National Technical Approval

German Institute of Building Technology (DIBt)

Approval body for construction products and forms of construction

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Approval No.:	Valid until:
Z-34. 14-209	**30 April 2013**

Applicant:

Friedr. Ischebeck GmbH
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Object of approval :

TITAN injection piles

The aforementioned object of the approval is hereby granted a National Technical Approval.
This National Technical Approval comprises 14 pages and 8 sheets of annexes.
This National Technical Approval supersedes National Technical Approval No. Z-34.14-209 of 28 March 2008, revised by the notice of 22 March 2010.

I. GENERAL PROVISIONS

1. The National Technical Approval verifies the usability of the object of the approval in the meaning of the building regulations of the federal states.

2. In so far as the National Technical Approval places requirements on the particular knowledge and experience of the persons entrusted with the provision of construction products and forms of construction according to the federal state regulations corresponding to cl. 17 para. 5 of the Model Building Code (Musterbauordnung), it should be noted that this knowledge and experience can also be furnished by equivalent documentation of other Member States of the European Union. This shall also apply for equivalent documentation submitted within the scope of the European Economic Area (EEA) Agreement or other bilateral agreements.

3. The National Technical Approval is not a substitute for statutory authorisations, agreements and certificates prescribed for the execution of construction projects.

4. The National Technical Approval is issued without prejudice to the rights of third parties, especially private trademark rights.

5. Without prejudice to more detailed regulations in the "specific provisions", the manufacturer and distributor of the object of approval must provide users of the object of approval with copies of the National Technical Approval and point out that the National Technical Approval must be available at the place of use. Upon request, the authorities involved must be provided with copies of the National Technical Approval.

6. The National Technical Approval 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 the National Technical Approval. Translations of the National Technical Approval must include the remark "Translation of original German edition not checked by Deutsches Institut für Bautechnik".

7. The National Technical Approval may be revoked. The provisions of the National Technical Approval can be supplemented and changed at a later date, especially when new technical findings make this necessary.

II. SPECIFIC PROVISIONS

1. Object of the approval and scope of applicability

1.1 Object of the approval

The object of this National Technical Approval are the TITAN injection 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 the steel hollow threaded bar

		Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
Nominal outside diameter	mm	30	40	40	52	73	73	73	103	103

The hollow threaded bar may be used as a drilling rod when forming the borehole and subsequently left in the borehole as a loadbearing element.
These are injection piles (composite piles) for which the stipulations of DIN 4128[1] are to be observed, unless otherwise stated in the following.

1.2 Scope of applicability

The injection piles may be used as tension or compression piles, also under cyclic loading, for permanent or temporary (≤ 2 years) usage.
The inclination of the pile, related to a vertical line, may be up to 70°.
The length of the pile may not exceed the following values:

Table 2: Maximum pile length

		Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
max. pile length	m	12	18	18	21	21	21	21	33	33

The injection piles should be designed to carry axial loads only.
The injection piles may be used in cohesive and non-cohesive soils according to DIN 1054[2] , sections 5.2.2 and 5.2.3
A specialist geotechnical engineer must be consulted when the soil includes constiuents (e.g. substances of organic origin) that could impair the corrosion protection if they are able to penetrate the body of grout.

1	DIN 4128:1983-04	Small diameter injection piles (cast-in-place concrete and composite piles); construction procedure, design and permissible loading
2	DIN 1054:2005-01	Subsoil – Verification of the safety of earthworks and foundations
	DIN 1054 Ber. 1:2005-04	Corrections to DIN 1054:2005-01
	DIN 1054 Ber. 2:2007-04	Corrections to DIN 1054:2005-01
	DIN 1054 Ber. 3:2008-01	Corrections to DIN 1054:2005-01
	DIN 1054 Ber. 4:2008-10	Correction to DIN 1054:2005-01
	DIN 1054/A1:2009-07	Subsoil – Verification of the safety of earthworks and foundations; amendment A1

The injection piles may not be installed when the subsoil contains groundwater or seepage water from dumps and/or filled ground that leads to the expectations of a high risk of pitting of the steel according to DIN 50929-3[3] , table 7, with $W_0 < -8$. It must also be verified that the valuation figure B_0 for the subsoil according to DIN 50929-3[3], table 2, is not less than -10.

2. Provisions for the building 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 mortar over its full length according to annex 1.

2.1.2 Steel loadbearing element: grade of steel and dimensions

The steel loadbearing element is to be manufactured with the dimensions according to annex 2. The properties of the materials are deposited with the DIBt. The fabrication of the thread profile is to be carried out according to the manufacturing instructions deposited with the DIBt. The mechanical values of the steel loadbearing element can be found in section 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

The joints between loadbearing elements are formed with coupling nuts according to annex 2 made from the material deposited with the DIBt.
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

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

2.1.4 Centralisers

A centralizer (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 up to max. 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, the star-type centraliser may also be used at these angles.

2.1.5 Toe of the 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.

3 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

2.1.6 Connection of pile to foundation (head of pile)

The steel loadbearing elements are to be anchored to the foundation according to annex 4 or 5 by means of end anchorages that consist of washer plate and two spherical collar nuts according to annex 3. It must be ensured that the washer plate cannot be rotated or displaced when casting the concrete of the foundation. To ensure this, the two spherical collar nuts are to be tightened against the washer plate with a torque of 300 Nm for type 30/11, 1500 Nm for types 40/20 and 40/16, and 3200 Nm for types 52/26, 73/53, 73/45, 73/35, 103/78 and 103/51.
In the case of compression piles, additional reinforcement as shown in annex 5 is to be positioned below the washer plate in the vicinity of the spherical collar nuts. This reinforcement is to be provided in addition to the reinforcement required for structural purposes.
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 strength of $f_{ck} \geq 25$ N/mm^2.
Verification of the transfer of the relevant pile forces within the foundation, including verification of the uniformly distributed load, is to be carried out according to the valid technical codes of practice (e.g. DIN 1045-1[4]).

2.1.7 Tube at neck of pile

A tube made from PE-HD plastic according to DIN 8074[5] and DIN 8075[6] 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 plastic 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.
When piles that are subjected to a compression test loading are to be used as structural piles, then the tube is to be made from steel grade S235JR, see section 4.1.

2.2 Storage, transport and marking

2.2.1 Storage and transport

The steel loadbearing elements are to be stored and transported dry. 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 clean 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.).
Damaged steel loadbearing elements may not be used.

2.2.2 Marking

The delivery slip for the parts of the piles or the prefabricated pile constructions intended for installation must be marked with the German attestation of conformity symbol (Ü mark) according to the regulations of the German federal states covering this symbol. Parts may only be marked with the symbol when the requirements according to section 2.3 (attestation of conformity) are complied with.

4 DIN 1045-1:2008-08 Concrete, reinforced and prestressed concrete structures – Part 1: Design and construction
5 DIN 8074:1999-08 Polyethylene (PE) pipes – PE 63, PE 80, PE 100, PE-HD – Dimensions
6 DIN 8075:1999-08 Polyethylene (PE) pipes – PE 63, PE 80, PE 100, PE-HD – General quality requirements, testing

The delivery slip must also indicate clearly the injection piles for which the parts are intended and the plant in which the parts were produced. The unequivocal allocation of the parts to the injection pile type must be clear from the delivery slip.

2.3 Attestation of conformity

2.3.1 General

Confirmation of the compliance of the pile components with the provisions of this National Technical Approval must be provided for every production plant by means of an attestation of conformity based on in-house production control and regular auditing by an external institute, including an initial inspection, in accordance with the following provisions.

For the issuing of the attestation of conformity and the auditing by an external institute, including the product tests to be carried out, the manufacturer of the pile components must appoint a certification body and an auditing body, both of which are accredited for such work.

The declaration that a certificate of conformity has been issued must be provided by the manufacturer marking the construction products with the German conformity symbol (Ü mark) and including information about the intended purpose.

One copy of the attestation of conformity issued by the certification body is to made available to the DIBt for information purposes.

One copy of the initial inspection report is to made available to the DIBt for information purposes.

2.3.2 In-house production control

2.3.2.1 General

In-house production control is to be set up and carried out at every manufacturing plant. In-house production control is understood to be continual monitoring of production carried out by the manufacturer's personnel in order to guarantee that the building products manufactured in that plant comply with the provisions of this National Technical Approval.

The procedural instructions deposited with the DIBt are to be taken into account in this monitoring.

The results of in-house production control are to be recorded and evaluated. The records must include the following details at least:

- designation of the building product or the raw material and components;
- type of inspection or testing;
- date of production and testing of the building 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 in-house production control.

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.

If the results of tests are unsatisfactory, the manufacturer must take the necessary measures to rectify the defects without delay. Building 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.

In-house 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[7]. The applicant must carry out spot checks of the properties of the raw material.

Following the rolling of the thread, 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 in-house production control is to be carried out in the respective production plant.

2.3.2.3.2 Spherical collar nuts

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 acceptance test certificate "3.1" according to DIN EN 10204[7].

The execution and scope of the tests must take into account the procedural instructions deposited with the DIBt.

2.3.2.3.4 Washer plates

Verification of the material properties is to be effected by way of works certificate "2.2" according to DIN EN 10204[7].

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 steel grade S235JR

Verification of the material properties is to be effected by way of works certificate "2.2" according to DIN EN 10204[7].

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

The in-house production control in every production plant is to be audited regularly, but at least twice annually, by an external body.

An initial inspection of the building product is to be carried out within the scope of the external auditing. Samples for spot checks are to be taken and the testing instruments inspected. The sampling and the tests are in all cases the responsibility of the accredited auditing body.

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.

7 DIN EN 10204:2005-1 Metallic products – Types of inspection documents; German version EN 10204:2004

3 Provisions for design and sizing

3.1 General

DIN 1054[2] applies for the design and sizing when using the injection piles. The design of the reinforced concrete foundation is to be carried out according to elastic theory in accordance with DIN 1045-1[4], sections 8.2 and 8.3.
Proof of load-carrying capacity is to be carried out according to DIN 1054[2], sections 8.3 to 8.5. Proof of serviceability is to be carried out according to DIN 1054[2], section 8.6. DIN 1054[2], section 8.4.2, shall apply for pile loading tests. The minimum number of pile loading tests to be carried out shall be in accordance with DIN 1054[2], section 8.4.2 (10). The following characteristic values are to be used for the steel loadbearing element in the case of deformation calculations:

Table 4: Characteristic values for deformation calculations

		TITAN Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
Cross-sectional area A	mm²	415	730	900	1250	1615	2239	2714	3140	5680
Strain stiffness AE	[kN]	83×10^3	135×10^3	167×10^3	231×10^3	299×10^3	414×10^3	502×10^3	580×10^3	1022×10^3
Bending stiffness EI	[kN/mm²]	$4{,}6 \times 10^6$	15×10^6	17×10^6	42×10^6	143×10^6	178×10^6	195×10^6	564×10^6	794×10^6

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.
The injection piles should be designed for axial loads only.
The diameter of the drill bit is to be selected depending on the diameter of the body of grout required to guarantee the necessary grout cover c according to section 3.2.1 or 3.2.2.

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 2×10^6 load cycles. Accordingly, with a stress range of $\Delta\sigma = 70$ N/mm², this results in the following ranges in kN:

Table 5: Ranges

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

Section 3.5 applies for the fatigue analysis.

3.2 Proof of load-carrying capacity

3.2.1 Proof for piles in tension

When determining the design value of the component resistance $R_{M,d}$ (pile resistance) according to DIN 1054[2], section 8.5.6, the forces for the characteristic load-carrying capacity $R_{M,k}$ of the steel loadbearing element as given in Table 6 below shall apply.

Table 6: Characteristic load-carrying capacity $R_{M,k}$ [kN] of the steel loadbearing element

Grout cover c [mm]	TITAN Type								
	30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]	$R_{M,k}$ [kN]
20	190	322	400	548	745	960	1250	1290	2325
25	200	344	427	585	795	1100	1300	1387	2325
30	210	360	447	614	835	1150	1386	1465	2325
35	220	372	465	620	860	1200	1386	1530	2325
40	225	372	465	620	860	1218	1386	1550	2325

Intermediate values may be interpolated. $R_{M,k}$ values greater than the maximum values specified in the table may not be used, even if the value selected for the grout cover c is greater than that given in the lowest line of the table.
In the case of injection piles for temporary purposes, the $R_{M,k}$ values given in the lowest line of the table may be used irrespective of the grout cover c. The design value of the pile resistance is calculated from $R_{M,d} = R_{M,k} / \gamma_R$.
The partial safety factor for load cases LC 1 to LC 3 is to be used, i.e γ_R = 1,15.
The stresses in the extreme fibres of the steel loadbearing element must be checked in the case of bending actions not allowed for in the design. The following characteristic strengths apply in such a case:

Table 7: Characteristic strengths of the steel loadbearing element

		TITAN Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
f_{yk}	[N/mm²]	542	515	515	500	530	544	510	495	410

The partial safety factor for load cases LC 1 to LC 3 is to be used, i.e. γ_R = 1,15.

3.2.2 Proof for piles in compression

When determining the design value of the component resistance $R_{M,d}$ (pile resistance) according to DIN 1054[2], section 8.5.6, the forces for the characteristic load-carrying capacity $R_{M,k}$ of the steel loadbearing element as given in the following table shall apply.

Table 8: Characteristic load-carrying capacity $R_{M,k}$ (kN) of the steel loadbearing element

		TITAN Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
$R_{M,k}$	[kN]	225	372	465	620	860	1218	1386	1550	2325

The design value of the pile resistance is calculated from $R_{M,d} = R_{M,k} / \gamma_R$.
The partial safety factor for load cases LC 1 to LC 3 is to be used, i.e. γ_R = 1,15. In the case of bending actions not allowed for in the design, the stresses in the extreme fibres of the steel loadbearing element are to be checked. The characteristic strengths applicable in such a case can be found in table 7. The partial safety factor for load cases LC 1 to LC 3 is to be used, i.e. γ_R = 1,15. The minimum grout cover min c to the loadbearing element must comply with the following table:

Table 9: Minimum grout cover min c to steel loadbearing element

		TITAN Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
min c	[mm]	25	30	30	40	55	55	55	80	80

Proof of buckling resistance is to be established if an injection pile is partially free-standing or surrounded by a soil with an undrained shear strength of c_u < 30 kN/m². Lateral support by the soil may be assumed with an undrained shear strength of $c_u \geq 10$ kN/m², an elastic linear support of $k_l = 60 \cdot c_u$ and a maximum contact stress between grout and soil of $\sigma_{gr} = 6 \cdot c_u$. In this case an inherent deformation with a radius of curvature of 200 m is to be considered.
In the case of free-standing piles and an undrained shear strength of c_u < 10 kN/m², proof of buckling resistance, without assuming any lateral support by the soil but taking account of the deformations (second-order theory), is to be carried out according to DIN 18800-2[8].
When determining the effective bending stiffness, only the grout in the region of the tube may be included, and possible splitting of the grout as far as the centre of the cross-section is to be taken into account.

3.3 Proof of force transfer length (bond-to-ground length) in the soil

must be ensured that the force transfer length in the soil is greater than the force transfer length $l_ü$ required between steel loadbearing element and grout.
Proof of the force transfer length is to be carried out according to DIN 1045-1[4]. In doing so, the following bond stresses f_{bd} are to be used:

Table 10: Bond stresses f_{bd}

	Strength of grout f_{ck} [N/mm²]			
	30	35	45	55
f_{bd} [N/mm²]	3,0	3,4	4,0	4,4

The fbd values in the above table are based on DIN 1045-1[4], section 12.5 (4), and are to be reduced by the following factors α:

Table 11: Reduction factors α

	TITAN Type								
	30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
α	1,0	0,92	0,92	0,82	0,62	0,62	0,62	0,32	0,32

A separate verification of the transverse tensile stresses in the body of grout is not necessary when verifying the force transfer length.

3.4 Proof of anchorage in foundation

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.
In the case of compression piles, additional reinforcement as shown in annex 5 is to be provided in addition to that required for structural purposes. This is to ensure that a part of the force can be transferred directly from the foundation into the body of grout. However, the transfer of the complete pile force via the washer plate must be verified.
Verification of the transfer of the relevant pile forces within the foundation, including verification of the uniformly distributed load, is to be carried out according to the valid technical codes of practice (e.g. DIN 1045-1[4]).

8 DIN 18800-2:2008-11 Steel structures – Part 2: Stability – Buckling of bars and skeletal structures

3.5 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[9] . The fatigue strength curve for notch type 70 ($\Delta\sigma_c$ = 70 N/mm² pour N = 2 x 10^6 stress cycles) may be used here. DIN EN 1993-1-9[9], table 3.1, then applies for the partial safety factor γ_{Mf}.

4 Provisions for construction

4.1 General

The assembly and installation of the piles may only be carried out under the responsibility of the technical supervision of the Friedr. Ischebeck GmbH company. However, the assembly and installation of the injection piles may also be carried out by companies that can present a certificate issued by Friedr. Ischebeck GmbH indicating that they have been comprehensively trained in the construction of the piles according to this National Technical Approval. The company performing the work must provide a declaration that the TITAN injection piles it has installed comply with the provisions of this National Technical Approval.

Test piles that – in the form of compression piles – have successfully passed a loading test may only be used as structural piles when a tube made from steel grade S235JR according to annex 1 or 5 with the following minimum wall thickness min t and minimum length min L was positioned at the head of the pile during the loading test:

Table 12: Minimum wall thickness min t and minimum length of tube min L

		TITAN Type								
		30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
min L	[cm]	37	46	53	58	70	80	82	86	96
min t	[mm]	4,1	4,6	4,6	5,4	6,7	6,7	6,7	8,8	8,8

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.

The min t values given above include a corrosion allowance of 2 mm. In the case of piles for temporary purposes, the min t values may therefore be reduced by 2 mm.

The construction of the injection piles is to be supervised by a specialist geotechnical engineer. This engineer can specify special monitoring measures in conjunction with the building measures, e.g. whether a test pile is to be excavated. In the case of pile angles between 45°and 70° measured from the vertical, at least one pile is to be excavated per building site and assessed by the specialist. 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 from piles at a similar or greater angle to the vertical in comparable soils are available which are assessed as satisfactory by a specialist geotechnical engineer.

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.

9 DIN EN 1993-1-9:2005-07 Eurocode 3: Design of steel structures – Part 1-9: Fatigue; German version EN 1993-1-9:2005

4.2 Pile shaft

4.2.1 Drilling the borehole, installing the pile

The drilling of the borehole and the installation of the pile in the borehole are related operations that are to be carried out according to the description given in annex 6.
A pile log is to be compiled during the construction of every pile and this must include the details given in annex 7.
The boreholes are to be drilled with a minimum inclination of 20° to the horizontal, see section 1.2.
The boreholes are drilled without a casing using a drill bit screwed to the first segment of the loadbearing element.
Prior to commencing the drilling, the approx. 1.5 m long tube (see annex 1) for guiding the steel loadbearing element is to be inserted into the soil. This tube may remain as the tube for the pile/foundation transition provided it complies with the requirements for the final tube (see section 4.3 and annex 4 or 5).
The drill bit, the centralisers and the guiding tube are to be selected such that the required minimum diameter of the body of grout is achieved.
The following maximum values for torque, blow impulse and associated blow energy, depending on the drilling plant used, may not be exceeded during drilling:

Table 13: Maximum values for torque, blow impulse and blow energy

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

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 borehole through the loadbearing element.
After achieving the intended depth, the cement suspension is to be introduced according to section 4.2.3.2.

4.2.2 Joints

Longer piles are produced by screwing additional segments of loadbearing element to those already in the soil with the help of coupling nuts.
The distance between the 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 borehole being held in place by the hydraulic clamping mechanism on the drilling carriage. In this case, the torque is to be controlled via the operating pressure, which can be found in the technical documents for the hammer drill being used (pneumatically or hydraulically driven hammer drill). The torque values given in section 2.1.3 apply.

4.2.3 Cement mortar filling to boreholes

4.2.3.1 Composition of the cement mortar

The pile shaft is to be constructed by injecting a cement mortar according to DIN 4125[10] , section 7.3, or DIN 4128[1], section 7.2.

The raw materials for the cement mortar are cements with special properties according to DIN 1164-10[11] and cements to DIN EN 197-1[12] – taking into account the relevant exposure class according to DIN EN 206-1[13] in conjunction with DIN 1045-2[14] (tables 1, F.3.1 and F.3.2) –, water according to DIN EN 1008[15] and, if applicable, admixtures according to DIN EN 934-2[16] taking into account DIN 1045-2[14] or – with a corresponding National Technical Approval and concrete aggregates with max. 4 mm grain diameter according to DIN EN 12620[17] – taking into account DIN 1045-2[14].

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 mortar must be mixed by machine. No segregation nor lump formation may occur prior to injection.

For verification of the compressive strength, three samples of the cement mortar must be taken twice per shift. Sampling is to be recorded in the pile log. The compressive strength is to be determined according to DIN EN 445[18] . The cylinder strength of the cement mortar must be at least f_{ck} = 35 N/mm² after 28 days. If the compressive strength is tested prior to 28 days, the injection piles may be loaded if a cylinder strength of at least f_{ck} = 32 N/mm² is established.

4.2.3.2 Filling the boreholes (injection)

After reaching the intended depth, injection must be carried out with a cement mortar according to section 4.2.3.1. 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 borehole. To ensure that no air is introduced into the body of grout, the reservoir containing the cement suspension may not be pumped empty during the injection procedure.

Subsequent injection of the injection piles is not permitted.

10	DIN 4125:1990-11	Ground anchorages – Design, construction and testing
11	DIN 1164-10:2004-08	Special cement – Part 10: Composition, requirements a nd conformity evaluation for special common cement
	DIN 1164-10 Corr. 1:2005-01	Corrections de DIN 1164-10:2004-08
12	DIN EN 197-1:2004-08	Cement – Part 1: Composition, specifications and conformity criteria for common cements; German version EN 197-1:2000 + A1:2004
	DIN EN 197-1 Corr. 1:2004-11	Corrigenda to DIN EN 197-1:2004-08
	DIN EN 197-1/A3:2007-9	Cement – Part 1: Composition, specification and conformity criteria for common cements; German version EN 197-1:2000/A3:2007
13	DIN EN 206-1:2001-07	Concrete – Part 1: Specification, performance, production and conformity; German version EN 206-1:2000
	DIN EN 206-1/A1:2004-10	Concrete – Part 1: Specification, performance, production and conformity; German version EN 206-1:2000/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
14	DIN 1045-2:2008-08	Concrete, reinforced and prestressed concrete structures – Part 2: Concrete – Specification, properties, producion and conformity – Application rules for DIN EN 206-1
15	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
16	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
17	DIN EN 12620:2008-07	Aggregates for concrete; German version EN 12620:2002 + A1:2008
18	DIN EN 445:1996-07	Grout for prestressing tendons – Test methods – German version EN 445:1996

4.2.3.3 Centring and covering the loadbearing element

The dimensions of the centralisers and the 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. The minimum grout cover c depends on the aggressiveness of the soil and groundwater or fissure water; the following minimum values are to be adhered to:

Table 14: Minimum values for grout cover

Concrete attack to DIN 4030-1[19]	Grout cover c	Remarks
Not aggressive	≥ 20 mm	--
Not aggressive, but with sulphate content XA1	≥ 20 mm	Blastfurnace cement CEM III/B to DIN 1164-10[11] must be used
XA1	≥ 20 mm	Appoint expert1
XA2	≥ 30 mm	Appoint expert1

[1] The piles may only be used when the report of an expert confirms that the long-term load-bearing behaviour of the piles is not impaired by the decrease in the skin friction over time. The cover dimension must be specified within the scope of the report.

In addition, the required minimum grout cover c as given in sections 3.2.1 or 3.2.2 is to be adhered to.

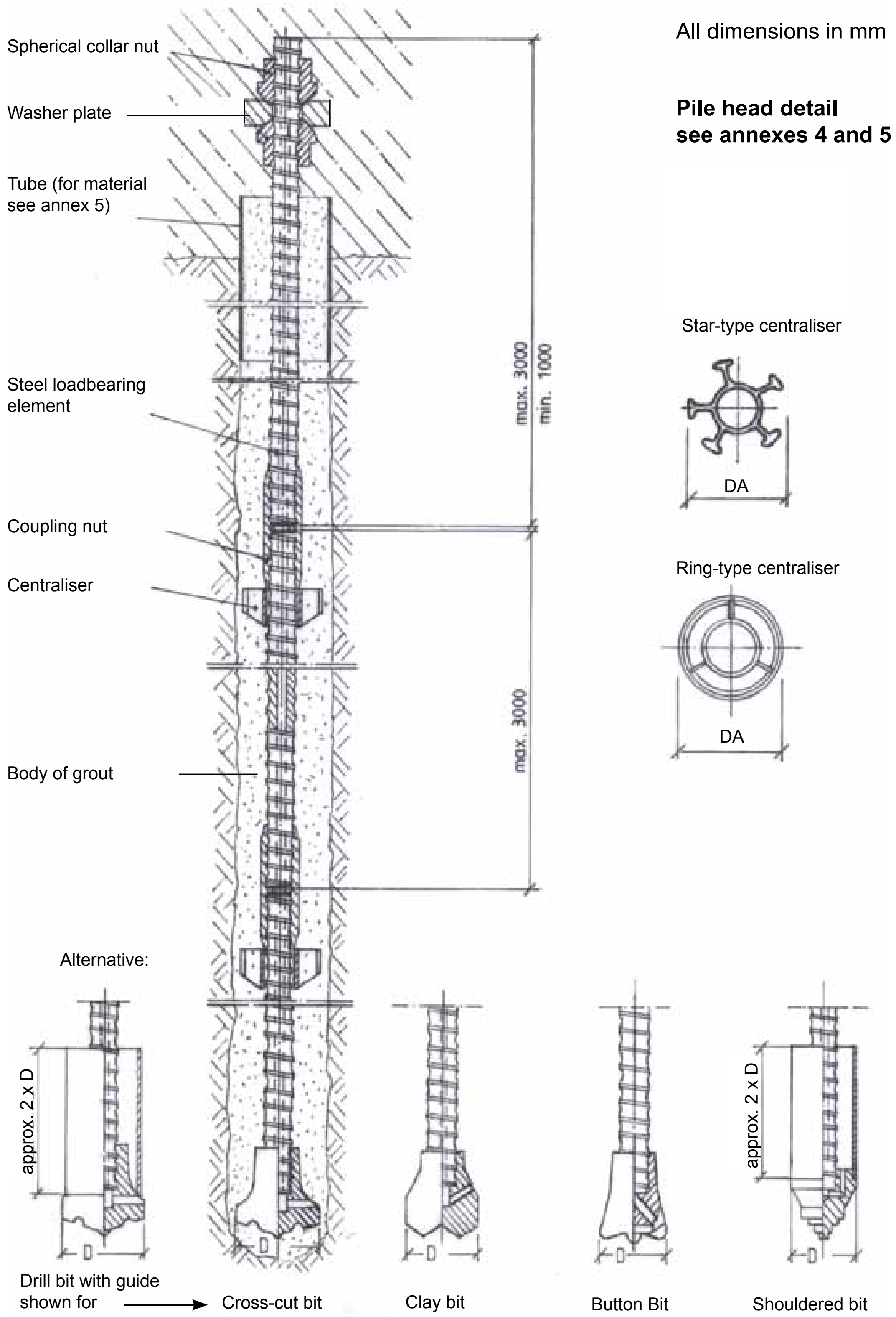
4.3 Neck of pile

After installing the loadbearing element in the borehole, the PE-HD 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 plastic tube is given in annex 4 or 5. Instead of a tube introduced in this way, the plastic 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 4.2.1 and annex 4 or 5).

4.4 Head of pile

The minimum tube lengths L and K given in annex 4 or 5 must be adhered to.
In the case of compression piles, the washer plate is to be mounted with the minimum distance A from the top edge of the tube as specified in annex 5.
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.

19 DIN 4030-1:2008-06 Assessment of water, soil and gases for the aggressiveness to concrete – Part 1: Principles and limiting values



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TITAN injection pile

Overview

Annex 1

to National Technical
Approval No. Z-34.14-209
of 20 December 2010
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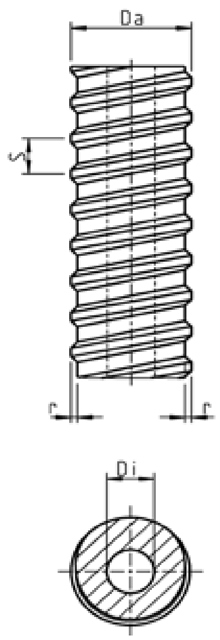
Dimensions [mm]

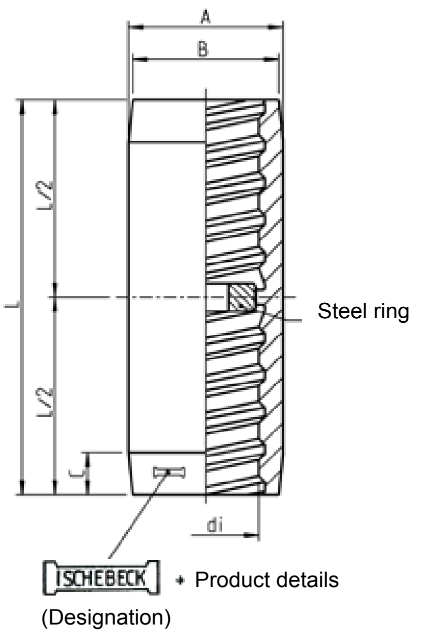
			Pile Type								
			30/11	**40/20**	**40/16**	**52/26**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
Steel load bearing element	Thread		TITAN 30 single left	TITAN 40 single left	TITAN 40 single left	TITAN 52 single right	TITAN 73 double right	TITAN 73 double right	TITAN 73 double right	TITAN 103 double right	TITAN 103 double right
	Da	mm	29,0	40,5	40,5	50,3	72,4	72,4	72,4	101,0	101,0
	r	mm	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2
	S	mm	13	13	13	13	8	8	8	12	12
	Di	mm	13	20	16	26	53	45	37	76	51
Coupling nut	L	mm	105	140	140	160	235	245	245	255	290
	A	mm	38	57	57	70	89	95	95	123	132
	B	mm	36	51	51	65	82	88	88	116	122
	C	mm	15	15	15	15	20	20	20	20	20
	di	mm	25,4	37,0	37,0	46,8	69,6	69,6	69,6	98,0	98,0

Materials deposited with DIBt

Steel loadbearing element



Coupling nut



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TITAN injection pile

Loadbearing tendon
Coupling nut

Annex 2

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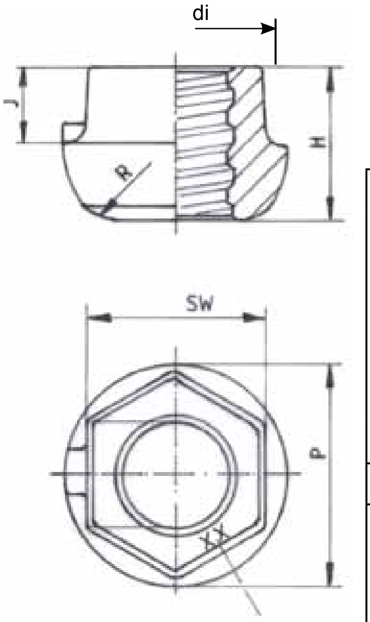
Spherical collar nut, type 1

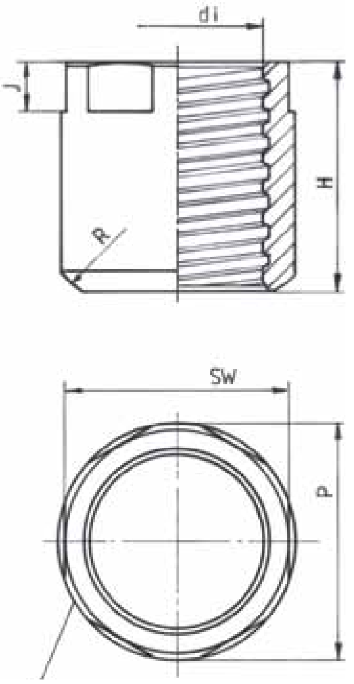


ISCHEBECK + Product details
(Designation)

Dimensions [mm]

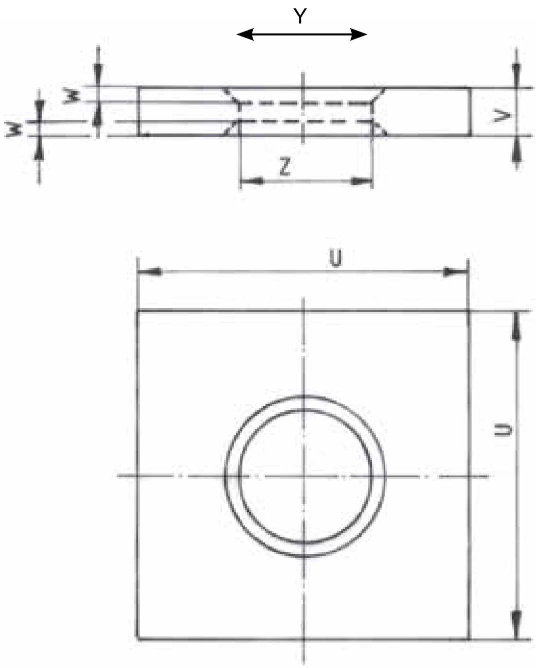
	Type								
	30/11	**40/20**	**40/16**	**52/26**	**73/53**	**73/45**	**73/35**	**103/78**	**103/51**
	Spherical collar nut								
	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 1	Type 2
SW	46	65	65	80	95	95	95	125	125
P	55	75	75	102	110	110	110	140	132
H	35	50	50	70	70	70	70	80	130
J	19	34	34	35	25	25	25	28	28
R	34	50	50	75	75	75	75	96	96
di	25,5	37,3	37,3	46,8	69,6	69,6	69,6	98,0	98,0
	Material deposited with DIBt								
	Washer plate								
U	100	115	125	145	175	210	210	240	285
V	20	20	24	27	34	50	50	48	67
W	7	7	7	7	7	7	7	7	7
Y	54	72	72	90	100	100	100	130	130
Z	40	56	56	65	80	80	80	110	110
	Material deposited with DIBt								

Spherical collar nut, type 2



ISCHEBECK + Product details
(Designation on circumference)

Washer plate



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TITAN injection pile

Spherical collar nut
Washer plate

Annex 3

to National Technical Approval No. Z-34.14-209 of 20 December 2010
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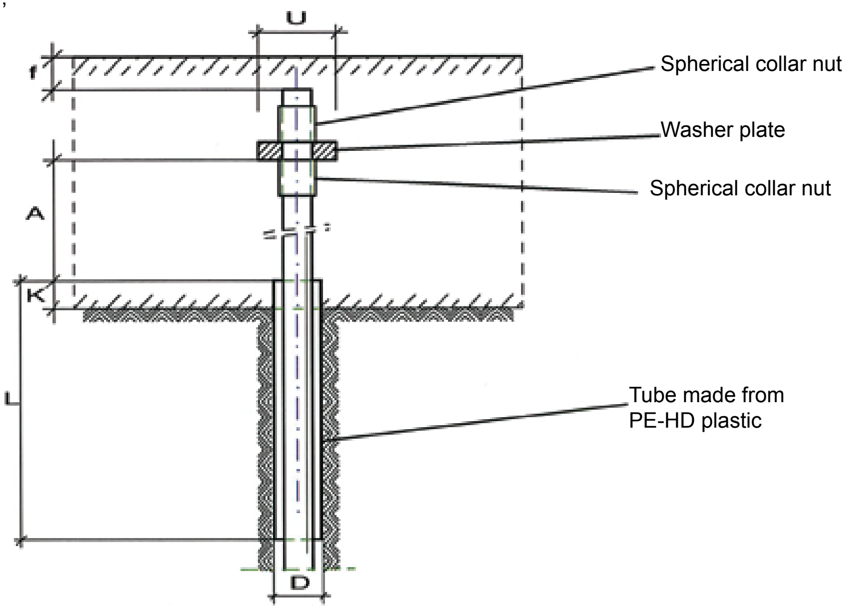
f = necessary concrete cover,
e.g. c_{nom} to DIN 1045-1



Verification of the transfer of the pile forces relevant for the design within the foundation, including verification of the uniformly distributed load, is to be carried out according to the valid technical codes of practice (e.g. DIN 1045-1).

			TITAN type								
			30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
Washer plate	U	mm	100	115	125	145	175	210	210	240	285
Tube	min K	mm	100	100	100	100	100	100	100	100	100
	min L	mm	370	460	530	580	700	800	820	860	960
	Wall thk. min t	mm	2,7	2,7	2,7	4,3	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 3.2.1.									

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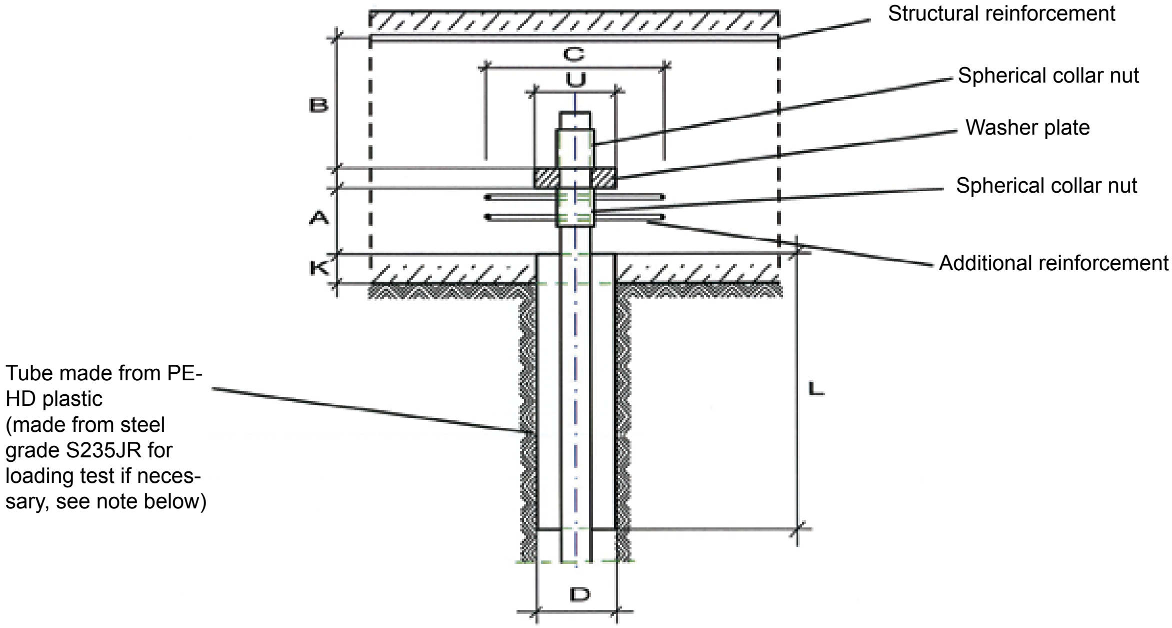
TITAN injection pile

Head of pile, tension pile

Annex 4

to National Technical Approval No. Z-34.14-209 of 20 December 2010



Verification of the transfer of the pile forces relevant for the design within the foundation, including verification of the uniformly distributed load, is to be carried out according to the valid technical codes of practice (e.g. DIN 1045-1).

Additional reinforcement in n layers is to be positioned at the level of the lower spherical collar nut. This reinforcement is to be provided in addition to that required for structural purposes.
Furthermore, the following distances are to be maintained:

- min. distance of washer plate from structural reinforcement: B ≥ D
- min. edge distance of axis of pile from edge of foundation: R ≥ 1,5 x B + 0,5 x U
- min. centre-to-centre spacing of piles: X ≥ 3 x B + U

			TITAN type								
			30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
Additional reinforcement, grade BSt 500 S	Ø	mm	8	10	10	12	14	16	16	16	16
	C	mm	B + U								
	n	--	2	2	2	2	2	2	2	3	4
Washer plate	U	mm	100	115	125	145	175	210	210	240	285
Tube	min K	mm	100	100	100	100	100	100	100	100	100
	min L	mm	370	460	530	580	700	800	820	860	960
	Wall thk min t	mm	2,7	2,7	2,7	4,3	4,9	4,9	4,9	4,9	4,9
	min A	mm	100	100	100	125	140	140	140	170	225
	D	The diameter of the tube is to be chosen so that the grout cover c is maintained; see specific provisions, section 3.2.1.									

Note: When piles that have been subjected to a compression loading test are to be used as structural piles, the tube during the loading test is to be made from steel grade S235, see section 4.1.

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TITAN injection pile

Head of pile, compression pile

Annex 5

to National Technical Approval No. Z-34.14-209 of 20 December 2010 “Translation of original German edition not checked by Deutsches Institut für Bautechnik”

Pile installation (operations)

1 Pile log

A pile log is to be compiled during the installation of the piles

2 Plant

2.1 Normally, a fully hydraulic hammer drill is used, mounted on a base machine with drilling rig.

2.2 The jaw mechanism must be able to prevent rotation of the pile while the coupling nuts are being screwed on.

2.3 The hammer drill must be fitted with a mechanism for adjusting the torque, blow energy and blow impulse.

2.4 The grouting plant must be fitted with a separate reservoir so that pumping can be carried out independently of mixing.

3. Preparing the parts of the pile

3.1 Count off the number of loadbearing elements required and store them on timber bearers adjacent to the drilling position.

3.2 First loadbearing element: screw on drill bit.

3.3 Subsequent loadbearing elements: screw on coupling nuts hand-tight on soil end.

4. Preparing the plant

4.1 Set up the drilling plant with base machine, drilling rig and jaw mechanism.

4.2 Mixing and pumping plant:
Connect plant to flushing head with a hose.
Set the w/c ratio.
The cement suspension is pumped out of the reservoir without interruption during the drilling operation for a loadbearing element segment.

5. Preparing the borehole

At the point where drilling is to begin, first set up a guide tube in the soil at the intended angle of the pile prior to beginning the drilling. The tube can be used as a guide and left at the mouth of the borehole after finishing the drilling work.

6. Constructing the pile

6.1 Placing the loadbearing element on the drilling plant

6.1.1 Place the loadbearing element segment with coupling nut on the drilling rig. (The first loadbearing element segment is connected to the drill bit instead of a coupling nut.)

6.1.2 Close the jaw mechanism in order to clamp the loadbearing element.

6.1.3 Screw the loadbearing element to the flushing head and coupling nut by means of the hammer drill. (Screwing to the coupling nut is not necessary for the first loadbearing element segment.)

6.2 Drilling the loadbearing element into the ground

6.2.0 For first loadbearing element segment only: clear the guide tube, with water flushing if necessary.

6.2.1 Start pumping the flushing/drilling fluid (w/c = 0.4 – 0.7).

6.2.2 Open the jaw mechanism.

6.2.3 Drill the loadbearing element into the ground.
Rotary percussive drilling with constant pumping of the flushing/drilling fluid.
Drilling feed rate: max. 1 m/min.
If the flow of flushing/drilling fluid at the mouth of the hole is interrupted, pump fluid into the hole until the flow is restored. During this operation, the topmost loadbearing element segment may be retracted and inserted again several times while constantly rotating and flushing.

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6.2.4 Switch off the hammer drill and the pump for the flushing/drilling fluid (when the end of the loadbearing element protrudes approx. 30 – 50 cm from the mouth of the hole).

6.2.5 Close the jaw mechanism in order to clamp the loadbearing element.

6.2.6 Unscrew the flushing head from the loadbearing element using the hammer drill. Retract the hammer drill.

6.2.7 Slip a centraliser over the loadbearing element.

6.2.8 For the next loadbearing element segment, continue as described under 6.1

6.3 Injecting the grout (after having drilled to the required depth)

6.3.0 Injection (6.3.1 to 6.3.4) may be deemed unnecessary when the flushing/drilling fluid has already been pumped in with a w/c ratio corresponding to the cement suspension (i.e. w/c = 0.4 – 0.5).

6.3.1 Continuous rotation of the hammer drill without feed.
If the w/c ratio of the flushing/drilling fluid (w/c = 0.4 – 0.7) is greater than that of the cement suspension (w/c = 0.4 – 0.5), initially continue pumping until only approx. 10 l of the fluid remains in the reservoir. Caution: Do not pump the reservoir completely dry!

6.3.2 If necessary: Change the flushing/drilling fluid mix (w/c = 0.4 – 0.7) to the cement suspension mix (w/c = 0.4 – 0.5).

6.3.3 Inject the cement suspension (w/c = 0.4 – 0.5) into the loadbearing element to displace the flushing/drilling fluid. Do not pump the reservoir completely dry while doing this.

6.3.4 Terminate the operation when at least the volume of the pile plus the hose has been pumped out of the reservoir into the pile. (Calculate the volume of the pile using the diameter of the drill bit used.)

6.3.5 Measure and record the max. pumping pressure achieved.

6.4 Preparing the head of the pile (while the cement mortar is still fluid)

6.4.1 If the guide tube used during drilling is not to be used for the final pile, extract the guide tube and insert the final tube for the neck of the pile.

6.4.2 Slip a centraliser or a spacer over the top end of the steel loadbearing element in order to centre it within the tube.

6.4.3 If necessary: Fill the annular space between steel loadbearing element and tube with the cement suspension.

6.5 Constructing the head of the pile

6.5.1 This operation is carried out once the cement mortar has cured sufficiently.

6.5.2 Mark the position of the underside of the washer plate on the tube (marking 1).

6.5.3 Establish the final top level of the tube by applying marking 2 at the necessary distance below marking 1.

6.5.4 Expose the steel loadbearing element: Shorten the tube down as far as marking 2 and remove the hardened cement mortar down as far as the top level of the shortened tube. Make sure that the steel loadbearing element is not damaged while doing this. Also remove any centraliser (or spacer) in this segment. Indicate the position of the washer plate by renewing marking 1 on the steel loadbearing element.

6.5.5 Mount the washer plate: Screw the lower spherical collar nut onto the steel loadbearing element down to the level specified. Slip the washer plate over the steel loadbearing element down as far as the lower spherical collar nut. Screw the upper spherical collar nut onto the steel loadbearing element down as far as the washer plate. Fix the spherical collar nuts hand-tight against the washer plate.

6.5.6 Tighten the spherical collar nuts against the washer plate with the necessary torque (see specific provisions, section 2.1.6).

PILE LOG TITAN INJECTION PILE

Site, location:	Log No. .... Date: ....
Contractor (client):	
Pile manufacturer (company):	
Foreman: .... Instructed by Ischebeck on .... by .... ; certificate dated	

	Typ	Dia.	Hammer drill:			Operating values must be limited to…								
Taillant					30/11	40/20	40/16	52/26	73/53	73/45	73/35	103/78	103/51
Centraliser			Torque	Nm	300	1500	1800	3200	8200	8200	8200	21000	25000
Guide tube at drilling start point	Length	Dia.	Blow impulse	kg m/s	18	58	58	96	170	170	170	224	224
			Blow energy	Nm	84	145	145	400	610	610	610	900	900

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

1. Drilling with flushing/drilling fluid:

Pile No.	1	2	3	4	5	6	7	8	9	10	11
Duration [min]											
Rotation/blows											
No. of retractions for clearing borehole											
Suspension: w/c											
Volume [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.

2. Injecting the cement suspension

Begin (time):	End (time):	Duration:.. [min]
w/c = ...	Length of hose from grouting plant to pile: .... [m]	
Volume injected V = ...[l] > min. V = ...l]		max. pressure: .... [bar]
min. V is calculated taking into account hole diameter and hose length		

Associated samples for testing compressive strength, see log No. ....

Remarks:

.... Location	.... Date	.... Signature of foreman	.... Signature of client

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TITAN injection pile

Pile log (sample)