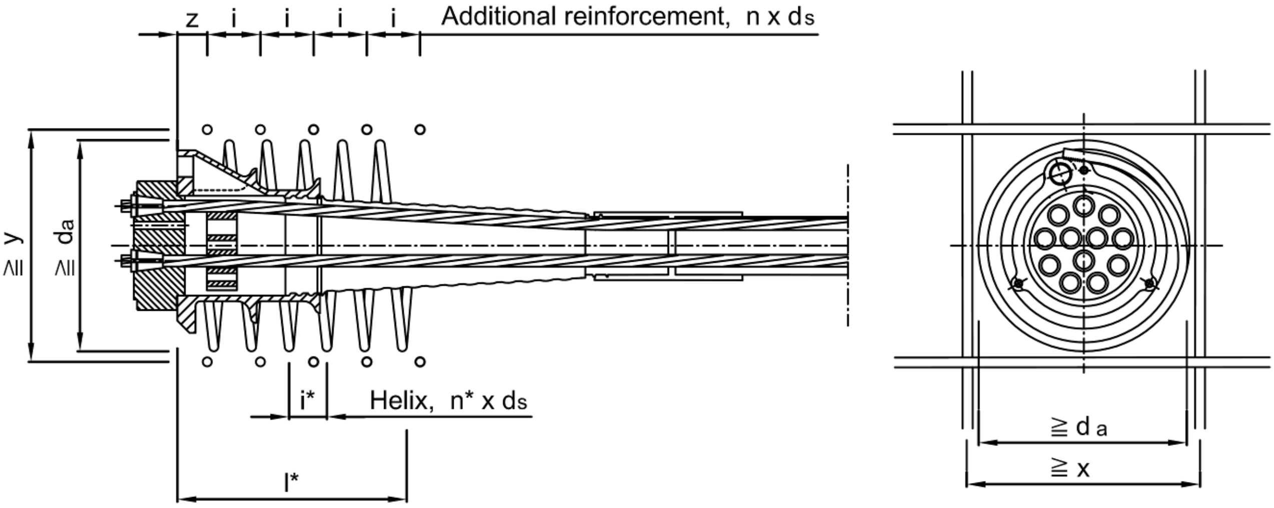
Tendon size	6805			6807			6809			6812			6815		
Strand	150mm², f_{pk}=1860N/mm² (F_{pk}=279kN) and 150mm², f_{pk}=1770N/mm² (F_{pk}=265,5kN)														
No. of strands	05			07			09			12			15		
Minimum actual concrete strength at stressing $f_{cm,0,cyl}$ [N/mm²]	23	33	42	23	33	42	23	33	42	23	33	42	23	33	42
Center distance A	270	230	210	320	270	245	360	305	280	415	355	320	470	395	355
Edge distance R	0,5 x Center distance + Concrete cover - 10 mm														
Additional reinforcement (Material see Annex 17)															
No. n	5	5	5	6	5	5	6	5	4	7	6	5	7	6	6
∅ d_s	12	12	12	12	12	12	12	12	12	12	12	14	14	14	14
z	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
i	50	50	50	50	55	55	50	60	65	50	60	65	60	65	70
x/y	240	200	180	290	240	215	330	275	250	385	325	285	435	360	320
Helix (Material see Annex 17)															
Turns n*	4,5	4,5	4	5	5	5	6	5,5	5	7	6,5	6	7	7	7
∅ d_s	14	14	14	14	14	14	14	16	16	14	16	16	16	16	16
∅ d_a	230	205	185	270	240	210	300	260	230	360	300	270	400	350	300
i*	45	45	40	45	45	40	45	45	40	45	45	45	45	45	45
min l*	270	270	230	295	295	270	340	320	270	385	365	340	385	385	385

DYWIDAG Bonded Strand Post-tensioning System

Multiplane anchorage MA

Center and edge distances of tendon sizes 6805 - 6815
for strand Y1860S7 15,7 and for strand Y1770S7 15,7

Annex 9



Dimensions in mm

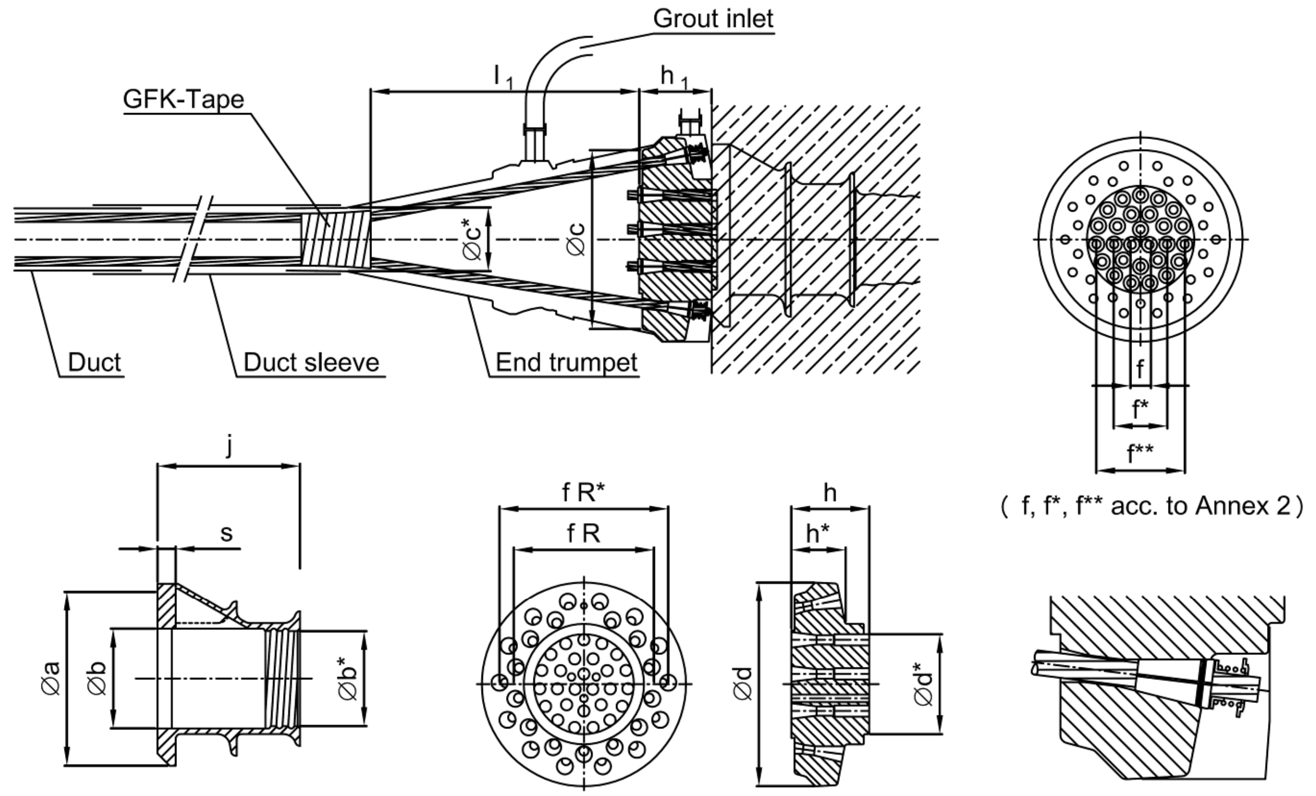
Tendon size	6819			6822			6827			6831			6837		
Strand	150mm², f_{pk}=1860N/mm² (F_{pk}=279kN) and 150mm², f_{pk}=1770N/mm² (F_{pk}=265,5kN)														
No. of strands	19			22			27			31			37		
Minimum actual concrete strength at stressing $f_{cm,0,cyl}$ [N/mm²]	23	33	42	23	33	42	23	33	42	23	33	42	23	33	42
Center distance A	530	445	400	570	485	435	640	540	490	690	590	535	760	650	600
Edge distance R	0,5 x Center distance + Concrete cover - 10 mm														
Additional reinforcement (Material see Annex 17)															
No. n	8	7	6	8	8	7	9	8	7	9	8	8	10	9	8
∅ d_s	16	16	16	16	16	16	16	16	16	20	20	20	20	20	20
z	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
i	60	65	70	60	65	65	60	65	70	75	80	80	75	75	85
x/y	495	410	365	535	450	400	605	505	455	650	550	495	720	610	560
Helix (Material see Annex 17)															
Turns n*	7,5	7,5	7,5	8	7,5	7,5	7	7	7	10	9	8	11	9	8
∅ d_s	16	16	16	16	16	16	20	20	20	20	20	20	20	20	20
∅ d_a	460	400	330	510	440	370	560	460	420	620	530	480	660	570	520
i*	45	45	45	45	50	50	55	55	55	55	60	65	50	60	65
min l*	410	410	410	430	445	445	460	460	460	625	615	595	625	615	595

DYWIDAG Bonded Strand Post-tensioning System

Multiplane anchorage MA

Center and edge distances of tendon sizes 6819 - 6837
for strand Y1860S7 15,7 and for strand Y1770S7 15,7

Annex 10



Anchor body MA | Coupler plate R | Wedge / Spring

Dimensions in mm

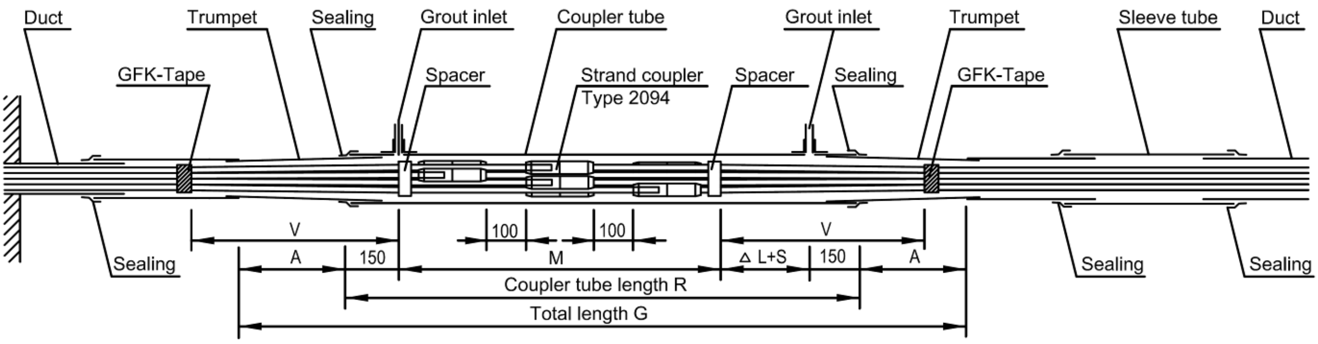
Tendon size			6805	6807	6809	6812	6815	6819	6822	6827	6831	6837
No. of strands			05	07	09	12	15	19	22	27	31	37
Anchor body MA Type 2302	Ø	a	150	170	190	220	250	280	310	340	420	420
	Ø	b	90	98	114	130	150	162	179	190	217	217
	Ø	b*	80	90	100	120	130	145	161	161	196	196
		j	90	100	125	180	200	220	220	240	350	350
		s	18	18	18	21	23	27	32	38	50	50
Coupler plate R Type 2320	Ø	d	207	207	224	246	264	289	340	380	435	435
	Ø	d*	88	96	112	128	148	159	176	188	214	214
		h	115	115	115	115	120	130	135	145	170	170
		h*	75	75	75	75	76	85	90	100	120	120
		h_1	105	105	105	105	110	120	125	135	158	158
Pitch circles	Ø	f_R	152	152	168	188	207	224	244	261	306	306
	Ø	f_R*							276	314	370	370
End trumpet	Length	l_1	460	370	350	500	450	570	640	660	870	870
	Ø	c	185	185	205	232	250	268	297	333	395	395
	Ø	c*	75	75	85	90	100	105	120	120	137	137

Center and edge distances and additional reinforcement and helix see Annex 7 - 10

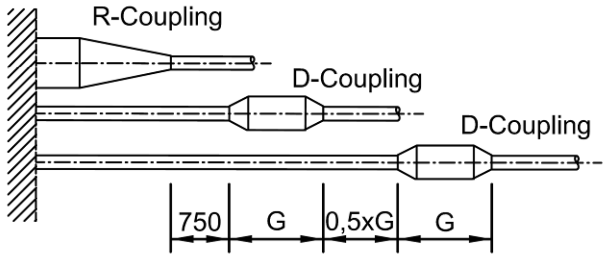
DYWIDAG Bonded Strand Post-tensioning System

Coupling R
Dimensions of Components

Annex 11

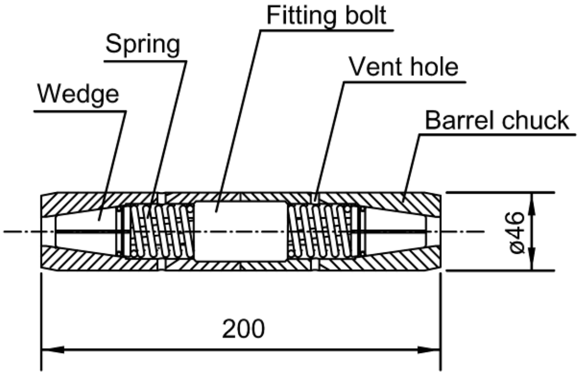


System sketch of staggering:



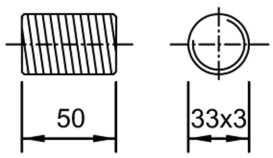
ΔL = Movement of coupling
S = 0,2 x ΔL ≧ 120 mm Safety clearance
Coupler tube length R = ΔL + S + M + 300
Total length G = R + 2 x A

Strand coupler D:



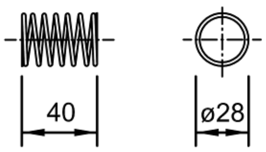
Fitting bolt

Special thread 33x3, l=50



Spring

ø28, l=40



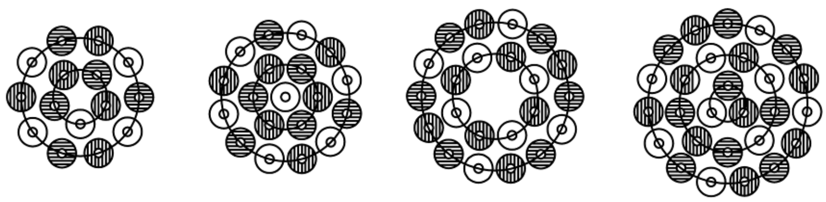
Note:
Outer dimensions are identical for both strand sizes!
At installation refer to marking 060 (140mm²) or 062 (150mm²), resp.!

DYWIDAG Bonded Strand Post-tensioning System	Annex 12a
Coupling D	

Arrangement of strand couplers

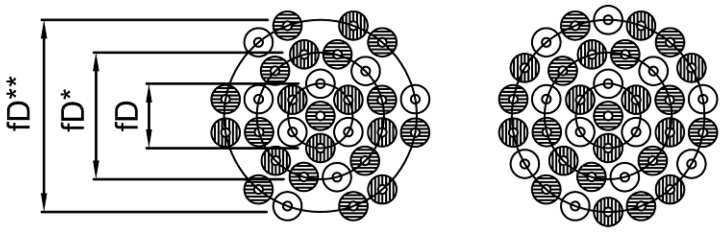
No. of strands: 3, 4, 5, 7, 9, 12

No. of strands: 15, 19, 22, 27



No. of strands: 31, 37

Strand couplers - position



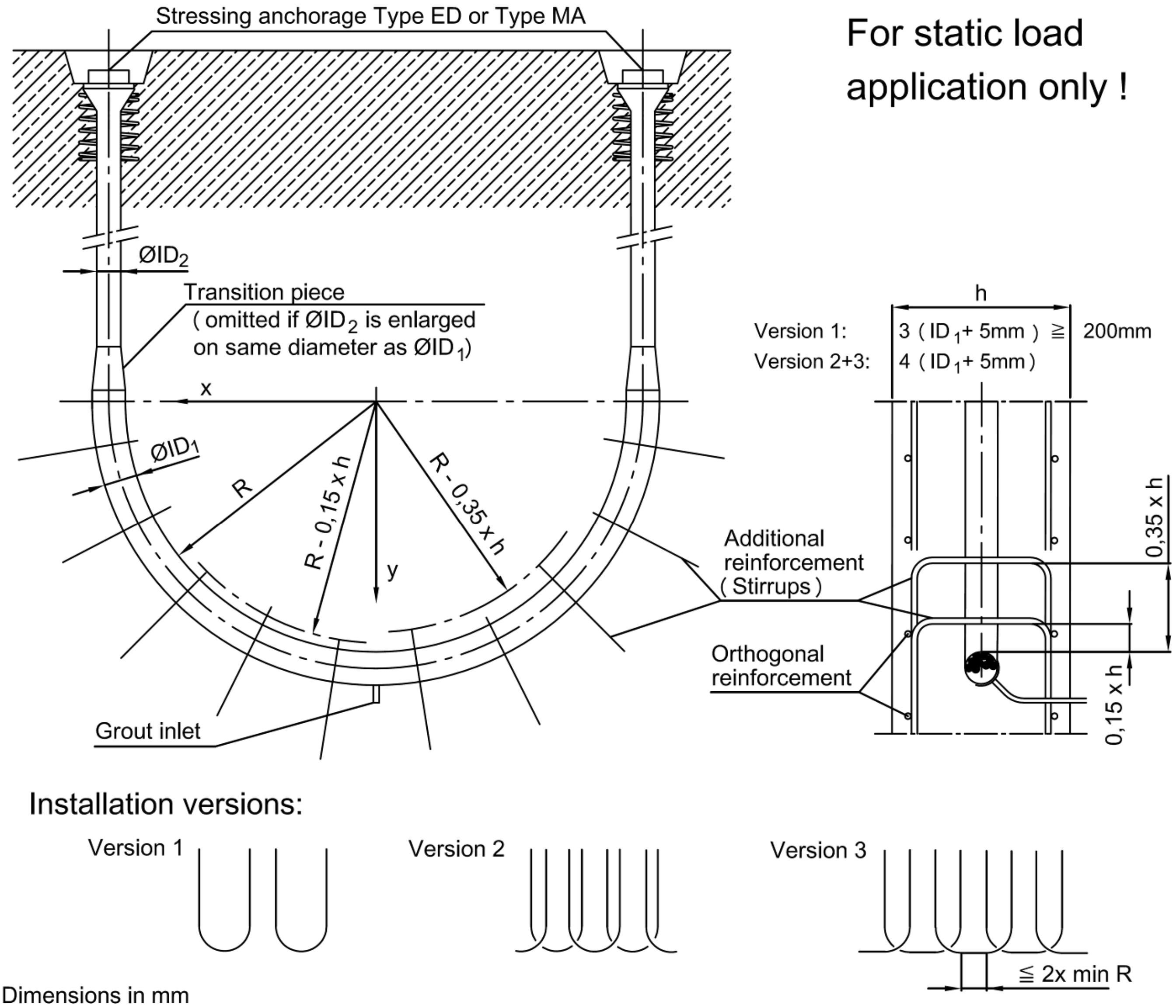
Dimensions in mm

Tendon size		6803	6804	6805	6807	6809	6812	6815	6819	6822	6827	6831	6837
no. of strands		03	04	05	07	09	12	15	19	22	27	31	37
Deviation length	V	300	350	400	500	550	650	700	750	900	900	1000	1000
Transition length	A	150	200	250	300	350	450	500	550	700	700	800	800
Length	M	900	600	900	900	900	900	900	940	940	940	940	940
		--	--	--	0	0	--	--	0	--	--	0	0
Pitch circles	Ø fD	44	50	60	70	86	40	60	70	86	38	65	65
Spacer	Ø fD*	--	--	--	--	--	105	125	136	152	100	126	126
	Ø fD**	--	--	--	--	--	--	--	--	--	165	190	190
Sleeve tube	Ø ID	100	110	120	125	140	160	180	200	225	225	250	250

DYWIDAG Bonded Strand Post-tensioning System

Coupling D

Annex 12b



Dimensions in mm

Tendon size		6803	6804	6805	6807	6809	6812	6815	6819	6822
No. of strand		03	04	05	07	09	12	15	19	22
Minimum actual concrete strength at stressing		min $f_{cm,0,cyl}$ = 23 N/mm²								
Loop	ØID$_1$ [mm]	50	55	60	75	85	95	110	120	130
with steel tube	min R [mm]	750	750	750	750	900	1100	1250	1500	1700
with duct	min R [mm]	1500	1500	1500	1500	1800	2200	2500	3000	3400
Duct	ØID$_2$ [mm]	40	45	50	60	75	80	90	95	100
Additional reinforcement (Mat. s. Annex 17)	[cm²]	12,50	16,50	21,00	29,00	37,50	50,00	62,50	79,00	91,50

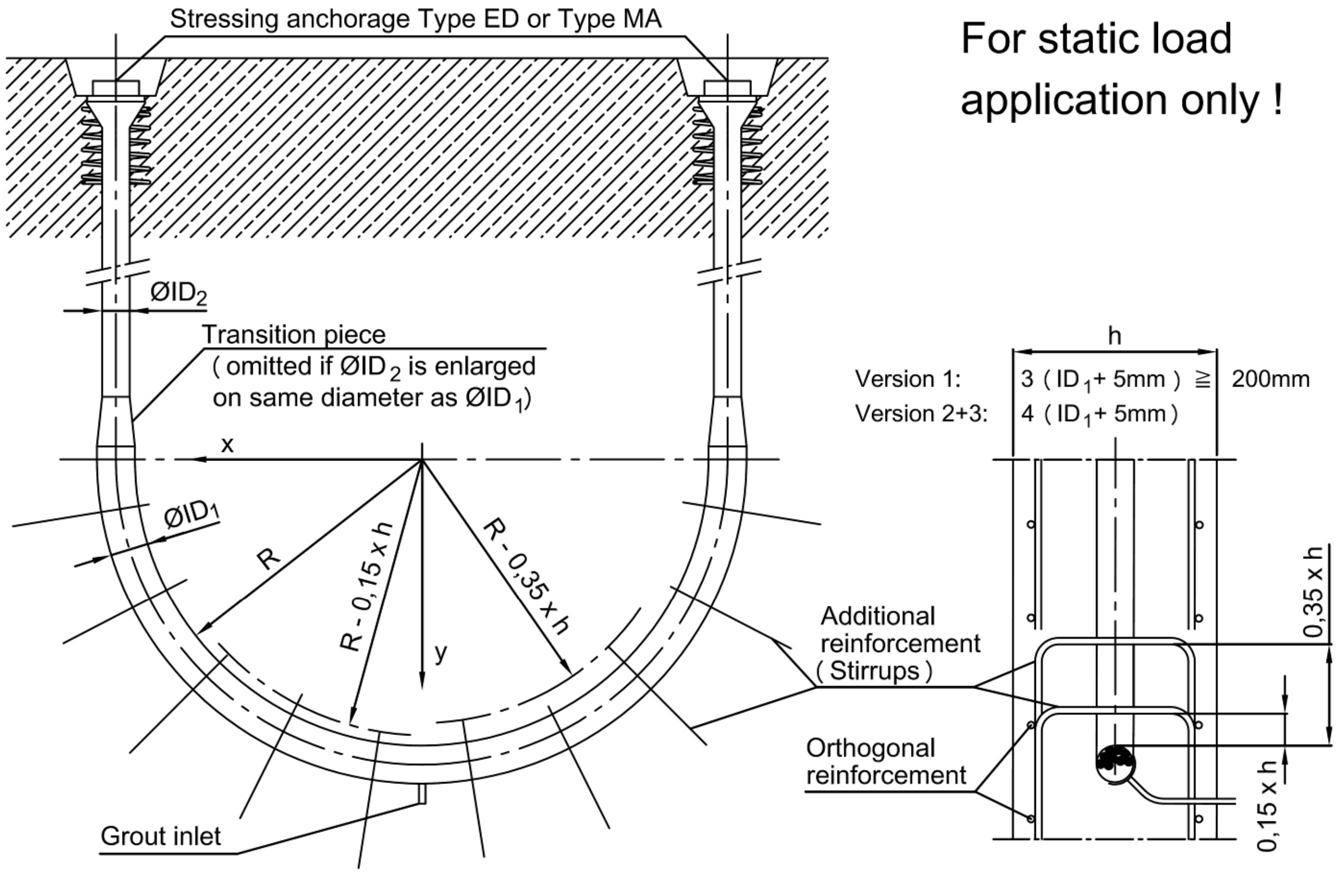
DYWIDAG Bonded Strand Post-tensioning System

Loop anchorage

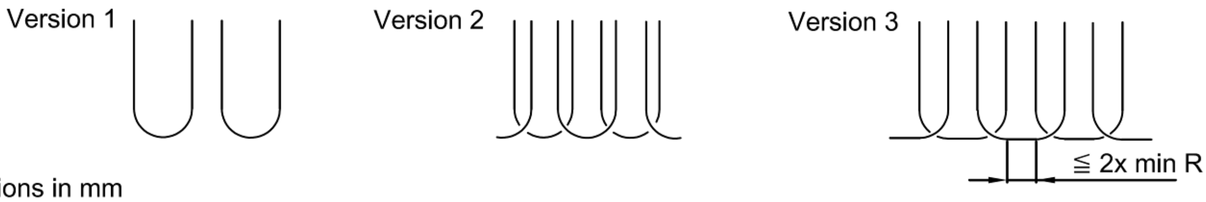
Dimensions and additional reinforcement
for strand Y1860S7 15,3 and for strand Y1770S7 15,3

Annex 13

For static load application only !



Installation versions:



Dimensions in mm

Tendon size		6803	6804	6805	6807	6809	6812	6815	6819	6822
No. of strand		03	04	05	07	09	12	15	19	22
Minimum actual concrete strength at stressing		min $f_{cm,0,cyl}$ = 23 N/mm²								
Loop	$ØID_1$ [mm]	50	55	60	75	85	95	110	120	130
with steel tube	min R [mm]	800	800	800	800	950	1150	1350	1600	1800
with duct	min R [mm]	1600	1600	1600	1600	1900	2300	2700	3200	3600
Duct	$ØID_2$ [mm]	40	45	50	60	75	80	90	95	100
Additional reinforcement (Mat. s. Annex 17)	[cm²]	13,50	18,00	22,00	31,00	40,00	53,50	67,00	85,00	98,00

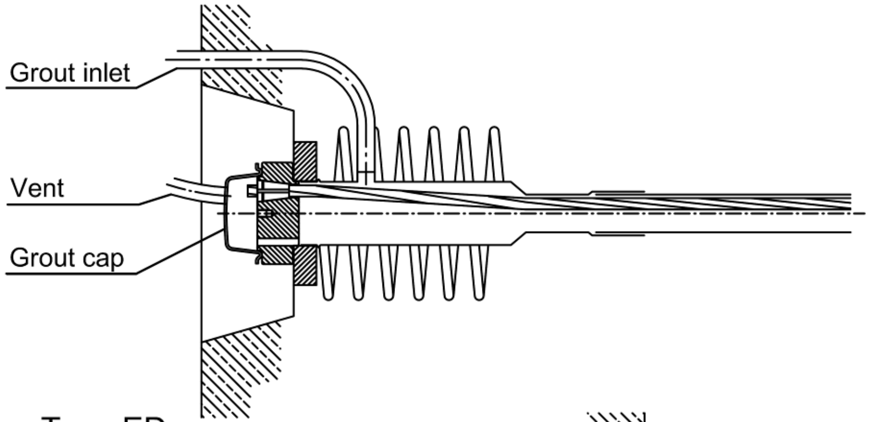
DYWIDAG Bonded Strand Post-tensioning System

Loop anchorage

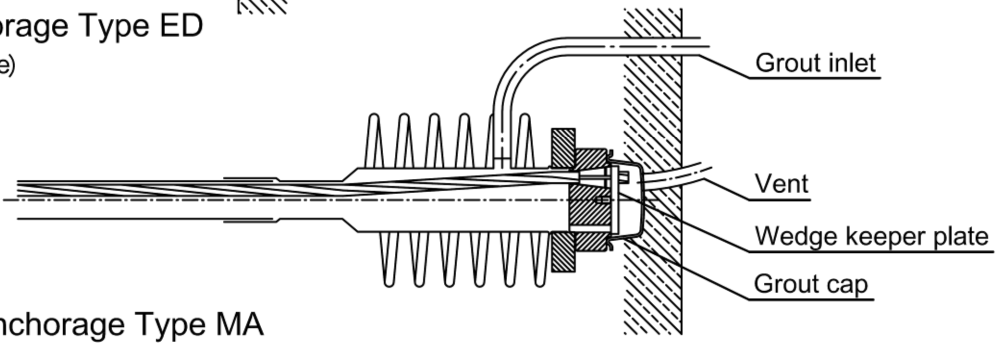
Dimensions and additional reinforcement
for strand Y1860S7 15,7 and for strand Y1770S7 15,7

Annex 14

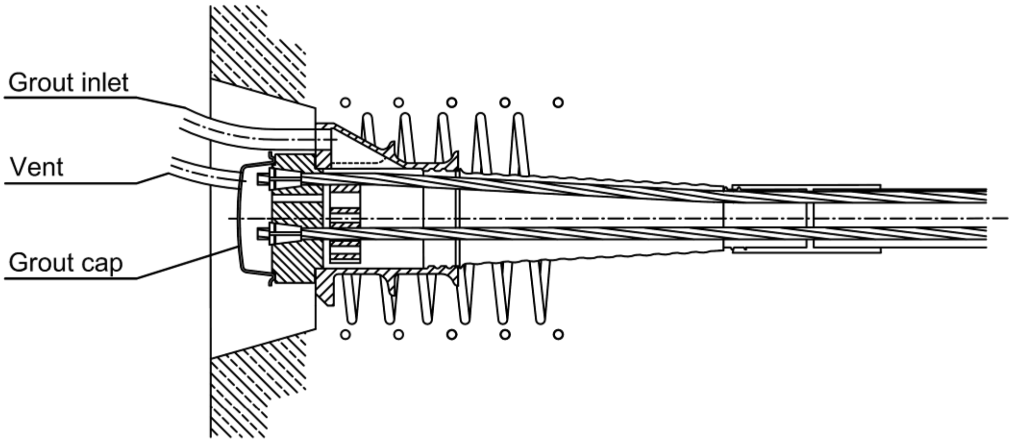
Stressing anchorage Type ED



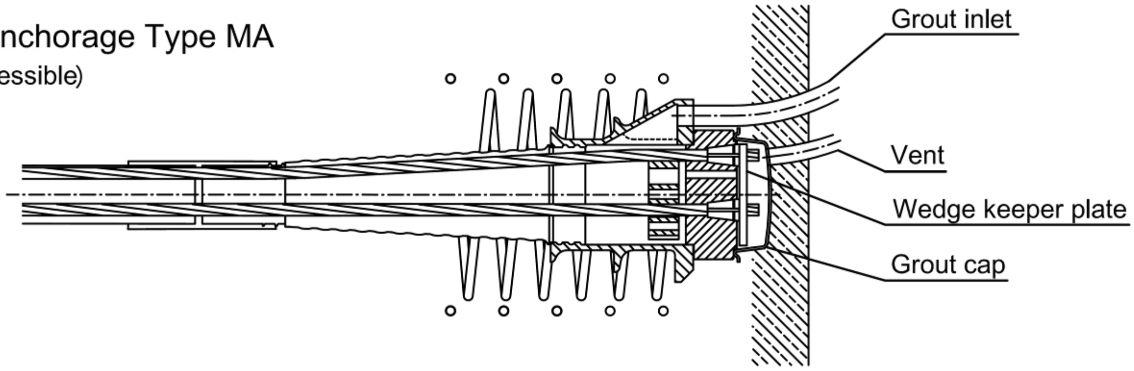
Fixed anchorage Type ED
(not accessible)



Stressing anchorage Type MA

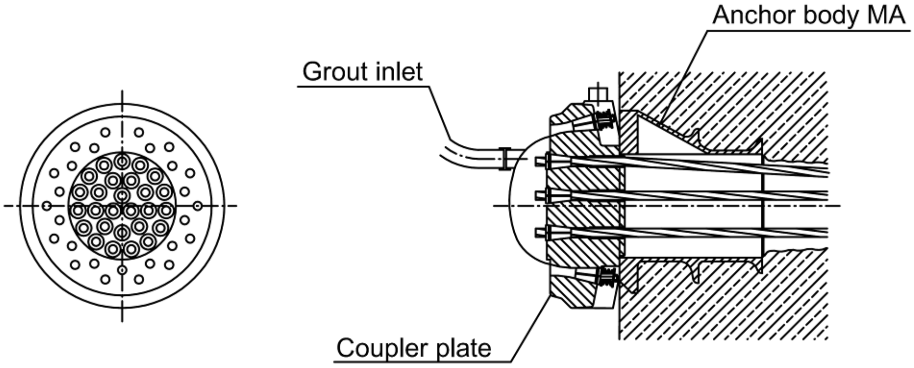


Fixed anchorage Type MA
(not accessible)

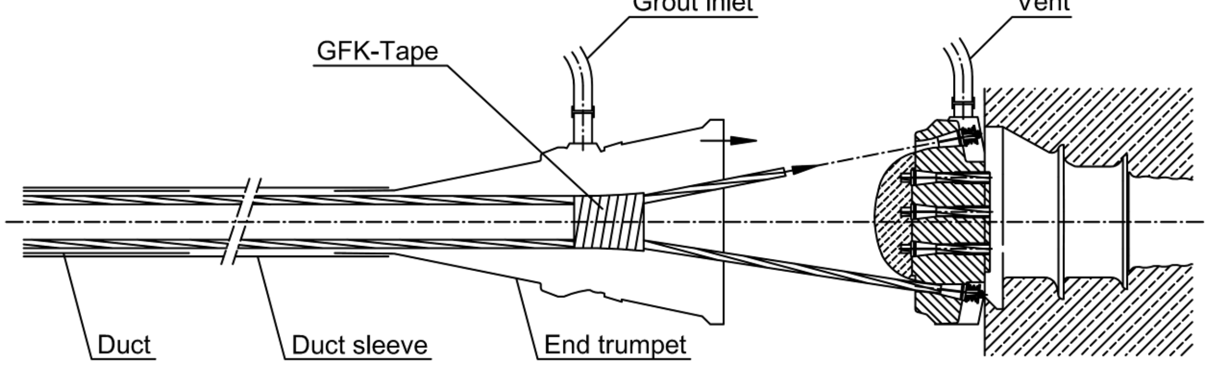


DYWIDAG Bonded Strand Post-tensioning System	Annex 15
Anchorages Type ED and Type MA	

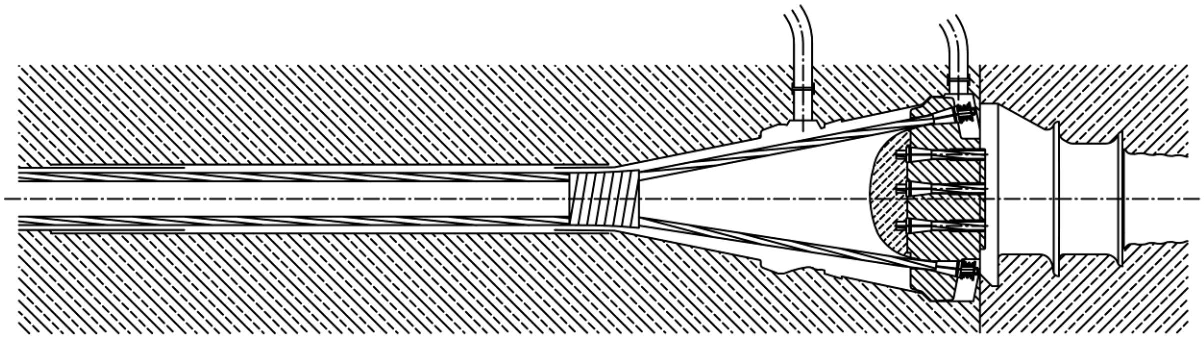
Installation
(1st. construction phase)



Coupling



Pouring of concrete, stressing
(2nd. construction phase)



DYWIDAG Bonded Strand Post-tensioning System	Annex 16
Coupling Type R	

Designation	Material	Standard
Wedge	Case hardened steel *	EN 10277-2: 1999-10 EN 10083-2: 1996-10
Wedge plate Type ED und MA	Quenched and tempered steel *	EN 10083-1: 1996-10 EN 10083-2: 1996-10
Multiplane anchor body Type MA	Cast ductile iron *	EN 1563 ASTM A536
Anchor plate Type ED	Structural steel *	EN 10025: 1994-03
Coupler plate Type R	Quenched and tempered steel *	EN 10083-1: 1996-10 EN 10083-2: 1996-10
Barrel chuck Type D	Quenched and tempered steel *	EN 10083-1: 1996-10 EN 10083-2: 1996-10
Fitting bolt Type D	Structural steel *	EN 10025: 1994-03
Spring Type D	Spring steel *	DIN 2098-1
Spacer	Polyethylen (PE)	EN 1872
Helix	S 235 JR Reinf. steel $R_e \geqq 500$ MPa	EN 10025: 1994-03 EN 10080
Additional reinforcement	$R_e \geqq 500$ MPa	EN 10080
Trumpet	Polyethylen (PE)	EN 1872

* exact material properties and definitions deposited at DIBt

DYWIDAG Bonded Strand Post-tensioning System	Annex 17
Materials and standard references	

DIMENSIONS AND PROPERTIES OF 7-WIRE STRANDS

Designation	Symbol	Unit	Value	
Tensile strength	R_m/F_{pk}	MPa	1770 or 1860	
Strand				
Nominal diameter	D	mm	15,3	15,7
Nominal cross section	A_p	mm²	140	150
Nominal mass	M	g/m	1093	1172
Surface configuration	-	-	plain	
Strength at 0,1%	$f_{p0,1k}$	MPa	1520 or 1600	
Strength at 0,2%	$f_{p0,2}$	MPa	1570 or 1660	
Modulus of elasticity	E	MPa	≈ 195.000	
Individual wires				
External wire diameter	d	mm	5,0 ± 0,04	5,2 ± 0,04
Core wire diameter	d'	mm	1,02 to 1,04 d	1,02 to 1,04 d

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

DYWIDAG Bonded Strand Post-tensioning System	Annex 18
7-wire strands 6803 - 6837	

CONTENT OF CONTROL PLAN

Component	Item	Test/ Check	Traceability [4]	Minimum frequency	Documen-tation
Anchor plate for 3 to 5 strands	material	check	bulk	100 %	"2.2" [1]
	detailed dimensions[5]	test		3 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Cast-iron anchor body for 5 to 37 strands	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		3% ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Wedge plate	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Coupler plate R Strand coupler D	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Wedge	material	check	full	100 %	"3.1" [2]
	treatment, hardness	test		0,5 % ≥ 2 specimen	yes
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Duct	material	check	“CE”	100 %	“CE”
	visual inspection[3]	check		100 %	no

Continuation of Control Plan and footnotes see Annex 19b

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CONTENT OF CONTROL PLAN - CONTINUED -

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

All samples shall be randomly selected and clearly identified.

1 "2.2" : Test report type "2.2" according to EN 10204
2 "3.1" : Inspection certificate type "3.1" according to EN 10204
3 Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, smoothness, corrosion, coating, etc., as given in the Control Plan
4 full : Full traceability of each component to its raw material.
bulk : Traceability of each delivery of components to a defined point.
5 Detailed dimensions mean measuring of all dimensions and angles according to the specification as given in the Control Plan
6 Characteristic material properties see Annex 18
7 Grease according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.1
8 Wax according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.2

DYWIDAG Bonded Strand Post-tensioning System

Control Plan continued

6803 - 6837

Annex 19b

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

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

2 All samples shall be randomly selected and clearly identified.

DYWIDAG Bonded Strand Post-tensioning System

Audit Testing

6803 - 6837

Annex 20

1 Manufacture

The setup of the DYWIDAG strand tendon allows its prefabrication in the workshop or on site or a production in the structure itself.

Tendons prefabricated at the factory are preassembled and ready for installation complete with the sheathing. Longer prefabricated tendons are transported to the site on coils or in the form of loop. The minimum transport diameter is 1.65 m, for tendons 6827 and beyond at least 2.0 m.

On-site the tendons are either preassembled as they are when manufactured in the factory or the strands are pulled/pushed into the already installed sheathings.

2 Ducts

Round corrugated steel ducts according to EN 523 are used as sheathings. Their joints are covered with threadable duct couplers. If the strands are pushed/pulled into already installed sheathing or after concreting, ducts of larger inner diameter (Type II) are used. The strands of tendons are placed in a duct without spacer. The sheathings are widened by means of trumpets in the region of the anchorages and couplers because of the need to spread out the strands. All transitions and joints are to be carefully sealed with adhesive tape.

The use of oval sheathings is also permissible for tendon types 6803, 6804 and 6805 in conjunction with the plate anchorage (ED). For the oval sheathing EN 523 applies accordingly.

3 Wedges

The three part wedges made of case-hardened steel differ in the shape of their teeth. The wedge length is 42 mm for 0.6” and 45 mm for 0.62” strands. Further dimensions of wedges and their distinguishing features can be found in Annex 2.

4 Anchorages

Anchorages depending on the tendon sizes are identical for both strand sizes and steel grades.

The anchorage consists of an anchor plate or an anchor body and a wedge plate with 3 to 37 conical borings – depending on the tendon size – in which the strands are anchored with wedges, each consisting of three segments.

4.1 Plate anchorage ED

At these anchorages for tendons 6803 – 6805 the wedge plate is supported by an anchor plate which transfers the prestressing force to the structure. This type of anchorage can be used as stressing- and accessible fixed anchorage and also as not accessible fixed anchorage if a wedge keeper plate is used. The conical borings of the not accessible fixed anchorages shall be filled with corrosion protection compound before threading and wedging of the strands.

The bursting forces caused by the load transfer to the concrete member shall be carried by a helix made of plain steel or reinforcement steel. Additional reinforcement beyond the common minimum reinforcement for structural concrete members such as straight bars or stirrups is not required.

4.2 Multiplane anchorage MA

These anchorages for tendons 6805 – 6837 consist of a concrete-encased anchor body and a wedge plate which can be mounted on it. This type of anchorage can likewise be used as a stressing and accessible passive anchorage – and with a wedge keeper plate as not accessible. The wedges of the embedded passive anchorages have to be sealed. The bursting forces caused by the load transfer to the concrete member shall be carried by a helix made of plain steel or reinforcement steel. Additional reinforcement such as straight bars or stirrups is also required.

4.3 Loop anchorage

The loop anchorage is a part of a tendon with standard anchorages at the tendon ends. This type of anchorage is designed for the application in flat structures with predominantly static loading. The length of the straight sections of the tendon at both sides of the loop must be the same. The strands will be pushed into the sheathing after hardening of concrete. The stressing must be applied at both anchorages simultaneously.
The sheathing in the curved area must be pre-bent with the aid of a bending template of a bending machine under consideration of the minimum bending radius.

5 Couplers

Tendons can be coupled with fixed or movable couplers.

5.1 Fixed coupler R

The coupler is supported directly on the concrete-encased anchor body. The coupler is preassembled and consists of a coupler plate, wedges, springs, lock washers and a cover cap in each conical hole which is removed prior for installation of the departing tendon. The cones are filled with corrosion protection grease. The strands of the arriving tendon are anchored in the coupler plate in the same way as in an active anchorage. The strands of the departing tendon are held in a radial pattern of inclined conical borings and anchored by three-segment wedges in the coupler. These wedges are retained by a spring and a lock washer in their seating.
The correct position of the strands of the departing tendon within the coupler is checked by colour marking on the strands ends.
During the stressing of the tendon a wedge slip of 4 mm occurs due to the seating of these wedges.
The transition area from the coupler to the duct will be closed with a coupler trumpet.

5.2 Movable coupler D

The strands are jointed individually by means of a strand coupler.
A strand coupler consists of two identical halves connected by a splice bolt. Each half consists of a barrel, a three segment wedge and a spring. The strands to be spliced are inserted into the preassembled coupler. The proper seating of the two strand ends is to be checked with colour markings.
The transition area from the coupler to the duct will be closed with a coupler trumpet.

6 Stressing

A hydraulic pump unit and a centre hole jack are used for the stressing of tendons. The strands pass through the jack and are anchored in the tension disk with clamping jaws. All strands of a tendon are stressed simultaneously. The prestressing force is checked with the aid of a pressure gauge. Furthermore, the elongation of the prestressing steel serves as control of the prestressing force. Long tendons for which the jack stroke is insufficient can be stressed in stages provided section 4.2.6 of specific conditions is observed.
Stressing in load steps and resetting of the jack is easily done. After stressing, the wedges are power seated by means of a seating device within the jack. A wedge slip of approx. 4 mm remains after the wedge seating procedure.
Straight tendons strands can be stressed individually by mono jacks.

7 Grouting

After stressing cement grout is injected into the void between prestressing steel and sheathing thus forming bond between strands and concrete. Moreover, cement grout serves as corrosion protection of the strands. The grout is injected through the anchor body MA, through the grout inlet in the trumpet of anchorage type ED or through inlets at the deepest points of the sheathing.
The ducts are vented at the ends of the tendons by means of venting pipes or grouting caps.
Intermediate venting points at high points are necessary in case of long tendons. Couplers are always equipped with vents. Grouting shall be executed in accordance with EN 445, EN 446 and EN 447.