terra infrastructure

safety: efficient and sustainable

ANCHOR AND MICROPILE EQUIPMENT

TECHNICAL HANDBOOK

SOLUTIONS FOR ALL CHALLENGES

Our anchors and micropiles are used in construction projects such as quays, foundations for onshore and offshore wind generators, tunnels, excavation pits, retaining walls and slope stabilization. We have an extensive product range that can be used to solve a wide variety of challenges.

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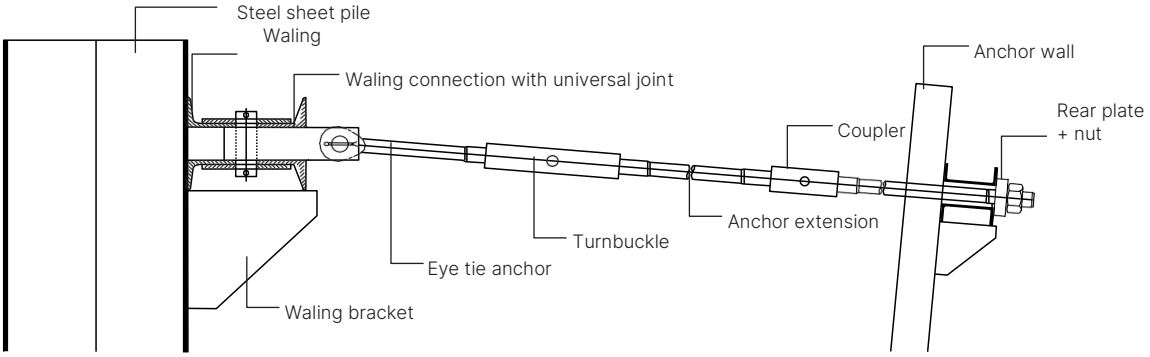
Anchor equipment

Round steel tie rods

Round steel tie rod components and connecting elements

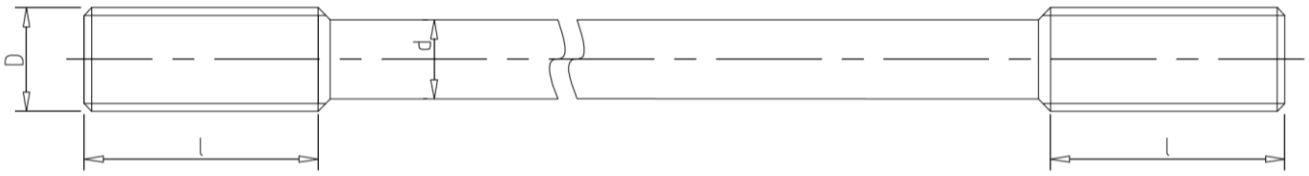


*Accessory parts as shown above on request

Anchor with upset ends – rolled thread

Round steel tie rods acc. to DIN EN 1993-5 and EAU 2020

Anchor force according to DIN EN 1993-5 - kt = 0.60			**M39**	**M42**	**M45**	**M48**	**M52**	**M56**	**M60**	**M64**	**M68**	**M72**	**M76**	**M80**	**M85**	**M90**
Nominal diameter	**D**	**mm**	**39**	**42**	**45**	**48**	**52**	**56**	**60**	**64**	**68**	**72**	**76**	**80**	**85**	**90**
Shaft diameter	d	mm	36	39	42	45	49	52	56	60	64	68	72	76	81	86
Tensile stress area Thread	As	mm²	976	1,121	1,306	1,473	1,758	2,030	2,362	2,676	3,055	3,460	3,889	4,344	4,948	5,591
Cross sectional area Shaft	Ag	mm²	1,017	1,194	1,385	1,590	1,847	2,124	2,463	2,827	3,217	3,632	4,072	4,536	5,153	5,809
ASF 355 Permissible design resistance	**Rd**	**kN**	**346**	**398**	**464**	**523**	**624**	**721**	**839**	**950**	**1,085**	**1,228**	**1,381**	**1,542**	**1,757**	**1,985**
ASF 460 Permissible design resistance	**Rd**	**kN**	**449**	**516**	**601**	**678**	**809**	**934**	**1,087**	**1,231**	**1,405**	**1,592**	**1,789**	**1,998**	**2,276**	**2,572**
ASF 500 Permissible design resistance	**Rd**	**kN**	**478**	**549**	**639**	**721**	**861**	**994**	**1,156**	**1,310**	**1,496**	**1,694**	**1,904**	**2,127**	**2,423**	**2,737**
ASF 720 Permissible design resistance	**Rd**	**kN**	**632**	**726**	**846**	**955**	**1,139**	**1,315**	**1,531**	**1,734**	**1,980**	**2,242**	**2,520**	**2,815**	**3,206**	**3,623**
Weight (Shaft)	G	kg/m	7.99	9.38	10.88	12.49	14.80	16.62	19.34	22.20	25.25	28.51	31.96	35.61	40.45	45.60



Anchor force according to DIN EN 1993-5 - kt = 0.60			**M95**	**M100**	**M105**	**M110**	**M115**	**M120**	**M125**	**M130**	**M135**	**M140**	**M145**	**M150**	**M155**	**M160**
Nominal diameter	**D**	**mm**	**95**	**100**	**105**	**110**	**115**	**120**	**125**	**130**	**135**	**140**	**145**	**150**	**155**	**160**
Shaft diameter	d	mm	91	96	101	106	111	116	121	126	131	136	141	146	151	156
Tensile stress area Thread	As	mm²	6,273	6,995	7,755	8,556	9,395	10,274	11,191	12,149	13,145	14,181	15,256	16,370	17,524	18,716
Cross sectional area Shaft	Ag	mm²	6,504	7,238	8,012	8,825	9,677	10,568	11,499	12,469	13,478	14,527	15,615	16,742	17,908	19,113
ASF 355 Permissible design resistance	**Rd**	**kN**	**2,227**	**2,483**	**2,753**	**3,037**	**3,335**	**3,647**	**3,973**	**4,313**	**4,666**	**5,034**	**5,416**	**5,811**	**6,221**	**6,644**
ASF 460 Permissible design resistance	**Rd**	**kN**	**2,886**	**3,218**	**3,567**	**3,936**	**4,322**	**4,726**	**5,148**	**5,589**	**6,047**	**6,523**	**7,018**	**7,530**	**8,061**	**8,609**
ASF 500 Permissible design resistance	**Rd**	**kN**	**3,071**	**3,425**	**3,797**	**4,189**	**4,600**	**5,030**	**5,479**	**5,948**	**6,436**	**6,943**	**7,469**	**8,015**	**8,580**	**9,163**
ASF 720 Permissible design resistance	**Rd**	**kN**	**4,065**	**4,533**	**5,025**	**5,544**	**6,088**	**6,658**	**7,252**	**7,873**	**8,518**	**9,189**	**9,886**	**10,608**	**11,356**	**12,128**
Weight (Shaft)	G	kg/m	51.06	56.82	62.89	69.27	75.96	82.96	90.27	97.88	105.80	114.04	122.57	131.42	140.58	150.00

Anchor with rolled thread

Anchor force according to DIN EN 1993-5 - kt = 0.90			**M 39**	**M 42**	**M 45**	**M 48**	**M 52**	**M 56**	**M 60**	**M 64**	**M 68**	**M 72**	**M 76**	**M 80**	**M 85**	**M 90**
Nominal diameter	**D**	**mm**	**39**	**42**	**45**	**48**	**52**	**56**	**60**	**64**	**68**	**72**	**76**	**80**	**85**	**90**
Shaft diameter	d	mm	36	39	42	45	49	52	56	60	64	68	72	76	81	86
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ASF 460 Permissible design resistance	**Rd**	**kN**	**449**	**516**	**601**	**678**	**809**	**934**	**1,087**	**1,231**	**1,405**	**1,592**	**1,789**	**1,998**	**2,276**	**2,572**
ASF 500 Permissible design resistance	**Rd**	**kN**	**478**	**549**	**639**	**721**	**861**	**994**	**1,156**	**1,310**	**1,496**	**1,694**	**1,904**	**2,127**	**2,423**	**2,737**
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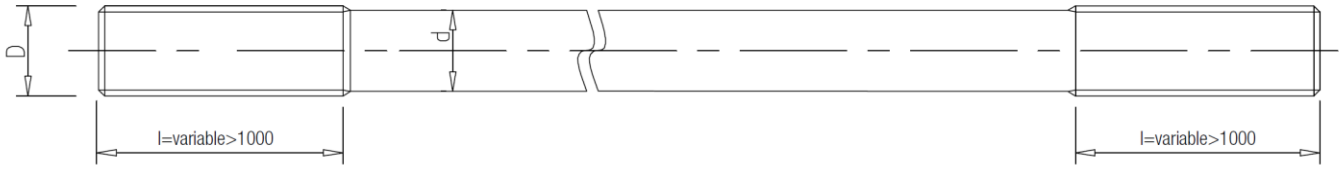
Weight (Shaft)	G	kg/m	7.99	9.38	10.88	12.49	14.80	16.62	19.34	22.20	25.25	28.51	31.96	35.61	40.45	45.60



Anchor force according to DIN EN 1993-5 - kt = 0.90			**M 95**	**M 100**	**M 105**	**M 110**	**M 115**	**M 120**	**M 125**	**M 130**	**M 135**	**M 140**	**M 145**	**M 150**	**M 155**	**M 160**
Nominal diameter	**D**	**mm**	**95**	**100**	**105**	**110**	**115**	**120**	**125**	**130**	**135**	**140**	**145**	**150**	**155**	**160**
Shaft diameter	d	mm	91	96	101	106	111	116	121	126	131	136	141	146	151	156
Tensile stress area Thread	As	mm²	6,273	6,995	7,755	8,556	9,395	10,274	11,191	12,149	13,145	14,181	15,256	16,370	17,524	18,716
Cross sectional area Shaft	Ag	mm²	6,504	7,238	8,012	8,825	9,677	10,568	11,499	12,469	13,478	14,527	15,615	16,742	17,908	19,113
ASF 355 Permissible design resistance	**Rd**	**kN**	**2,227**	**2,483**	**2,753**	**3,037**	**3,335**	**3,647**	**3,973**	**4,313**	**4,666**	**5,034**	**5,416**	**5,811**	**6,221**	**6,644**
ASF 460 Permissible design resistance	**Rd**	**kN**	**2,886**	**3,218**	**3,567**	**3,936**	**4,322**	**4,726**	**5,148**	**5,589**	**6,047**	**6,523**	**7,018**	**7,530**	**8,061**	**8,609**
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ASF 720 Permissible design resistance	**Rd**	**kN**	**4,065**	**4,533**	**5,025**	**5,544**	**6,088**	**6,658**	**7,252**	**7,873**	**8,518**	**9,189**	**9,886**	**10,608**	**11,356**	**12,128**
Weight (Shaft)	G	kg/m	51.06	56.82	62.89	69.27	75.96	82.96	90.27	97.88	105.80	114.04	122.57	131.42	140.58	150.00

Permissible design resistances Rd according to DIN 1993-5 (D) / Stressed area

Round steel tie rods and bolts

(The threads - Metric thread - are rolled up)

The design resistances are calculated using the following equation over the minimum cross section:

$F_{tg,Rd}$ =	(Shaft cross section)	$A_g \times f_{y,k} / \gamma_{M0}$	$A_{Schaft} \times f_{y,k} / \gamma_{M0}$	where γ_{M0} = 1.00
$F_{tt,Rd}$ =	(Thread cross section)	$k_t \times A_S \times f_{ua,k} / \gamma_{M2}$	$k_t \times A_{Sp} \times f_{ua,k} / \gamma_{M2}$	where γ_{M2} = 1.25

Verification for the ultimate limit state to DIN EN 1993-5:

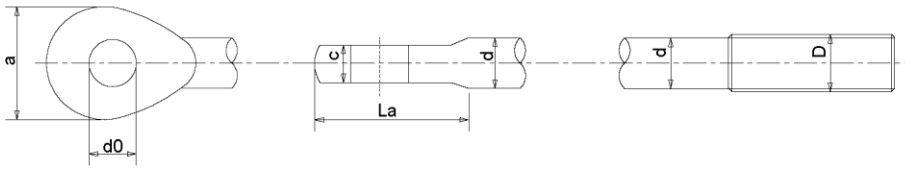
$Z_d < R_d$

Z_d:	design value of anchor force $Z_d = Z_{G,k} * \gamma_G + Z_{Q,k} * \gamma_Q$	$f_{y,k}$:	yield stress
R_d:	design resistance of anchor R_d = Min [$F_{tg,Rd}$; $F_{tt,Rd}$]	$f_{ua,k}$:	tensile strength
A_g :	cross-sectional area in shaft zone	γ_{M0} :	partial safety factor to DIN EN 1993-5 for anchor shaft
A_S :	tensile stress area in threaded zone	γ_{M2} :	partial safety factor to DIN EN 1993-5 for threaded area
		k_t :	notch factor to DIN 1993-5 (k_t = 0.60 or 0.90)

Eye anchor

ASF 355 anchor force acc. to DIN EN 1993-5 with kt = 0.6			**A150**	**A175**	**A200**	**A200**	**A225**	**A225**	**A225**	**A250**	**A275**	**A300A**	**A300B**	**A325**	**A350**	**A375A**
Shaft diameter	d	mm	36	39	42	42	45	45	45	48	52	56	60	64	68	72
Thickness eye	c	mm	25	30	33	33	39	39	39	42	47	50	50	55	60	63
Length eye	La	mm	86	106	127	127	135	135	135	147	166	190	190	210	220	235
Width eye	a	mm	72	85	105	105	110	110	110	125	135	155	155	165	180	190
Bolt diameter	d0	mm	30	33	36	36	40	40	40	47	52	56	56	62	68	70

ASF 355 anchor force acc. to DIN EN 1993-5 with kt = 0.6			**A375B**	**A400**	**A425**	**A450**	**A450**	**A475**	**A500**	**A525**	**A550**	**A575**	**A575**	**A600**	**A625**	**A650**
Shaft diameter	d	mm	75	80	85	90	90	95	100	105	110	115	115	120	125	130
Thickness eye	c	mm	63	66	72	75	75	80	85	90	95	100	100	105	115	120
Length eye	La	mm	235	253	290	300	300	323	340	350	365	373	373	380	439	459
Width eye	a	mm	190	210	230	240	240	255	270	275	290	300	300	310	330	340
Bolt diameter	d0	mm	70	76	80	85	85	90	95	100	100	105	105	110	115	120

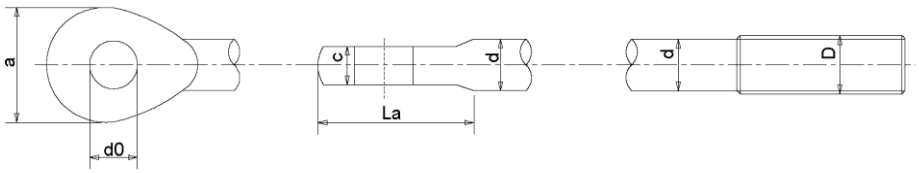


ASF 500 anchor force acc. to DIN EN 1993-5 with kt = 0.6			**A150**	**A175**	**A200**	**A200**	**A225**	**A225**	**A225**	**A250**	**A275**	**A300A**	**A300B**	**A325**	**A350**	**A375A**
Shaft diameter	d	mm	36	39	42	42	45	45	45	48	52	56	60	64	68	72
Thickness eye	c	mm	25	30	33	33	39	39	39	42	47	50	50	55	60	63
Length eye	La	mm	86	106	127	127	135	135	135	147	166	190	190	210	220	235
Width eye	a	mm	72	85	105	105	110	110	110	125	135	155	155	165	180	190
Bolt diameter	d0	mm	30	33	36	36	41	41	41	47	52	56	56	62	68	70

ASF 500 anchor force acc. to DIN EN 1993-5 with kt = 0.6			**A375B**	**A400**	**A425**	**A450**	**A450**	**A475**	**A500**	**A525**	**A550**	**A575**	**A575**	**A600**	**A625**	**A650**
Shaft diameter	d	mm	75	80	85	90	90	95	100	105	110	115	115	120	125	130
Thickness eye	c	mm	63	66	72	75	75	80	85	90	95	100	100	105	115	120
Length eye	La	mm	235	253	290	300	300	323	340	350	365	373	373	380	439	459
Width eye	a	mm	190	210	230	240	240	255	270	275	290	300	300	310	330	340
Bolt diameter	d0	mm	70	76	80	85	85	90	95	100	105	110	110	115	120	125

ASF 720 anchor force acc. to DIN EN 1993-5 with kt = 0.6			**A150**	**A175**	**A200**	**A200**	**A225**	**A225**	**A225**	**A250**	**A275**	**A300A**	**A300B**	**A325**	**A350**	**A375A**
Shaft diameter	d	mm	36	39	42	42	45	45	45	48	52	56	60	64	68	72
Thickness eye	c	mm	25	30	33	33	39	39	39	42	47	50	50	55	60	63
Length eye	La	mm	86	106	127	127	135	135	135	147	166	190	190	210	220	235
Width eye	a	mm	72	85	105	105	110	110	110	125	135	155	155	165	180	190
Bolt diameter	d0	mm	30	33	40	40	44	44	44	50	55	61	61	66	72	76

ASF 720 anchor force acc. to DIN EN 1993-5 with kt = 0.6			**A375B**	**A400**	**A425**	**A450**	**A450**	**A475**	**A500**	**A525**	**A550**	**A575**	**A575**	**A600**	**A625**	**A650**
Shaft diameter	d	mm	75	80	85	90	90	95	100	105	110	115	115	120	125	130
Thickness eye	c	mm	63	66	72	75	75	80	85	90	95	100	100	105	115	120
Length eye	La	mm	235	253	290	300	300	323	340	350	365	373	373	380	439	459
Width eye	a	mm	190	210	230	240	240	255	270	275	290	300	300	310	330	340
Bolt diameter	d0	mm	76	85	90	95	95	100	105	110	110	115	115	125	130	135



terra ASF micropile

General information

The terra ASF micropile is a system according to DIN 14199 and DIN SPEC 18539. A main feature of the terra ASF micropile is the use of a good-tolerance steel grade. As a result, the system has low steel elongation under load and higher load-bearing reserves than comparable micropile systems. Currently, micropiles with a length of up to 34 meters can be supplied in one piece.

Corrosion protection

Permanent corrosion protection is ensured with the help of the cement stone covering of the grout body. The use of an additional grouted corrugated sheathing, as in comparable systems, is not necessary. The permanent corrosion protection of the pile head is achieved either by placing the pile head in concrete or by using the pile head construction in accordance with the approval.

Intended purpose

Micropile for tie-back anchoring

- According to DIN EN 14199 for load transfer of tensile loads into deeper, load-bearing soil layers

Micropile for foundations

- According to DIN EN 14199 for load transfer of compressive and tensile loads in deeper, load-bearing soil layers

Nominal size		**Inch**	**3**	**3½**	**4**	**4¼**
Outer diameter	Ø	mm	71.0	83.0	96.0	102.0
Cross-sectional area	A	cm^2	37.0	51.3	67.7	77.3
Yield strength/tensile strength	fy/fu	N/mm^2	500/700	500/700	500/700	500/700
Characteristic load-bearing capacity for tensile load[1)]	R_k	kN	2,036	2,598	3,385	4,139
Characteristic load-bearing capacity under compressive load[1)]	R_k	kN	2.127	2.598	3,385	4,242
Elongation stiffness	E · A	MN	611	912	1,365	1,650
Weight		kg/m	31.1	42.5	56.8	64.1

1. Utilization of the load-bearing capacity is dependent on the cement stone cover according to approval Z-34.14-243
2. The use of the terra ASF micropile are regulated in Germany by the National Technical Approval Z-34.14-243 issued by the German Institute for Civil Engineering (DIBt)

Dimensioning

The verification of the internal and external load-carrying capacity must always be performed out when mircopiles are used as a tie-back anchorage or as an foundation pile. Further verifications such as the buckling analysis and the serviceability analysis may be required depending on the intended use.

Verification of the load-carrying capacity of the pile materials

The verification of the load-carrying capacity of the pile material proves that the design value of actions Ed is less than the design value of the pile resistance.
The verification of the load-carrying capacity of the pile materials is carried out as follows:

Design value of actions (E_d) ≤ design value of pile resistance (R_d)

where:

$$E_d = \gamma_G * G_k + \gamma_Q * Q_k$$

$$R_d = {R_k}/{\gamma_M}$$

with

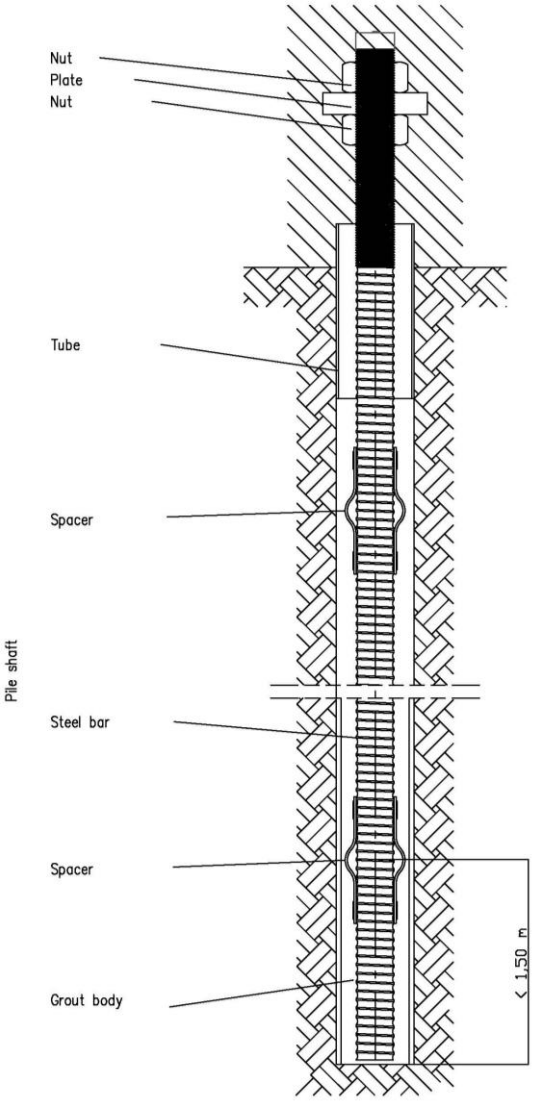
E_d	Design value of actions
γ_G	Partial safety factor for permanent actions
	= 1.35 for BS-P (constant situation)
	= 1.20 for BS-T (temporary situation)
γ_Q	Partial safety factor for variable actions
	= 1.50 for BS-P (constant situation)
	= 1.30 for BS-T (temporary situation)
R_d	Design value of the pile resistance
R_k	Characteristic load capacity
γ_M	Partial safety factor Material resistance
	= 1.15 for BS-P, BS-T und BS-A

Verification of the external load carrying capacity of the grout/soil friction

Micropiles transfer loads to the soil via the skin friction. For this purpose, it must be ensured that the surface of the grout body is sufficiently large enough. The required surface area is determined by the diameter and length of the grout body and the skin friction value $q_{s,i,k}$, of the soil layer.

With the help of site investigations and pile test, the actually existing skin friction value of the existing soils can be determined.
Alternatively, the design of the external load-carrying capacity can be performed with the empirical values of the skin friction according to EA-Piles Tab. 5.29 und 5.30.

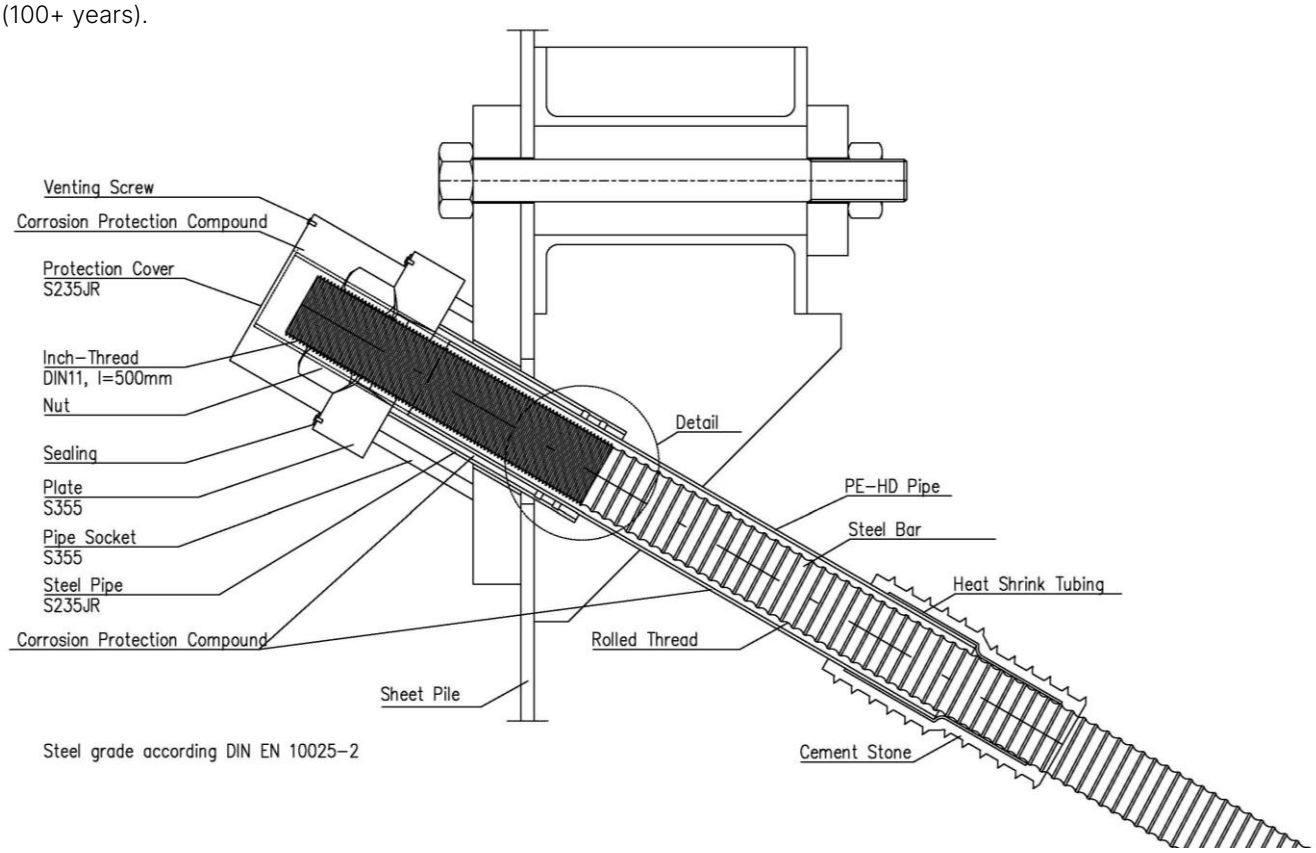
Application example deep foundation



Permanent pile head construction in detail according to Approval Z-34.14-243

In the case of tie-back anchoring of a sheet pile or combina-tion wall, installation of the pile head in concrete is not al-ways wanted or possible. For this reason, a pile head con-struction was developed for the thyssenkrupp ASF drilled injection pile that allows the permanent use (100+ years).

For the planning of the micropile, the required dimensions of the pile head-construction can be taken from the approval. The additional verification of the plates, the pipe sockets and the weld seams can be omitted. Because of this the planning of the micropiles can be performed more quickly and effi-ciently



terra infrastructure GmbH, Hollestr. 7a, 45127 Essen, Germany
T: +49 201 5657832110
info@terra-infrastructure.com | www.terra-infrastructure.com

Australia

terra infrastructure Pty Ltd, 11 Woodford Pl, Thornton NSW 2322, Australia
P: +61 2 8448-3555
Info.anz@terra-infrastructure.com
www.terra-infrastructure.com.au

New Zealand

terra infrastructure Pty Ltd, 180 Fred Taylor Drive, Whenuapai Auckland 0814, New Zealand
P: +64 9 416-8891
Info.anz@terra-infrastructure.com
www.terra-infrastructure.co.nz

Baltic States

terra infrastructure UAB, Liepų str. 83, 93269 Klaipėda, Lithuania
P: +370 46 355-401
www.terra-infrastructure.com/lt

Russian Federation

OOO terra infrastructure, Bolschevikov Str. 54 B, Office 211, 193315 St. Petersburg, Russia
P: +7 812 337-6510
www.terra-infrastructure.com/ru

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