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National Technical Approval /
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National Form of Construction Approval

Approval body for construction products and forms of construction

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Approval No:
Z-34.14-209

Period of validity:
from: **2 May 2018**
to: **2 April 2021**

Applicant:
Friedr. Ischebeck GmbH
Loher Str. 31-79
58256 Ennepetal
Germany

Object of this notification:
TITAN micropiles

The aforementioned regulated object is hereby approved/authorised for use in construction.
This [English translation of the] notification comprises 14 pages and 6 sheets of annexes.

I GENERAL PROVISIONS

1 This notification verifies the usability of the regulated object in the meaning of the building regulations of the federal states.

2 This notification is not a substitute for statutory authorisations, agreements and certificates prescribed for the execution of construction projects.

3 This notification is issued without prejudice to the rights of third parties, especially private intellectual property rights.

4 Without prejudice to more detailed regulations in the "specific provisions", copies of this notification must be made available to the user of the regulated object. In addition, it must be pointed out to the user of the regulated object that this notification must be available at the place of use. Upon request, the authorities involved must also be provided with copies.

5 This notification may only be reproduced in whole. Publication of extracts shall require the consent of the Deutsches Institut für Bautechnik (DIBt). Texts and drawings in advertising materials may not contradict this notification. Translations must include the remark "Translation of original German edition not checked by Deutsches Institut für Bautechnik".

6 This notification is granted until revoked. The provisions can be supplemented and amended at a later date, especially when new technical findings make this necessary.

7 This notification is based on the details and documents provided by the applicant. Changes to those details and documents are not covered by this notification and must be made known to the Deutsches Institut für Bautechnik (DIBt) without delay.

8 The National Form of Construction Approval covered by this notification is at the same time valid as a National Technical Approval for the form of construction.

II SPECIFIC PROVISIONS

1 Regulated object and scope of usability or applicability

1.1 Regulated object

(1) The regulated object is the TITAN micropiles (piles for temporary and permanent usage) of the Friedr. Ischebeck GmbH company, which have a fine-grained structural steel hollow threaded bar (loadbearing element) with the following nominal outside diameters:

Table 1: Nominal outside diameter of steel hollow threaded bar

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
Nominal outside diameter [mm]	30	40	40	52	52	73	73	73	73	103	103

(2) The hollow threaded bar may be used as a drilling rod when forming the hole and subsequently left in the hole as a steel loadbearing element.
(3) These are micropiles (composite piles) for which the stipulations of DIN EN 14199[1] in conjunction with DIN SPEC 18539[2] are to be observed, unless otherwise stated below.

1.2 Scope of applicability

(1) The micropiles may be used as tension or compression piles, also under cyclic loading, and for permanent or temporary (≤ 2 years) applications.
(2) The inclination (rake) of the pile, related to a vertical line, may be up to 80° depending on the pile type.
(3) The maximum permissible pile length depends on the pile type and the pile inclination (with respect to the vertical) and is shown in Table 2.

Table 2: Maximum pile length [m]

Pile inclination (with respect to vertical)	TITAN type										
	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
≤ 80°	12	12	12	12	12	–	–	–	–	–	–
≤ 75°	15	18	18	21	21	24	24	27	30	–	–
≤ 70°	18	24	24	27	27	30	30	33	36	39	42

(4) The micropiles should be designed to carry axial loads only.

[1] DIN EN 14199:2012-01 Execution of special geotechnical work – Micropiles; German version EN 14199:2005

[2] DIN SPEC 18539:2012-02 Supplementary provisions to DIN EN 14199:2012-01, Execution of special geotechnical works – Micropiles

(5) The micropiles may be installed in cohesive and non-cohesive soils (see DIN EN 1997-1[3] in conjunction with DIN EN 1997-1/NA[4] and DIN 1054[5], section 3.1) and in rock.
(6) A specialist geotechnical engineer must be consulted when the soil includes constituents (e.g. substances of organic origin) that could impair the corrosion protection if they are able to penetrate the grout body.
(7) The micropiles may not be installed in subsoil containing groundwater or seepage water from dumps and/or filled ground which could possibly lead users to expect a high risk of pitting of the steel according to DIN 50929-3[6], table 7, with $W_0 < -8$.

2 Provisions for the construction product

2.1 Properties and composition

2.1.1 General

The piles are to be constructed from a continuous steel loadbearing element that is surrounded uniformly by a layer of cement grout over its full length according to annex 1.

2.1.2 Steel loadbearing element; grade of steel and dimensions

(1) The steel loadbearing element is to be manufactured with the dimensions according to annex 2. The properties of the material are deposited with the DIBt. The production of the thread profile is to be carried out according to the manufacturing instructions deposited with the DIBt.
(2) The mechanical values of the steel loadbearing element can be found in section 3.
(3) The steel loadbearing element is manufactured from max. 3.0 m long hollow sections that are butt-jointed together with coupling nuts; it may not be welded.

2.1.3 Joints

(1) The joints between loadbearing elements are formed with coupling nuts according to annex 2 which are made from the material deposited with the DIBt.
(2) The steel loadbearing element and coupling nut are to be tightened against one another with a torque M according to the following table:

Table 3: Torque M

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
min. M [Nm]	300	1350	1600	2900	2900	3200	3200	3200	3200	3200	3200
max. M [Nm]	350	1500	1800	3200	3200	8200	8200	8200	8200	21000	25000

[3] DIN EN 1997-1:2009-09 Eurocode 7: Geotechnical design – Part 1: General rules; German version EN 1997-1:2004 + AC:2009
[4] DIN EN 1997-1/NA:2010-12 National Annex – Nationally determined parameters – Eurocode 7: Geotechnical design – Part 1: General rules
[5] DIN 1054:2010-12 Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1
DIN 1054/A1:2012-08 Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1:2010; Amendment A1:2012
DIN 1054/A2:2015-11 Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1:2010; Amendment A2:2015
[6] DIN 50929-3:1985-09 Corrosion of metals; probability of corrosion of metallic materials when subject to corrosion from the outside; buried and underwater pipelines and structural components

2.1.4 Centralisers

(1) A centraliser (spacer) according to annex 1 is to be positioned in the vicinity of every coupling nut. The diameter of the centraliser is to be chosen such that the required minimum grout cover is maintained. Star- or ring-type centralisers may be used in cohesive and non-cohesive soils with piles inclined at $\leq 15°$ from the vertical. Ring-type centralisers must be used in cohesive soils with piles inclined at angles > 15° from the vertical. In the presence of exclusively non-cohesive soils, star-type centralisers may also be used at these angles.

2.1.5 Toe of pile

A drill bit according to annex 1 must be screwed onto the soil end of the first segment of the loadbearing element prior to commencing the drilling. The diameter of the drill bit must be chosen such that the required minimum grout body diameter, taking into account the minimum grout cover necessary, is maintained.

2.1.6 Connection of pile to foundation (head of pile)

(1) The steel loadbearing elements are to be anchored in the foundation according to annex 4 or 5 by means of end anchorages that consist of a washer plate and two spherical collar nuts according to annex 3. It must be ensured that the washer plate cannot rotate or be displaced when concreting the foundation. To ensure this, the two spherical collar nuts are to be tightened finger-tight (torque $\geq$ 100 Nm) against the washer plate for all types.
(2) In the case of compression piles with a plastic tube at the top of the pile, additional top and bottom reinforcement is to be installed as shown in annex 5. This reinforcement is to be provided in addition to the reinforcement required for structural purposes.
(3) The dimensions of the washer plates and the bearing pressure they exert on the concrete have been verified within the scope of the approval procedure for concrete with a cylinder compressive strength $f_{ck} \geq 25$ N/mm^2.
(4) Verification of the transfer of the relevant pile forces within the foundation, including verification of the patch loading, is to be carried out according to the valid technical codes of practice (e.g. DIN EN 1992-1-1[7] in conjunction with DIN EN 1992-1-1/NA[8]).

2.1.7 Tube at neck of pile

(1) A tube made from S235JR steel or HDPE to DIN 8074[9] and DIN 8075[10] is to be provided at the neck of the pile according to annex 1 in order to create a good transition from pile to foundation. The wall thickness min t required for the steel or HDPE tube is given in annex 4 or 5. The embedment length of the tube in the foundation must be at least equal to the dimension min K specified in annex 4 or 5.
(2) When piles subjected to a compression loading test are to be used as structural piles in the finished works, then the tube must be made from grade S235JR steel, see section 3.2.

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7 DIN EN 1992-1-1:2011-01 Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004 + AC:2010

8 DIN EN 1992-1-1/NA:2013-04 National Annex – Nationally determined parameters – Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings

9 DIN 8074:1999-08 Polyethylene (PE) pipes – PE 63, PE 80, PE 100, PE-HD – Dimensions

10 DIN 8075:1999-08 Polyethylene (PE) pipes – PE 63, PE 80, PE 100, PE-HD – General quality requirements, testing

2.2 Storage, transport and marking

2.2.1 Storage and transport

(1) The steel loadbearing elements are to be stored and transported in dry conditions. They are to be protected against damage, soiling and moisture; they must be clean and free from any damaging rust. Steel loadbearing elements with a minimal film of rust may be used. The expression "minimal film of rust" applies to an even covering of rust that has not yet led to the formation of corrosion pits visible to the naked eye and can generally be removed by wiping with a dry cloth. The means of transport and places of storage for the steel loadbearing elements may not be contaminated by substances that could cause or favour corrosion (e.g. chlorides, nitrates, acids, etc.).
(2) Damaged steel loadbearing elements may not be used.

2.2.2 Marking

(1) The delivery slip for the pile parts or prefabricated pile assemblies intended for installation must be marked with the German attestation of conformity symbol (Ü mark) according to the associated regulations of the German federal states. Parts may only be marked with the symbol when the requirements according to section 2.3 are complied with.
(2) The delivery slip must also state clearly the micropiles for which the parts are intended and the plant in which the parts were produced. The unequivocal allocation of the parts to the micropile type must be clear from the delivery slip.

2.3 Confirmation of conformity

2.3.1 General

(1) Confirmation of the compliance of the pile components with the provisions of the National Technical Approval covered by this notification must be provided for every production plant by means of a declaration of conformity of the manufacturer based on factory production control and a certificate of conformity of an accredited certification body plus regular auditing by an accredited external institute in accordance with the following provisions: Issuing the certificate of conformity and auditing by an external institute, including the product tests to be carried out, requires the manufacturer of the pile components to appoint a certification body and an auditing body, both of which must be accredited for such work.
(2) The declaration of conformity must be indicated by the manufacturer marking the construction products with the German attestation of conformity symbol (Ü mark) and including information about the intended purpose.
(3) One copy of the certificate of conformity issued by the certification body is to be made available to the DIBt for information purposes.
(4) One copy of the initial test report is to be made available to the DIBt for information purposes.

2.3.2 Factory production control

2.3.2.1 General

(1) Factory production control is to be set up and carried out at every manufacturing plant. Factory production control is understood to be the continual monitoring of production carried out by the manufacturer's personnel in order to guarantee that the construction products manufactured comply with the provisions of the National Technical Approval covered by this notification.
(2) The procedural instructions deposited with the DIBt are to be taken into account in this monitoring.

(3) The results of factory production control are to be recorded and evaluated. The records must include the following details at least:
- designation of the construction product or the raw material and components;
- type of inspection or testing;
- date of production and testing of the construction product or the raw material or components;
- results of inspections and tests and, if applicable, a comparison with the requirements;
- signature of the person responsible for factory production control.

(4) The records are to be retained for at least five years and made available to the external auditing body appointed to carry out auditing work. Upon request, they are to be made available to the DIBt and the senior building authority responsible.
(5) If the results of tests are unsatisfactory, the manufacturer must take the necessary measures to rectify the defects without delay. Construction products that do not comply with the requirements are to be marked in such a way that they cannot be mistaken for compliant products. After rectifying the defects, the test involved must be repeated without delay, in so far as this is technically possible and is required for verifying the rectification of the defects.
(6) Factory production control should at least include the measures listed below.

2.3.2.2 Steel loadbearing element

Verification of the properties of the raw material is to be effected by way of acceptance test certificate "3.1" according to DIN EN 10204[11]. The applicant must carry out spot checks of the properties of the raw material.
Following the rolling of the thread, audit tests are to be carried out on the steel loadbearing elements according to the procedural instructions deposited with the DIBt.

2.3.2.3 Spherical collar nuts, coupling nuts and washer plates

2.3.2.3.1 General

The spherical collar nuts, coupling nuts and washer plates are to be marked with the manufacturer's symbol. The factory production control is to be carried out in the respective production plant.

2.3.2.3.2 Spherical collar nuts

Audit tests are to be carried out by the applicant according to the procedural instructions deposited with the DIBt.

2.3.2.3.3 Coupling nuts

Verification of the properties of the raw material is to be effected by way of inspection certificate "3.1" according to DIN EN 10204[11].
The execution and scope of the tests must take into account the procedural instructions deposited with the DIBt.

[11] DIN EN 10204:2005-01 Metallic products – Types of inspection documents; German version EN 10204:2004

2.3.2.3.4Washer plates

Verification of the material properties is to be effected by way of test report "2.2" according to DIN EN 10204[11].
The dimensions of all washer plates are to be checked. Furthermore, every washer plate must be visually inspected for serious flaws by means of a yes/no check (no records necessary here).

2.3.2.4 Tubes of grade S235JR steel

Verification of the material properties is to be effected by way of test report "2.2" according to DIN EN 10204[11].

2.3.2.5 Centralisers

The dimensions must be checked on at least 5% of all centralisers (no records necessary here).

2.3.3 Auditing by an external body

(1) The plant and the factory production control in every manufacturing plant are to be audited regularly, but at least twice annually, by an external body.
(2) An initial test of the construction product is to be carried out within the scope of the external auditing. Samples are to be taken for spot checks and the testing instruments inspected. The sampling and the tests are in all cases the responsibility of the accredited auditing body.
(3) The results of the certification and the external auditing are to be retained for at least five years. Upon request, the certification or auditing body shall make them available to the DIBt and the senior building authority responsible.

3 Provisions for planning, design and installation

3.1 Planning and design

3.1.1 General

(1) The technical codes of practice apply, especially DIN EN 1997-1[3], DIN EN 1997-1/NA[4] and DIN 1054[5], unless otherwise stated below.
(2) A partial safety factor γ_M = 1.15 is to be used for the material resistance of the steel loadbearing element for design situations DS-P, DS-T and DS-A.
(3) The design of the reinforced concrete foundation is to be carried out on the basis of elastic theory in accordance with DIN EN 1992-1-1[7], sections 5.4 and 5.5, in conjunction with DIN EN 1992-1-1/NA[8]**.**
(4) The following characteristic values are to be used for the steel loadbearing element when performing deformation calculations:

Table 4: Characteristic values for deformation calculations

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
Cross-sectional area A [mm^2]	415	730	900	1050	1250	1460	1615	2239	2714	3140	5680
Strain stiffness AE [kN]	83 x 10^3	135 x 10^3	167 x 10^3	195 x 10^3	231 x 10^3	272 x 10^3	299 x 10^3	414 x 10^3	502 x 10^3	580 x 10^3	1022 x 10^3
Bending stiffness EI [$kNmm^2$]	4.6 x 10^6	15 x 10^6	17 x 10^6	37 x 10^6	42 x 10^6	138 x 10^6	143 x 10^6	178 x 10^6	195 x 10^6	564 x 10^6	794 x 10^6

(5) The load-carrying capacity of the joint (see section 2.1.3) and the connection between pile and foundation (see section 2.1.6) have been verified within the scope of the approval procedure.
(6) The micropiles should be designed for axial loads only.
(7) The diameter of the drill bit is to be selected depending on the diameter of the grout body required to guarantee the necessary grout cover c according to section 3.1.2.
(8) The fatigue strength of the steel loadbearing elements with the coupling nuts and end anchorages (pile head anchorages) – see annexes 1 and 2 – has been checked by means of tests involving 2 x 10^6 load cycles. Accordingly, with a stress range $\Delta\sigma$ = 70 N/mm², this results in the following stress ranges in kN:

Table 5: Stress ranges

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
Range [kN]	29	51	63	73	88	102	113	156	190	220	397

(9) Section 3.1.5 applies for the fatigue analysis.

3.1.2 Design for load-carrying capacity of steel element

3.1.2.1 Piles loaded in tension

(1) The characteristic load-carrying capacity R_k of each steel loadbearing element is given in Table 6.

Table 6: Characteristic load-carrying capacity R_k [kN] of steel loadbearing element depending on grout cover c

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
Grout cover c = 20 mm	190	322	400	461	548	673	745	960	1250	1290	2325
c = 25 mm	200	344	427	492	585	717	795	1100	1300	1387	2500
c = 30 mm	210	360	447	517	614	752	835	1150	1386	1465	2500
c = 35 mm	220	372	465	537	638	780	860	1200	1386	1530	2500
c = 40 mm	225	372	478	553	650	803	889	1218	1386	1587	2500
c = 45 mm	225	372	490	567	650	822	900	1218	1386	1626	2500

(2) Intermediate values may be interpolated. It is not permitted to use R_k values greater than the maximum values specified in the table, even if the value selected for the grout cover c is greater than that given in the lowest line of the table.
(3) The minimum covers according to DIN SPEC 18539[2], A annex C, must also be taken into account.
(4) In the case of micropiles for temporary purposes, the values given in Table 7 may be used for the characteristic load-carrying capacity R_k irrespective of the grout cover c.

Table 7: Characteristic load-carrying capacity for temporary applications

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
R_k [kN]	250	372	490	640	650	865	900	1218	1386	1626	2500

3.1.2.2 Piles loaded in compression

(1) The characteristic load-carrying capacity R_k of each steel loadbearing element is given in Table 8.

Table 8: Characteristic load-carrying capacity R_k of steel loadbearing element depending on grout cover c

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
c [mm] R_k [kN]	25 225	30 372	30 490	40 640	40 650	55 865	55 900	55 1218	55 1386	80 1626	80 2500
c [mm] $0.75 \cdot R_k$ [kN]	25 169	25 280	25 368	30 480	30 488	40 649	40 675	40 914	40 1040	55 1220	55 1875
c [mm] $0.50 \cdot R_k$ [kN]	25 113	25 186	25 245	25 320	25 325	25 433	25 450	25 609	25 693	30 813	30 1250

(2) Intermediate values may be interpolated. It is not permitted to use R_k values greater than the maximum values specified in the table, even if the value selected for the grout cover c is greater than that given in the topmost line of the table.
(3) The minimum covers according to DIN SPEC 18539[2], A annex C, must also be taken into account.
(4) In the case of micropiles for temporary purposes and a grout cover c = 25 mm, a characteristic load-carrying capacity R_k = 250 kN may be used for TITAN type 30/11.

3.1.3 Verification of force transfer length (bond-to-ground length) in the soil

(1) It must be ensured that the force transfer length in the soil is greater than the force transfer length required between the steel loadbearing element and the grout.
(2) Verification of the force transfer length is to be carried out according to DIN EN 1992-1-1[7], section 8.4.2, in conjunction with DIN EN 1992-1-1/NA[8].
(3) In doing so, the η_2 factor given in Table 9 must be included to take account of the bar diameter.

Table 9: η_2 factor

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
η_2	1.0	0.92	0.92	0.82	0.82	0.62	0.62	0.62	0.62	0.32	0.32

(4) Separate verification of the transverse tensile stresses in the grout body is not necessary when verifying the force transfer length.

3.1.4 Verification of anchorage in foundation

(1) To ensure force transfer, the end anchorages shown in annex 1 are to be used with the washer plates and spherical collar nuts shown in annex 3.
(2) It is necessary to verify the transfer of the complete pile force via the washer plate.
(3) Verification of the transfer of the relevant pile forces within the foundation, including verification of the patch loading, is to be carried out according to the valid technical codes of practice (e.g. DIN EN 1992-1-1[7] in conjunction with DIN EN 1992-1-1/NA[8]).
(4) In the case of compression piles with a plastic tube at the top of the pile, additional top and bottom reinforcement is to be installed as shown in annex 5. The minimum spacings and edge distances given in annex 5 must be maintained.

3.1.5 Fatigue analysis

The fatigue analysis for the steel loadbearing elements connected via coupling nuts and anchored at the head of the pile via end anchorages (see annexes 1 and 2) may be carried out according to DIN EN 1993-1-9[12] in conjunction with DIN EN 1993-1-9/NA[13]. The fatigue strength curve for notch type 70 ($\Delta\sigma_c$ = 70 N/mm² for N = 2 x 10^6 stress cycles) may be used here. DIN EN 1993-1-9[12], table 3.1, then applies for the partial safety factor γ_{Mf}.

3.2 Installation

3.2.1 General

(1) DIN EN 14199[1] in conjunction with DIN SPEC 18539[2] applies for the installation of micropiles, unless otherwise stated below.
(2) Test piles that – in the form of compression piles – have successfully passed a loading test may only be used as structural piles in the finished works when a tube made from grade S235JR steel according to annex 1 or 5 was used at the head of the pile during the loading test. The topmost edge of the steel tube must be located at a level at least equal to that intended for the tube in the later structure.
(3) The min t values for the steel tube wall thickness given in annex 5 include a corrosion allowance of 2 mm. Where piles are installed for temporary purposes only, the min t values may therefore be reduced by 2 mm.
(4) The installation of the micropiles is to be monitored, checked and inspected according to DIN EN 14199[1] in conjunction with DIN SPEC 18539[2]. Special monitoring measures can be specified in conjunction with the building measures, e.g. whether a test pile is to be excavated.

(5) In the case of pile angles between 45° and < 80° measured from the vertical, at least one pile is to be excavated per building site and assessed by the specialist geotechnical engineer. As a rule, only the upper section in the soil has to be exposed, a length of 1.5–2.0 m. Excavating the pile may be deemed unnecessary when results for piles at a similar or greater angle from the vertical in comparable soils are available and have been assessed as satisfactory by a specialist geotechnical engineer. However, in the case of pile angles of 80° measured from the vertical, it must be verified that the pile shaft can be fully filled by excavating one pile.

3.2.2 Installation contractor

(1) The assembly and installation of the piles may only be carried out within the scope of responsibility of the technical supervision of the Friedr. Ischebeck GmbH company. However, the assembly and installation of the micropiles may also be carried out by companies that can present a certificate issued by Friedr. Ischebeck GmbH indicating that they have been fully trained in the installation of the piles according to this National Technical Approval. The company performing the installation work must provide a declaration that the TITAN micropiles it has installed comply with the provisions of this notification.
(2) The Friedr. Ischebeck GmbH company shall maintain a list of structures built using permanent piles. The list shall include details of the structure, the number of piles and their inclination and length.

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[12] DIN EN 1993-1-9:2010-12 Eurocode 3: Design of steel structures – Part 1-9: Fatigue; German version EN 1993-1-9:2005 + AC:2009

[13] DIN EN 1993-1-9/NA:2010-12 National Annex – Nationally determined parameters – Eurocode 3: Design of steel structures – Part 1-9: Fatigue

3.2.3 Pile shaft

3.2.3.1 Drilling the hole, installing the pile

(1) The drilling of the hole and the installation of the pile in the hole are related operations that are to be carried out according to the description of the procedure provided by Friedr. Ischebeck GmbH and deposited with the DIBt.
(2) A pile log is to be compiled according to DIN 14199[1], section 10, in conjunction with DIN SPEC 18539[2] during the installation of every pile. Annex 6 shows a sample pile log.
(3) Depending on the pile type, the holes are to be drilled with a minimum inclination of 10° from the horizontal (see section 1.2).
(4) The holes are drilled without a casing using a drill bit screwed to the first segment of the loadbearing element.
(5) If the mouth of the hole tends to collapse during drilling/flushing, it should be stabilised with a temporary guide tube. The tube for the pile/foundation transition may be used as the guide tube (see section 3.2.4 and annexes 4 and 5).
(6) The drill bit, the centralisers and the guide tube are to be selected such that the required minimum diameter of the grout body is achieved.
(7) The following maximum values for torque, blow impulse and associated blow energy, which depend on the drilling plant used, may not be exceeded during drilling:

Table 10: Maximum values for torque, blow impulse and blow energy

TITAN type	30/11	40/20	40/16	52/29	52/26	73/56	73/53	73/45	73/35	103/78	103/51
max. torque [Nm]	300	1500	1800	3200	3200	8200	8200	8200	8200	21000	25000
max. blow impulse [kg · m/s]	18	58	58	96	96	170	170	170	170	224	224
max. blow energy [Nm]	84	145	145	400	400	610	610	610	610	900	900

(8) During drilling, a cement suspension with a water/cement ratio w/c = 0.4–0.7 is to be used as a flushing/drilling fluid. This cement suspension is to be introduced into the hole through the loadbearing element.
(9) Flushing with water is not permitted.
(10) Once the intended depth has been reached, the cement suspension according to section 3.2.3.3.1 must be introduced.

3.2.3.2 Joints

(1) Longer piles are produced by screwing additional segments of loadbearing element onto those already in the soil with the help of coupling nuts.

(2) The distance between joints must be at least 1 m. The two ends of the loadbearing elements are to be tightened against one another with a torque according to section 2.1.3 in order to achieve a sufficient self-locking effect between the loadbearing element and the coupling nut. A calibrated torque wrench must be used for this. The torque may also be applied by the rotation mechanism of the hammer drill, with the parts of the steel loadbearing element already in the hole being held in place by the hydraulic clamping mechanism on the drilling rig. In this case the torque is to be controlled via the operating pressure, which can be found in the technical documents for the (pneumatic or hydraulic) hammer drill being used. The torque values given in section 2.1.3 apply.

3.2.3.3 Cement grout filling to holes

3.2.3.3.1 Cement grout

(1) The raw materials for the cement grout are cements with special properties according to DIN 1164-10[14] and cements to DIN EN 197-1[15] (taking into account the relevant exposure class according to DIN EN 206-1[16] in conjunction with DIN 1045-2[17], tables 1, F.3.1 and F.3.2), water according to DIN EN 1008[18] and, if applicable, admixtures according to DIN EN 934-2[19] in conjunction with DIN EN 206-1[16]/DIN 1045-2[17] or with a National Technical Approval and natural aggregates with max. 4 mm grain diameter according to DIN EN 12620[20] taking into account DIN EN 206-1[16]/DIN 1045-2[17].
(2) The water/cement ratio of the flushing/drilling fluid must be w/c = 0.4–0.7 and that of the injected suspension w/c = 0.4–0.5. The cement grout must be mixed by machine. No segregation or lump formation is permitted prior to injection.
(3) To verify the compressive strength, two sets of three samples of the cement grout must be taken every seven working days on which piles are constructed or on every building site. Sampling is to be recorded in the pile log. The compressive strength is to be determined according to DIN EN 445[21]. The cylinder compressive strength of the cement grout must be at least f_{ck} = 35 N/mm² after 28 days. If the compressive strength is tested prior to 28 days, the micropiles may be loaded if a cylinder compressive strength of at least f_{ck} = 32 N/mm² is verified.

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[14] DIN 1164-10:2004-08 Special cement – Part 10: Composition, requirements and conformity evaluation for special common cement
DIN 1164-10 Ber. 1:2005-01 Corrigenda to DIN 1164-10:2004-08

[15] DIN EN 197-1:2011-11 Cement – Part 1: Composition, specifications and conformity criteria for common cements; German version EN 197-1:2011

[16] DIN EN 206-1:2001-07 Concrete – Part 1: Specification, performance, production and conformity
DIN EN 206-1/A1:2004-10 Concrete – Part 1: Specification, performance, production and conformity; German version EN 206-1/A1:2004
DIN EN 206-1/A2:2005-09 Concrete – Part 1: Specification, performance, production and conformity; German version EN 206-1:2000/A2:2005

[17] DIN 1045-2:2008-08 Concrete, reinforced and prestressed concrete structures – Part 2: Concrete – Specification, properties, production and conformity – Application rules for DIN EN 206-1

[18] DIN EN 1008:2002-10 Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete; German version EN 1008:2002

[19] DIN EN 934-2:2009-09 Admixtures for concrete, mortar and grout – Part 2: Concrete admixtures – Definitions, requirements, conformity, marking and labelling; German version EN 934-2:2009

[20] DIN EN 12620:2008-07 Aggregates for concrete; German version EN 12620:2002 + A1:2008

[21] DIN EN 445:1996-07 Grout for prestressing tendons – Test methods – German version EN 445:1996

3.2.3.3.2 Filling the holes (injection)

(1) After reaching the intended depth, injection must be carried out with a cement grout according to section 3.2.3.3.1. The volume to be injected must be large enough to ensure that the flushing/drilling fluid is completely displaced and ejected from the mouth of the hole. To ensure that no air is introduced into the grout body, the reservoir containing the cement suspension may not be pumped empty during the injection procedure.
(2) Injection may be deemed unnecessary when the flushing/drilling fluid has already been introduced with a water/cement ratio corresponding to the grout suspension according to 3.2.3.3.1, i.e. w/c = 0.4–0.5.
(3) Multi-stage grouting of the micropiles is not permitted.

3.2.3.3.3 Centring of and grout cover to the loadbearing element

(1) The dimensions of the centralisers and drill bits shown in annex 1 must be selected in such a way that adequate centring of the hollow threaded bar and grout cover c is ensured.
(2) The minimum grout covers according to DIN SPEC 18539[2], A annex C, apply.
(3) In addition, the required minimum grout cover c as given in section 3.1.2.1 or 3.1.2.2 is to be maintained.

3.2.4 Neck of pile

After installing the loadbearing element in the hole, the tube shown in annex 1 and annex 4 or 5 is to be inserted into the cement suspension while it is still fluid at the transition between pile shaft and foundation. The wall thickness min t required for the tube is given in annex 4 or 5. Instead of a tube introduced in this way, the guide tube used during drilling can remain in place to surround the neck of the pile, provided it complies with the requirements for a final tube (see section 3.2.3.1 and annex 4 or 5).

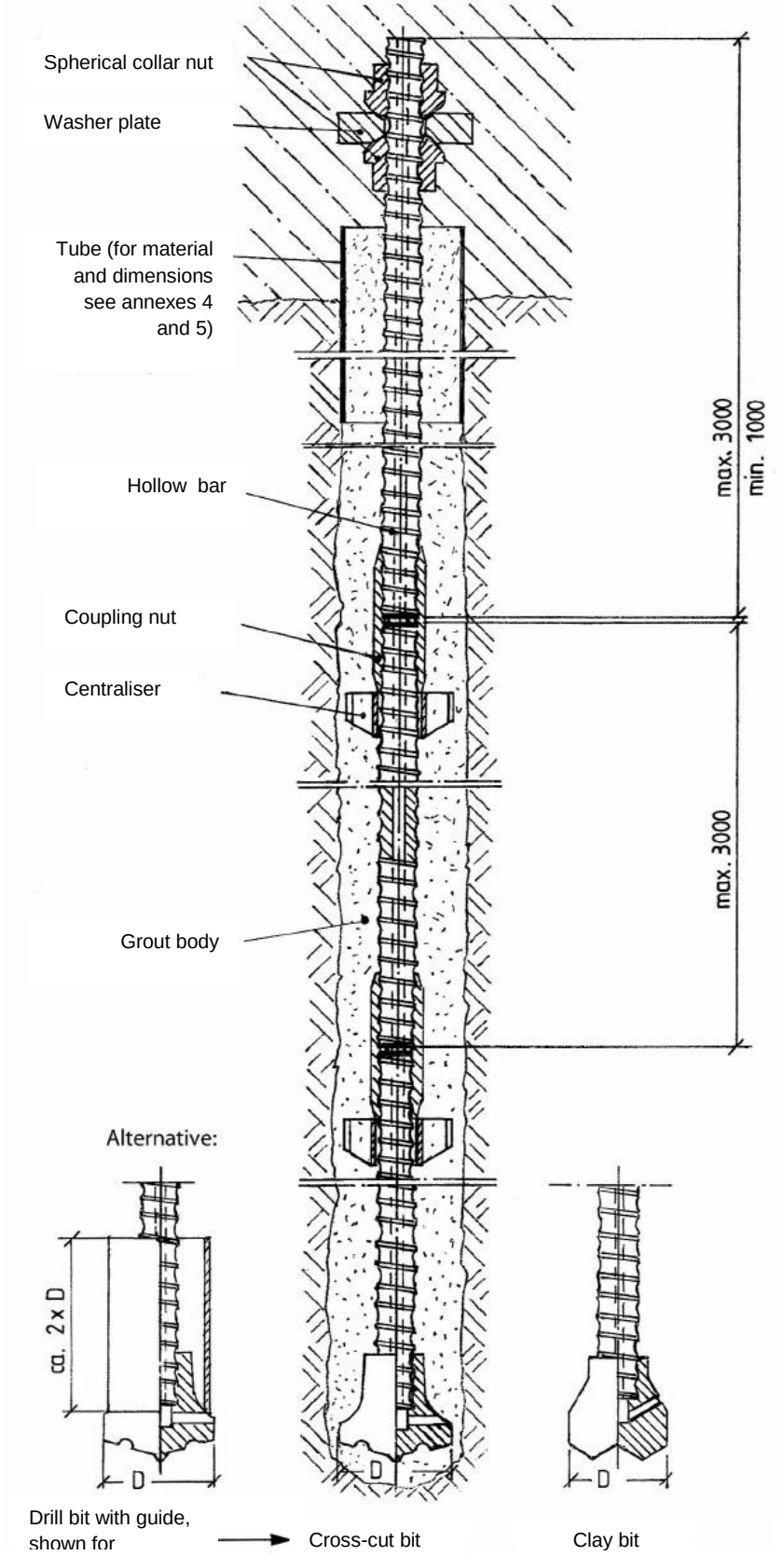
3.2.5 Head of pile

(1) The minimum tube lengths min L and min K given in annex 4 or 5 must be adhered to.
(2) In the case of compression piles, the washer plate is to be mounted at the minimum distance A from the top edge of the tube as specified in annex 5.
(3) The spherical collar nuts of the washer plate are to be tightened against the washer plate with a torque according to section 2.1.6.

Bettina Hemme
Head of Department

Certified

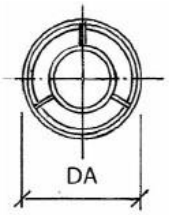
All dimensions in mm



Pile head detail, see annexes 4 and 5

Star-type centraliser made from EN-GJMW-400-5 to DIN EN 1562

Ring-type centraliser made from S235JR to DIN EN 10025-2



Drill bit with guide, shown for → Cross-cut bit | Clay bit | Button bit | Shouldered bit

TITAN micropiles

Annex 1

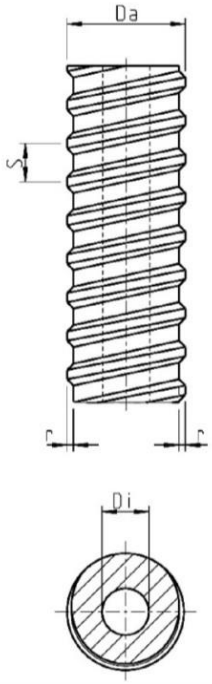
Overview

Dimensions [mm]

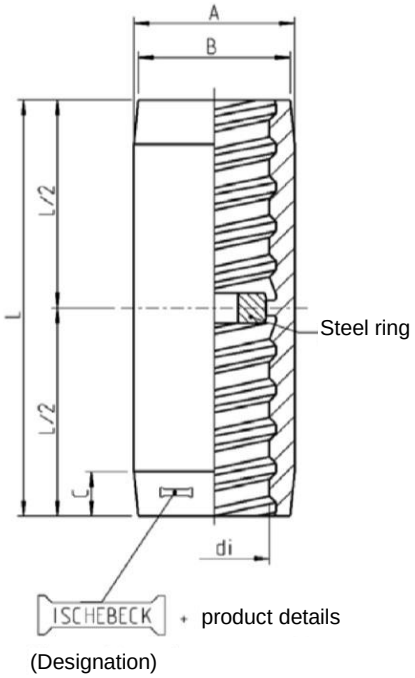
		Pile Type										
		30/11	**40/20**	**40/16**	**52/29**	**52/26**	**73/56**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
	Thread	TITAN 30	TITAN 40		TITAN 52		TITAN 73				TITAN 103	
		single					double					
		left	left	left	right	right	right	right	right	right	right	right
Steel load-bearing element	Da	29.0	40.5	40.5	50.3	50.3	72.4	72.4	72.4	72.4	101.0	101.0
	R	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	S	13	13	13	13	13	8	8	8	8	12	12
	Di	13	20	16	29	26	56	53	45	37	76	51
Coupling nut	L	105	140	140	160	160	180	235	245	245	255	290
	A	38	57	57	70	70	89	89	95	95	123	132
	B	36	51	51	65	65	82	82	88	88	116	122
	C	15	15	15	15	15	20	20	20	20	20	20
	di	25.4	37.0	37.0	46.8	46.8	69.6	69.6	69.6	69.6	98.0	98.0

Material deposited with DIBt

Hollow bar



Coupling nut



TITAN micropiles

Steel loadbearing element, coupling nut

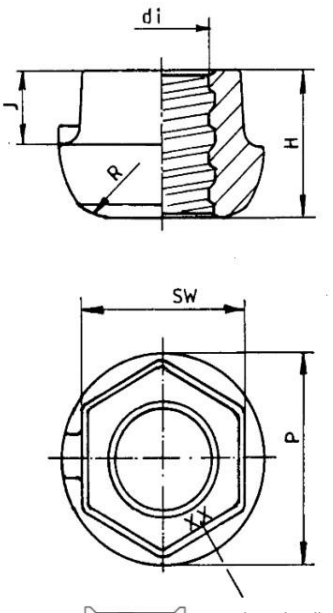
Annex 2

Dimensions [mm]

	Type										
	30/11	**40/20**	**40/16**	**52/29**	**52/26**	**73/56**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
	Spherical collar nut										
	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 2
AF	46	65	65	80	80	95	95	95	95	125	125
P	55	75	75	102	102	110	110	110	110	140	132
H	35	50	50	70	70	70	70	70	70	80	130
J	19	34	34	35	35	25	25	25	25	28	28
R	34	50	50	75	75	75	75	75	75	96	96
di	25.5	37.3	37.3	46.8	46.8	69.6	69.6	69.6	69.6	98.0	98.0
	Material deposited with DIBt										
	Washer plate										
U	100	115	125	145	145	175	175	210	210	240	285
V	20	20	24	24	28	35	35	50	50	50	70
W	7	7	7	7	7	7	7	7	7	7	7
Y	54	72	72	90	90	100	100	100	100	130	130
Z	40	56	56	65	65	80	80	80	80	110	110
	Material deposited with DIBt										

Spherical collar nut

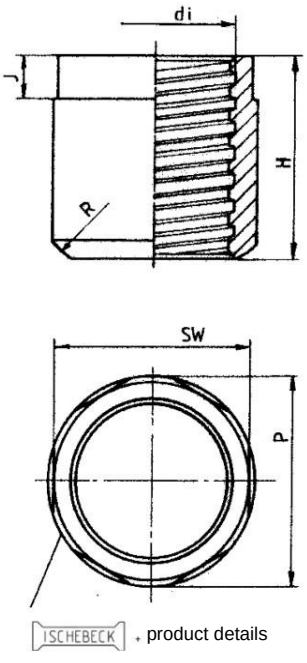
type 1



ISCHEBECK + product details
(Designation)

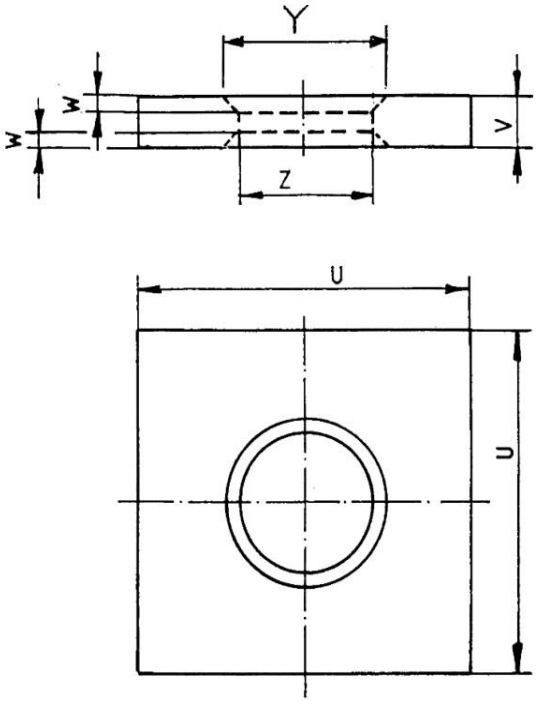
Spherical collar nut

type 2



ISCHEBECK + product details
(Designation on circumference)

Washer plate

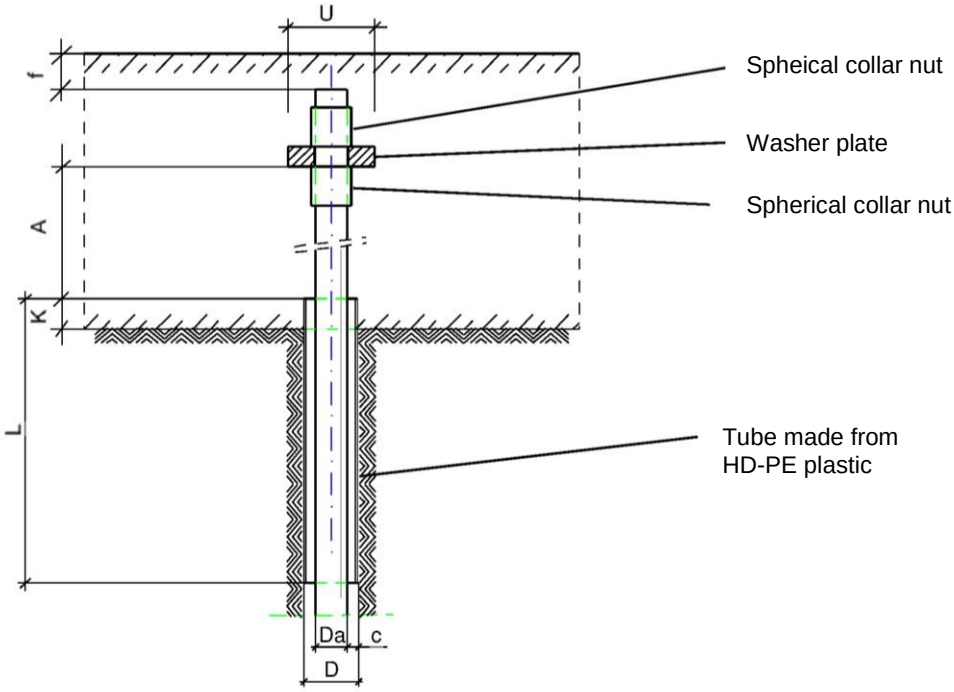


TITAN micropiles

Spherical collar nuts, washer plate

Annex 3

Take account of necessary concrete cover for f, e.g. c_{nom} to DIN EN 1992-1-1



Verification of the transfer of the pile forces relevant for the design within the foundation, including verification of the patch loading, is to be carried out according to the valid technical codes of practice (e.g. DIN EN 1992-1-1).

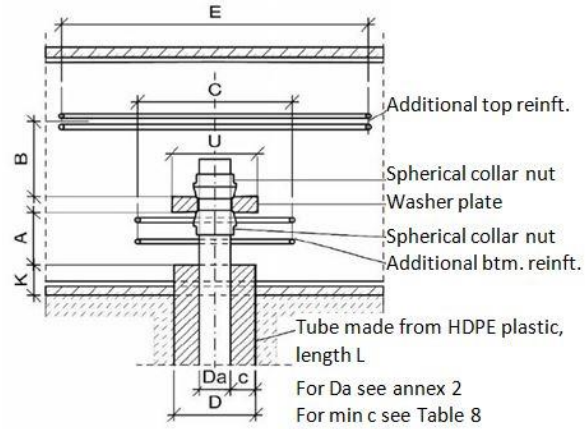
			TITAN type										
			30/11	**40/20**	**40/16**	**52/29**	**52/26**	**73/56**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
Washer plate	U	mm	100	115	125	145	145	175	175	210	210	240	285
Tube	min K	mm	100	100	100	100	100	100	100	100	100	100	100
	min L	mm	370	460	530	580	580	700	700	800	820	860	960
	Wall thk. min t	mm	2.7	2.7	2.7	4.3	4.3	4.9	4.9	4.9	4.9	4.9	4.9
	A	Is to be specified in accordance with the design of the reinforced concrete foundation.											
	D	The diameter of the tube is to be chosen so that the grout cover c is maintained; see specific provisions, section 3.1.2.1.											

TITAN micropiles

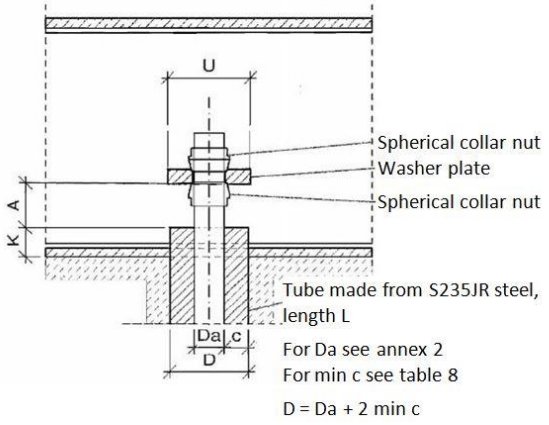
Head of pile, tension pile

Annex 4

Pile with plastic tube



Pile with steel tube



The minimum grout cover min c is specified in conjunction with the characteristic load-carrying capacity R_k of the steel loadbearing element given in table 8 of the specific provisions.
Verification of the transfer of the pile forces relevant for the design within the foundation, including verification of the patch loading, is to be carried out according to the valid technical codes of practice.

			TITAN type										
			30/11	**40/20**	**40/16**	**52/29**	**52/26**	**73/56**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
Washer plate	U	mm	100	115	125	145	145	175	175	210	210	240	285
	min A	mm	100	100	100	125	125	140	140	140	140	170	225
Tube: steel or plastic	D	mm	The diameter of the tube is to be chosen so that the grout cover c is maintained; see specific provisions, section 3.2.2.										
	min L	mm	370	460	530	580	580	700	700	800	820	860	960
	min K	mm	100	100	100	100	100	100	100	100	100	100	100
Wall thickness - steel tube [1] - plastic tube	min t	mm	4.1 2.7	4.6 2.7	4.6 2.7	5.4 4.3	5.4 4.3	6.7 4.9	6.7 4.9	6.7 4.9	6.7 4.9	8.8 4.9	8.8 4.9

[1] The min t values may be reduced by 2 mm for temporary piles, see specific provisions, section 4.1.

Compression pile with plastic tube

The following minimum spacing and edge distances apply to compression piles with a plastic tube:
min. distance from pile axis to edge of foundation: $R \geq 1.5 * D + 0.5 * U$
min. centre-to-centre spacing of piles: $X \geq 3 * D + U$
Additional top and bottom reinforcement is required in addition to the reinforcement required for structural purposes.
The additional top reinforcement consists of n layers positioned at a distance B from the washer plate.
The additional bottom reinforcement consists of n layers positioned at the level of the lower spherical collar nut.

			TITAN type										
			30/11	**40/20**	**40/16**	**52/29**	**52/26**	**73/56**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
Addtl. top reinft., grade B500A or B500B	B	mm	D										
	∅	mm	8	8	8	10	10	12	12	12	12	16	16
	n	–	2	2	2	2	2	2	2	2	2	2	2
	E	mm	3 * D + U										
Addtl. btm. reinft., grade B500A or B500B	∅	mm	8	10	10	12	12	14	14	16	16	16	16
	n	–	2	2	2	2	2	2	2	2	2	2	2
	C	mm	D + U										

Note: When piles that have been subjected to a compression loading test are to be used as structural piles in the finished works, the tube during the loading test must be made from steel according to section 4.1.

TITAN micropiles

Head of pile, compression pile

Annex 5

TITAN micropile installation log

Site, location: ……	Log No. ……
Contractor (client): ……	Date: ……
Pile manufacturer (company): ……	Pile length: …… [m] Pile rake: …… [°]
Foreman: …… Instructed by Ischebeck on ……..by ……..; certificate dated……..	

TITAN: ……	Type	Dia.	**Hammer drill:**	**Operating values must be limited to…**						
Drill bit	…….	……	……	**30/11**	**40/20**	**40/16**	**52 series**	**73 series**	**103/78**	**103/51**
Centraliser	……..	……..	Torque [Nm]	350	1500	1800	3200	8200	21000	25000
Guide tube at drilling start point	Length ……	Dia. ……..	Blow impulse [kg m/s]	18	58	58	96	170	224	224
			Blow energy [Nm]	84	145	145	400	610	900	900

Cement: ……	
Grouting plant: ……	Pressure-flow meter: ……

1. Drilling with flushing/drilling fluid:

Begin: ……	**End:** ……	**Duration:** …….. **[min]**
w/c: …….. **[-]**	**Volume injected V:** …….. **[l]**	**max. pressure:** …… **[bar]**
Once the final pile length has been achieved, pumping continues until approx. 10 l of the fluid remains in the reservoir.		
Remarks: e.g. number of joints (coupling nuts) and centralisers description of soil types with details of depths obstacles with details of depths sketches etc.		

2. Injecting the cement suspension

Begin: ……	**End:** ……	**Duration:** …….. **[min]**
w/c: …….. **[-]**	**Volume injected V:** …….. **[l]**	**max. pressure:** …… **[bar]**
Remarks: e.g. numer of samples for compressive strength test		

…… Location	…… Date	…… Signature of foreman	…… Signature of client

TITAN micropiles

Pile log (sample)

Annex 6