DYWIDAG

GEOTECHNICAL SYSTEMS

DYWIDAG Soil Nailing System

Approval Number Z-20.1-206
Validity 28th January 2016 - 02nd May 2022

Deutsches Institut für Bautechnik DIBt
(German Institute for Building Technology)

Approval Body for Building Products and Building Methods
Constructional Testing Authority
A statutory body jointly sponsored by the German national government and the German Länder
Member of EOTA, UEAtc and WFTAO

Notice

on the Amendment, Supplement and Extension of the Period of Validity of the General Construction Supervisory Authority Approval of January 28, 2016

Date:
06/22/2017

Reference No.:
I 62-1.34.13-1/17

Approval No.:
Z-20.1-106

Period of validity:
from: **May 2, 2017**
to: **May 2, 2022**

Applicant:
DYWIDAG-Systems International GmbH
Destouchesstrasse 68
80796 München

Subject of approval:
"DYWIDAG" Soil Nailing System

This notice amends/supplements the general construction supervisory authority approval and extends the period of validity of the general construction supervisory authority approval No. Z-20.1-106 of January 28, 2016. This notice comprises two pages and one annex. The notice is only valid in connection with the aforementioned general construction supervisory authority approval and may only be used together with it.

Important note
This notice is the translation of a document originally prepared in the German language which has not been verified and officially authorized by "Deutsches Institut für Bautechnik" (German Institute for Civil Engineering). In case of doubt in respect to the wording and interpretation of this notice, the original German version hereof shall prevail exclusively. Therefore, no liability is assumed for translation errors or inaccuracies.

II SPECIAL PROVISIONS

The Special Provisions of the general construction supervisory authority approval are amended and supplemented as follows:

1. Section 4.3.1 is amended as follows.

The first sentence is rephrased as follows:

The basic materials for the cement grout are cements with particular properties in accordance with DIN 1164-10[18] and cements in line with DIN EN 197-1[5], taking into consideration the present exposition class as defined by DIN EN 206-1[19] in conjunction with DIN 1045-2[20] (Tables 1, F.3.1 and F.3.2), water as stipulated by DIN EN 1008[21] and, where required, additives in accordance with DIN EN 934-2[22] in conjunction with DIN EN 206-1[19]/DIN 1045-2[20] or subject to a general construction supervisory authority approval, and natural aggregates for concrete in compliance with DIN EN 12620[23], taking into account DIN EN 206-1[19]/DIN 1045-2[20].

2. Section 4.5 is amended and supplemented as follows:

"N 94 welded steel mesh or equivalent" in the penultimate sentence is replaced with "N 94 welded steel mesh or equivalent or superior".

3. Annex 3 to the general construction supervisory authority approval of January 28, 2016 is replaced with Annex 3 to this notice.

Bettina Hemme
Section Head

Certified

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Deutsches Institut
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[18]	DIN 1164-10:2013-03	Special cement - Part 10: Composition, requirements and conformity evaluation for cement with low effective alkali content
[5]	DIN EN 197-1:2011-11	Cement - Part 1: Composition, specifications and conformity criteria of common cements; German version EN 197-1:2011
[19]	DIN EN 206-1:2001-07	Concrete - Part 1: Specification, performance, production and conformity
	DIN EN206-1/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
[20]	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
[21]	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
[22]	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
[23]	DIN EN 12620:2008-07	Aggregates for concrete; German version EN 12620:2002+A1:2008

Temporary and Permanent Soil Nails

GEWI steel dia.	16	20	25	28	32	40	50	63.5
Steel grade	B500B							S 555/700
Anchorage								
1 Locked end anchorage	approval Z-1.5-76					approval Z-1.5-149		approval Z-1.5-2
2 Plate anchorage -Anchor nut	based on approval Z-1.5-76					approval Z-1.5-149		approval Z-1.5-2
-Anchor plate (min. dimensions) axa s	80x80 10	90x90 12	110x110 15	120x120 20	120x120 30	150x150 40	190x190 45	245x245 50
3 Domed plate anchorage	see Annex 4					---		---

Temporary soil nails

Spring basket spacer dxs	20x1.5	25x1.9	32x2.4	40x3	48x3	63x3	75x3.6
L	210	225	235	280	285	285	285
min. dia.	65	70	80	100	100	125	125
Minimum borehole diameter	56	60	65	68 72	80	90	110
Coupler connection	Approval Z-1.5-76				Approval Z-1.5-149		Approval Z-1.5-2
Anti-rotation device (optional): -locked	Approval Z-1.5-76				Approval Z-1.5-149		Approval Z-1.5-2
- Shrink sleeve Type	Corrosion protection shrink sleeve CPSM						
max/min dia.	35/12	50/16	75/22	95/29	140/42		
- Gluing	Quick hardening glue or adhesive						

Permanent soil nails

Ribbed sheathing (PVC or PE) s	≥ 1mm						
min. dia.o/dia.i	34.5/28	42.5/35	50/44	56/49	65/57	80/71	100/91
Spacer	40x3	48x3	55x3	63x3	75x3.6	90x2.7	110x3.2
- Spring basket spacer dxs	280	285	275	285	285	285	285
L	100	100	125	125	125	140	175
min. dia.							
- Segment spacer L	---	---	---	130			
a	---	---	---	10			
Minimum borehole diameter	55	63	70	76	85	100	120
Coupler connection	Approval Z-1.5-76				Approval Z-1.5-149		Approval Z-1.5-2
Anti-rotation device	Corrosion protection shrink sleeve CPSM						
- Shrink sleeve Type	75/22		95/29				140/42
max/min dia.							

“DYWIDAG” Soil Nailing System	Annex 3
Temporary and permanent soil nails References and dimensions	

Deutsches Institut für Bautechnik DIBt
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Approval Body for Building Products and Building Methods
Constructional Testing Authority
A statutory body jointly sponsored by the German national government and the German Länder
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General Construction Supervisory Authority Approval

Date: 01/28/2016

Reference No.: I 64-1.34.13-3/12

Approval No.:
Z-20.1-106

Period of validity:
from: **January 28, 2016**
to: **May 1, 2017**

Applicant:
DYWIDAG-Systems International GmbH
Destouchesstrasse 68
80796 München

Subject of approval:
"DYWIDAG" Soil Nailing System

The above-mentioned subject of approval is hereby granted a general construction supervisory authority approval.
This general construction supervisory authority approval comprises 17 pages and 4 annexes.
This general construction supervisory authority approval supersedes the general construction supervisory authority approval No. Z-20.1-106 of April 5, 2007, modified and extended by notice of April 18, 2012. The subject matter was granted a general construction supervisory authority approval on February 20, 1989 for the first time.

Important Note
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I GENERAL PROVISIONS

1 This general construction supervisory authority approval verifies the suitability (fitness for the intended purpose) of the subject of approval in keeping with the *Land* building codes ("*Landesbauordnungen*").

2 If requirements for particular technical knowledge and experience of persons entrusted with the manufacture of building products and construction methods are imposed in accordance with Länder-specific regulations corresponding to Section 17(5) of the German Model Building Code ("*Musterbauordnung*"), it must be observed that such technical knowledge and experience can also be proven by equal supporting documents issued by other member states of the European Union. Where required, this also applies to equivalent verifications submitted within the scope of the Agreement on the European Economic Area (EEA) or other bilateral agreements.

3 This general construction supervisory authority approval does not replace the permissions, approvals and certificates required by law for the realization of building projects.

4 This general construction supervisory authority approval is granted without prejudice to the rights of third parties, especially private property rights.

5 Notwithstanding any other regulations in the "Special Provisions" section, the manufacturer and distributor of the subject of approval must provide the user or installer with copies of this general construction supervisory authority approval; furthermore, they must point out to the user or installer that this general construction supervisory authority approval must be available at the place of use. Copies of this general construction supervisory authority approval must be made available to the involved authorities on request.

6 This general construction supervisory authority approval may only be copied in its entirety. A publication of excerpts is subject to the approval of DIBt. Texts and drawings of advertising materials may not contradict this general construction supervisory authority approval. Translations of the general construction supervisory authority approval must contain the note "Translation of the German original which has not been verified by DIBt".

7 This general construction supervisory authority approval is granted subject to revocation. The provisions of this general construction supervisory authority approval can be subsequently amended or changed, especially if the latest technical findings give reason for this.

II SPECIAL PROVISIONS

1 Subject of approval, scope of application

1.1 Subject of approval

Subject matter of this general construction supervisory authority approval is the "DYWIDAG" soil nailing system. The soil bodies must be nailed using soil nails and an facing in the manner shown in the annexes, taking into account the following provisions. Nailing is a measure to increase the tensile and shear strengths of the soil to such an extent that the nailed soil body can be regarded and verified as a monolithic block. The outer skin does not need to be embedded underneath the bottom of the building excavation. The maximum distance between the nails is 1.5m in the horizontal and vertical direction and may only be exceeded if three-dimensional stability has been verified.

1.2 Scope of application

1.2.1 Construction measures

Soil nails may be used to secure abrupt topographical changes, e.g. excavations and tieback walls, secure existing slopes and stabilize earth bodies subjected to loads during underpinning works at any inclination. In this process, temporary (≤ 2 years) and permanent (> 2 years) installations must be distinguished.

1.2.2 Types of soil

The subject soil nailing system can be used in non-cohesive or cohesive soil (cf. DIN EN 1997-1[1] in conjunction with DIN EN 1997-1/NA[2] and DIN 1054[3], Section 3.1). Soil nailing may not be carried out if the soil or the groundwater contains substances which attack concrete (cf. DIN 4030-1[4]). If the sulphate content of the soil or groundwater is slightly corrosive (XA1) as specified by DIN 4030-1[4], Table 4, the soil nails may be installed, provided that cement with a high sulphate resistance (SR cement) as prescribed by DIN EN 197-1[5] is used.

1.3 Subsoil investigation

Based on DIN EN 1997-1[1] in conjunction with DIN EN 1997-1/NA[2] and DIN 1054[3], the geotechnical investigations required for supporting structures must be carried out and evaluated under the direction of an expert in geotechnical engineering. In this process, it must also be examined whether the in-situ soil is temporarily stable at the intended depth of excavation. The soil must not break up if the facing is produced using the sprayed concrete method.

[1]	DIN EN 1997-1:2009-09	Eurocode 7: Geotechnical design - Part 1: General rules; German version EN 1997-1:2004 + AC:2009
[2]	DIN EN 1997-1/NA:2010-12	National Annex - Nationally determined parameters - Eurocode 7: Geotechnical design - Part 1: General rules
[3]	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
[4]	DIN 4030-1:2008-06	Assessment of Waters, Soils and Gases attacking Concrete - Part 1: Basics and Threshold Values
[5]	DIN EN 197-1:2011-11	Cement - Part 1: Composition, specifications and conformity criteria of common cements; German version EN 197-1:2011

2 Regulations covering the construction product

2.1 Properties and composition

2.1.1 Steel tendon

Only general construction supervisory authority approved reinforcing bars with thread ribs B500B, nominal diameters 16mm, 20mm, 25mm, 28mm, 32mm, 40mm, 50mm, as well as general construction supervisory authority approved steel bars with thread ribs GEWI steel S 555/700 with the nominal diameter 63.5mm may be installed.

2.1.2 Corrosion protection and manufacture of prefabricated soil nails for installation and grouting

2.1.2.1 Temporary installation (temporary soil nail)

For the temporary installation of the soil nails, steel bars with thread ribs should be covered with 20mm cement stone; the minimum cover must be ≥ 15mm. For this purpose, the steel bars with thread ribs must be provided with spacers according to Annex 3, the interval of which must be ≤ 2m.

In the instance of cased boreholes, spacers may be omitted if the thickness of the casing inside the starter pipe or at the nipple passages is ≥ 2.0cm and if, at the same time, the shaft is grouted at a higher pressure than the hydrostatic pressure.

2.1.2.2 Permanent installation (permanent soil nail)

The corrosion protection of permanent soil nails is to be applied in the plant. A corrugated plastic sheathing must be pulled over the steel bar with thread ribs over approximately the entire length (see Annex 2). Only such plastic sheathings may be used, which consist of PVC-U in accordance with DIN EN ISO 1163-1[6], of polyethylene with a molding compound as specified by DIN EN ISO 1872-1[7] – PE,E,45 – T022 or of polypropylene with a molding compound pursuant to DIN EN ISO 1873-1[8] – PP – B, EAGC, 10-16-003 or DIN EN ISO 1873-1[8] – PP – H, E, 06-35-012/022. It must be ensured that only straight pipes are used. The sheathing must have a uniform wall thickness of ≥ 1mm; only pipes may be used which do not show any trapped bubbles and the pigmentation of which is uniform. The dimensions for the sheathings are stated in Annex 2.

Any individual segments of the PVC-U sheathings possibly required must be screwed together and carefully glued with a specific PVC adhesive or carefully sealed by wrapping them with a specific PVC tape. Unspliced pipes must be used as the PE or PP sheathings.

[6]	DIN EN ISO 1163-1:1999-10	Plastics - Unplasticized poly(vinyl chloride) (PVC-U) molding and extrusion materials - Part 1: Designation system and basis for specifications (ISO 1163-1:1995) - German version EN ISO 1163-1:1999
[7]	DIN EN ISO 1872-1:1999-10	Plastics - Polyethylene (PE) moulding and extrusion materials - Part 1: Designation system and basis for specifications (ISO 1872-1:1993) - German version EN ISO 1872-1:1999
[8]	DIN EN ISO 1873-1:1995-12	Plastics - Polypropylene (PP) molding and extrusion materials - Part 1: Designation system and basis for specifications (ISO 1873-1:1995) - German version EN ISO 1873-1:1995
[9]	DIN EN 447:1996-07	Grout for prestressing tendons - Specification for common grout; German version EN 447:1996
[10]	DIN EN 445:1996-07	Grout for prestressing tendons - Test methods; German version EN 445: 1996
[11]	DIN EN 446:1996-07	Grout for prestressing tendons - Grouting procedures; German version EN 446:1996

The sheathing must be closed with a grout cap (see Annex 2) at the earth-side end. For inclined nails, the annulus between the steel bar with thread ribs and the sheathing must be completely grouted with cement grout in accordance with DIN EN 447[9] from bottom to top. In addition, DIN EN 445[10] and DIN EN 446[11], as well as Building Regulation List A Part 1[12] must be taken into account. It must be ensured that a distance of ≥ 5mm between the steel bar with thread ribs and the sheathing is maintained by means of spacers mounted every 1.0m. Instead of spacers, a round steel helix 5mm dia. or a plastic helix 6mm dia. made of PE or PVC with a pitch of 0.5m may be used.
The cement grout injected sheathing must encase the steel bar with thread ribs to such an extent that it extends into the area of the facing.
The sheathings must be centered within the borehole by means of spacers, the distance of which must be ≤ 2m. The sheathings must be covered with at least 10mm cement grout.
In the instance of cased boreholes, spacers may be omitted if the thickness of the casing inside the starter pipe or at the nipple passages is ≥ 2.0cm and if, at the same time, the shaft is grouted at a higher pressure than the hydrostatic pressure.

2.1.3 Air-side anchorage

The steel bars with thread ribs must be anchored by anchorages according to the general construction supervisory authority approvals for DYWIDAG-Systems coupler connections and anchorages of reinforcing bars with thread ribs B500B-GEWI (BSt 500 S-GEWI), for Ø16 mm to Ø32 mm approval No. Z-1.5-76, for Ø40 mm and Ø50 mm approval No. Z-1.5-149, or according to the general construction supervisory authority approval No. Z-1.5-2 for DYWIDAG-Systems coupler connections and anchorages of steel bar with thread ribs S 555/700, Ø63.5 mm. In cases of deviations from the stipulations therein, e.g. with regard to the additional reinforcement, the load-bearing capacity of the anchor plates must be verified. This also applies to the transmission of the forces into the facing.

In the case of non-dynamic actions, steel bars with thread ribs Ø16 mm to Ø32 mm can also be anchored by means of domed nuts and domed plates according to Annex 4.
The onward transmission of the forces within the facing (e.g. splitting forces) must be verified on a case-to-case basis (see also Section 3.4).

2.1.4 Splice

The steel bars with thread ribs may be spliced by couplers according to the general construction supervisory authority approvals for DYWIDAG-Systems coupler connections and anchorages of reinforcing bars with thread ribs B500B-GEWI (BSt 500 S-GEWI), for Ø16 mm to Ø32 mm approval No. Z-1.5-76, for Ø40 mm and Ø50 mm approval No. Z-1.5-149, or according to the general construction supervisory authority approval No. Z-1.5-2 for DYWIDAG-Systems coupler connections and anchorages of steel bar with thread ribs S 555/700 Ø63.5mm. (see also Annexes 1 and 2, as well as Section 4.6).
The couplers must be locked with nuts.
In the case of non-dynamic actions, the lock nuts can be omitted if a heat shrink sleeve is arranged in accordance with Annexes 1 and 2. The material properties and dimensions of the heat shrink sleeves must correspond to the specifications deposited at DIBt.

[12] Building Regulation List A, Building Regulation List B and List C - edition 2015/2; available online from www.dibt.de

2.2 Transport, storage and marking

2.2.1 Transport and storage

The permanent soil nails may only be lifted from the assembly bench after the inner cement grout has hardened.

Special care must be taken during transport and storage of the corrosion protected soil nails so that the sheathings may not be damaged (e.g. parallel storage in sheet pile profiles or similar).

2.2.2 Marking

The delivery note for the soil nail prefabricated for installation and grouting must be marked by the manufacturer with the mark of conformity (Ü- Zeichen) in accordance with the conformity mark regulations issued by the German Länder. The marking may only be performed if the requirements pursuant to Section 2.3 have been met.

The delivery note must, among other things, state for which soil nails the components are designated and in which plant they have been manufactured. Only components for one soil nail type to be specified may be delivered on one delivery note.

2.3 Certificate of conformity

2.3.1 General

The conformity of the soil nail components and of the soil nail construction prefabricated for installation and grouting with the provisions of this general construction supervisory authority approval must be confirmed for every manufacturing plant with a certificate of conformity based on the manufacturer's own factory production control system and on a regular external monitoring including initial testing in accordance with the following provisions.

The manufacturer of the soil nail components and of the prefabricated soil nail construction must commission a notified product certification body and an external surveillance authority to issue the certificate of conformity and perform the external surveillance, including the product inspection/testing to be carried out in this process.

The declaration that a certificate of conformity has been issued must be made by the manufacturer by marking the construction products with the mark of conformity, indicating the intended purpose of use.

The certification body must forward a copy of the certificate of conformity issued to DIBt for information.

In addition, DIBt must be provided with a copy of the report on the initial testing for information.

The conformity of the "DYWIDAG" soil nailing system with the provisions of this general construction supervisory authority approval must be confirmed by means of a declaration of conformity based on the provisions set out in Section 2.3.4 hereof.

2.3.2 Factory production control

2.3.2.1 General

Every manufacturing plant must establish and implement its own factory production control system. A factory production control system is defined as the continuous monitoring of the production to be performed by the manufacturer who thus ensures that the building products manufactured meet the requirements covered by this general construction supervisory authority approval.

The results of the internal production control must be recorded and evaluated. The records must at least contain the following information:

- The description of the construction product or of the basic material and of its components,
- the type of the control or inspection,
- the date of manufacture and the date of inspection of the construction product or of the basic material or of its components,
- the results of the controls and inspections and, if applicable, a comparison with the relevant requirements,
- the signature of the person in charge of the internal production control system.

The records must be kept for a minimum of five years and submitted to the notified product certification body involved in continuous surveillance. They must be submitted to DIBt and to the competent highest construction supervisory authority on request.

If the test results are unsatisfactory, the manufacturer must immediately take the measures necessary to eliminate the identified deficiency. Construction products which do not meet the requirements must be handled in such a manner that they cannot be mistaken for conforming products. Once the deficiency has been eliminated, the test in question must be immediately repeated, provided that this is technically feasible and also required to verify the elimination of the deficiency.

The internal production control system should at least include the following measures:

2.3.2.2 Steel bars with thread ribs, anchoring and connecting means

Only steel bars with thread ribs, anchoring and connecting means may be used for which a certificate of conformity has been issued in accordance with the relevant general construction supervisory authority approvals.

The stipulations for the receiving inspection detailed therein must be observed.

The provisions of the general construction supervisory authority approval No. Z-1.5-76, Section 2.3, apply mutatis mutandis to the certificate of conformity for the anchorage by means of domed nuts and domed plates according to Annex 4.

2.3.2.3 Heat shrink sleeves

The material properties of the heat shrink sleeves and of the adhesive must be confirmed by certificate of compliance "2.1" in accordance with DIN EN 10204[13]. Per batch (100 pieces), the wall thickness must be measured at 3 locations on the basic material, and the application of the adhesive must be determined. The decision whether a batch is accepted or rejected must be made in accordance with Section 2.3.2.5.

2.3.2.4 Corrosion protection of permanent soil nails

2.3.2.4.1 Sheathings

The composition of the molding compound is to be attested by certificate of compliance "2.1" as per DIN EN 10204[13]. One sheathing per batch (100 pipes) must be sampled to measure the wall thickness both at one internal and one external rib and on the flank of the pipes, as well as the diameter. The dimensions must correspond to the drawings deposited at DIBt and the external surveillance authority. The decision whether a batch is accepted or rejected must be made in accordance with Section 2.3.2.5.

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

2.3.2.4.2 Factory applied corrosion protection

The corrosion protection measures to be carried out in the plant in accordance with Section 2.1.2.2 must be verified by visual inspection on each soil nail (statistical evaluation not necessary).

The inner cement grout must be inspected as prescribed by DIN EN 447[9]. In addition, DIN EN 445[10] and DIN EN 446[11], as well as Building Regulation List A Part 1[12] must be observed.

2.3.2.5 Inspection plan

If each individual measured value equals or exceeds the minimum value specified, the batch must be accepted. Otherwise, additional samples can be taken. The same measurements as those on the first sample must be carried out on these additional samples. The measuring results must be merged with the previous measurements. The mean value x and the standard deviation s must be derived from all values. If the test value (numerical value)

$$z = x - 1.64\ s$$

derived therefrom equals or exceeds the minimum value required, the batch must be accepted, otherwise rejected.

2.3.3 External surveillance

The fabric production control in each manufacturing plant must be monitored by external surveillance on a regular basis, but at least twice a year.

An initial inspection must be carried out as part of the external surveillance. Also samples for sampling tests must be taken and testing tools inspected. Both sampling and testing are incumbent on the notified product certification body involved in continuous surveillance.

The results of the certification and external surveillance must be kept for minimum five years. They must be presented to DIBt and to the competent highest construction supervisory authority by the notified product certification body on request.

2.3.4 Certificate of conformity for the construction of soil nails

The conformity of the "DYWIDAG" soil nailing system with the provisions of this general construction supervisory authority approval must be confirmed by the contractor by means of a declaration of conformity based on the inspection of the construction as set out in Section 4.7 hereof.

3 Provisions for planning and design

3.1 General

The technical building regulations, in particular, DIN EN 1997-1[1], DIN EN 1997-1/NA[2], DIN 1054[3] and DIN 1054/A1[3], apply to the planning and design of nailed supporting structures unless otherwise stated in the text below.

Nailed supporting structures must at least be classified as geotechnical category GK 2. It must be verified based on DIN 1054[3], Section A 9.1.3 A (4), whether criteria exist which require classification as geotechnical category GK 3.

The verifications to be produced for the ultimate limit state, as well as the related limit states and verification procedures are listed in Table 1. The verifications must be produced both for the final state and for decisive (intermediate) structural stages.

Table 1: Overview of load capacity verifications for nailed supporting structures

	Proof	Limit state/ verification method	Section in	
			DIN EN 1997-1[1]	DIN 1054[3]
Nailed supporting structure	Ground rupture	GEO-2	6.5.2	6.5.2
	Sliding	GEO-2	6.5.3	6.5.3
	Highly eccentric load	GEO-2	6.5.4	6.5.4
	Overall stability	GEO-3	11.5.1	11.5.1
Nails	Material failure	STR		
	Extracting	GEO-3		A 11.5.4.2
Facing	Partial area loading, punching, etc.			A 11.5.4.1
Note: The partial safety factors can be taken from DIN 1054[3], Tables A 2.1 to A 2.3.				

3.2 Verifications for the ultimate limit state of nailed supporting structures

For the calculation of a nailed supporting structure, a mathematical rear wall through the end of the nails is to be assumed. The following must be verified for the geometrically thus defined weight supporting wall made from a quasi-monolithic nailed soil body:

(a) stability against ground rupture,
(b) slide stability,
(c) protection from loss of balance due to a highly eccentric load,
(d) overall stability.

Note 1: Due to comparative calculations, verifications (a) to (c), in the case of up to 5m high nail walls, are always dispensable if $l_n \geq 0.6 \bullet h$ (nail length l_n; wall height h) applies and the soil conditions downwards do not become more infavorable.

Note 2: An explicit verification of the EQU limit state according to DIN 1054[3], section regarding 6.5.4 A (3), must not be performed. Sufficient protection from loss of balance due to a highly eccentric load is given if the conditions for the location of the bearing pressure resultants in accordance with DIN 1054[3], Section A 6.6.5, are met (see Section 3.6 of this general construction supervisory authority approval).

3.3 Nail verification

Sufficient safety against material failure and pull out of a soil nail must be verified in accordance with DIN 1054[3].

3.3.1 Design load of nails

The design load of the nails must be determined, as per DIN 1054[3], Section A 11.5.4.1,

(a) from the design earth pressure and the area of the facing allocated to the particular element for the GEO-2 limit state.

(b) from the deficit of the equilibrium of forces and/or moments on sliding bodies, which are limited by rupture mechanisms with straight or bent gliding surfaces, with the gliding surfaces to be varied crossing a portion of the retaining elements. The verification is performed in accordance with DIN 4084[14] for the limit state GEO-3.

The greater value of the design load is decisive.

Regarding (a) - Design load $E_{E,d}$ from earth pressure

The design action on the facing of the supporting structure must be determined, in the GEO-2 limit state, from the characteristic active earth pressure according to DIN 1054[3] and DIN 4085[15], taking into consideration the minimum earth pressure, where required, with the earth pressure inclination being assumed to be parallel to the inclination of the soil nails.

Note: Since the sprayed concrete skin does not transmit any forces into the subsoil, the earth pressure to fulfill the equilibrium of forces must act in the direction of the soil nails. However, these need not necessarily be vertical to the facing.

The earth pressure distribution for the portion from constant actions can be assumed to be equal due to the redistributions taking place. The ordinate of the rectangular figure then is:

$$e_{ag,k}(z) = e_{ag,k} = E_{ag,k} \bullet \cos(\alpha) / h = \text{constant} \qquad (3.1)$$

with α = inclination angle of the wall (as defined by DIN 4085[15])
h = wall height

This earth pressure from constant actions on the sprayed concrete skin may additionally be reduced by 15%.

$$\text{red } e_{ag,k} = 0{,}85 \bullet e_{ag,k} \qquad (3.2)$$

The earth pressure from variable actions must be specified in accordance with DIN 4085[15] and may not be reduced. Thus, the resulting design load from earth pressure emerges as:

$$e_{a,d}(z) = \text{red } e_{ag,k} \bullet \gamma_G + e_{ap,k}(z) \bullet \gamma_Q \qquad [kN/m^2] \qquad (3.3)$$

with γ_G, γ_Q = partial safety factors according to DIN 1054[3], Table A 2.1 for the limit state GEO-2

For a nail at the depth z_i, the design load thus emerges as:

$$E_{E,d} = e_{a,d} \bullet \Delta F \qquad [kN] \qquad (3.4)$$

with $\Delta F = s_h \bullet s_v / \cos(\alpha)$
s_h = horizontal nail distance
s_v = vertical nail distance

Note: All aforementioned values relate to the impact area of the considered nail i at the depth z_i. The related area of the facing can differ for nails in peripheral areas (e.g. top or bottom nail layer) from that of the remaining nails.

The decisive design load $E_{E,d}$ for the load-bearing capacity verification according to Section 3.3.3 of this general construction supervisory authority approval is the maximum from all nail forces thus determined.

14 DIN 4084:2009-01 Soil - Calculation of embankment failure and overall stability of retaining structures
15 DIN 4085:2011-05 Subsoil - Calculation of earth-pressure

Regarding (b) - Design load $E_{N,d}$ from the equilibrium of forces or moments

For the determination of the design load from the equilibrium of forces and/or moments, the safety against terrain rupture must be verified in accordance with DIN 4084[14], with the sliding surfaces to be varied crossing all of the nails or a part thereof. In this process, the force transmitted via the surface friction per meter of nail length along the force transmission section may be assumed to be constant and equal for all nails. The force of a nail $F_{Ni,d}$ in the anchoring area then emerges as:

$$F_{Ni,d} = T_{m,d} \bullet l_{r,i} \quad [kN] \quad (3.5)$$

with: $T_{m,d}$ = mean axial force per linear meter of nail outside the sliding joint mathematically required for the achievement of the limit equilibrium, i.e. in the "passive" or dormant floor area

$l_{r,i}$ = remaining nail length outside the sliding joint at the i^{th} nail layer

The unsafest rupture mechanism is that where $T_{m,d}$ becomes the maximum.

The decisive design load for a nail from the equilibrium of forces or moments emerges for the nail with the greatest remaining length $l_{r,max}$ outside the sliding joint:

$$E_{N.d} = T_{m,d} \bullet l_{r,max} \quad [kN] \quad (3.6)$$

with $l_{r,max}$ = greatest remaining nail length outside the sliding joint

If, according to DIN 1054[3], Section A 11.5.4.1 A (5), the deficit of the equilibrium of forces or moments is decisive for the design load of a nail, then the area of the facing ΔF allocated to this nail must be loaded with a correspondingly higher design earth pressure. This is derived by dividing the mathematically required design nail force $E_{N,d}$ by the area of the facing allocated to the nail. This is often decisive especially at the lowest nail layers.

3.3.2 Design resistance of nails

Pull out resistance $R_{A,d}$

The length-related characteristic pull out resistance of a soil nail $T_{Pm,k}$ must be determined by in-situ pull out tests (nail tests as defined in Section 4.7 hereof). The design value of the length-related pull out resistance $T_{Pm,d}$ emerges from the characteristic value as:

$$T_{Pm,d} = T_{Pm,k} / \gamma_a \quad [kN/m] \quad (3.7)$$

with γ_a = partial safety factor as per DIN 1054[3], Table A 2.3 for the limit state GEO-3

The design value for the greatest pull out resistance of an individual nail then emerges as:

$$R_{A,d} = T_{Pm,d} \bullet l_{r,max} \quad [kN] \quad (3.8)$$

The mean axial force per linear meter of nail $T_{Pm,d}$ must be assumed as constant over the depth t. In the case of t < 2.0m below ground level, $T_{Pm,d}$ is to be reduced by 50%.

Material resistance $R_{B,d}$

The characteristic axial tensile resistance $R_{B,k}$ of the soil nail is determined as:

$$R_{B,k} = A_s \bullet R_e \quad (3.9)$$

with A_s = nominal cross-sectional area of the steel tendon

R_e = tensile stress at the yield point

The design value of the material resistance then emerges as:

$$R_{B,d} = R_{B,k} / \gamma_M \quad [kN] \quad (3.10)$$

with $\gamma_M = 1.15$

In the case of dynamic actions, fatigue verification must be additionally performed in accordance with the provisions of the relevant general construction supervisory authority approvals for steel bars with thread ribs or for anchorages for steel bars with thread ribs.

3.3.3 Verification of the load-bearing capacity of the nails

The load-bearing capacity of the nails must be verified for the:

(1) pull out resistance (ground resistance),

(2) material resistance (component resistance). It must be verified:

$$R_{A,d} \text{ and/or } R_{B,d} \geq \max\begin{cases} E_{E,d} \\ E_{N,d} \end{cases} \quad (3.11)$$

3.4 Surface protection verification (facing)

The facing must be designed in accordance with DIN EN 1992-1-1[16] in conjunction with DIN EN 1992-1-1/NA[17]. In the area of the nail heads, verifications of the punching shear forces and of the partial area loading must be performed in accordance with DIN EN 1992-1-1[16] in conjunction with DIN EN 1992-1-1/NA[17].

The decisive design load emerges, analogue to Section 3.3.1 of this general construction supervisory authority approval, either from earth pressure or from the deficit of the equilibrium of forces and/or moments.

3.5 Deformations

If the deformations of nailed walls are to be restricted, then one can, in the case of no building above a wall, proceed in accordance with DIN 4084[14], Section 11. In the case of a building above a wall, the building project must be classified as geotechnical category GK 3; DIN 1054[3], section regarding 9.8 and section regarding 11.6, must be observed. Special measures such as the additional use of prestressed anchors may become necessary.

As far as cohesive soils are concerned that tend to creep, creep deformations must be taken into account over the long term. The compatibility of possible creep deformations with local boundary conditions must be verified for permanent structures.

Note: For tests with nailed walls, horizontal movements of up to 4‰ of the wall height have been measured under their own weight. In these tests, the nail lengths were 0.5 to 0.7 times of the wall height.

3.6 Verification of serviceability limit states

For the verification of the serviceability, the requirements as per DIN 1054[3], Section A 6.6.5, section regarding 9.8 and section regarding 11.6, must be observed. To limit, in particular, a gaping joint and the rotation of the supporting structure, the conditions regarding the location of the bearing pressure resultant must be observed in accordance with DIN 1054[3] Sections A 6.6.5 A (2) and A (3).

16	DIN EN 1/1/1992:2011-01	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004 + AC:2010
17	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

4 Provisions for the installation

4.1 General

The soil nails as defined herein may only be installed under the responsible technical supervision of DYWIDAG-Systems International GmbH.

The soil nails may also be installed by companies which can present a certificate issued by DYWIDAG-Systems International GmbH that they have been comprehensively trained in the production of the soil nailing system in accordance with this general construction supervisory authority approval.

The applicant must keep a list of structures secured with permanent soil nails in accordance with this general construction supervisory authority approval, indicating the structure, the type and the number of soil nails installed.

4.2 Drilling

The boreholes must be cased, unless it is verified on the construction site that the uncased boreholes are stable and that no earth can fall into the borehole when the soil nails are installed. The minimum borehole diameter can be taken from Section 2.1.2.1 or 2.1.2.2 and is set out in Annex 3. The boreholes must be drilled with a minimum inclination of 10° to the horizontal.

If in the case of a cased borehole, the projecting end of the drill set has an edged internal thread or a sharp-edged pipe end, the steel tendons of permanent soil nails may not be inserted into the borehole until an edge-free inserting trumpet or a pipe nipple which fully covers the internal thread of the casing has been put onto the projecting end of the drill set. It must be ensured that the corrosion protection is not damaged when the tendon is inserted.

4.3 Cement grout for injecting boreholes

4.3.1 Composition

The basic materials for the cement grout are cements with particular properties in accordance with DIN 1164-10[18] and cements in line with DIN EN 197-1[5], taking into consideration the present exposition class as defined by DIN EN 206-1[19] in conjunction with DIN 1045-2[20] (Tables 1, F.3.1 and F.3.2), water as stipulated by DIN EN 1008[21] and, where required, additives in accordance with DIN EN 934-2[22] in conjunction with DIN EN 206-1[19]/DIN 1045-2[20] or granted general construction supervisory authority approval, and natural aggregates for concrete in compliance with DIN EN 12620[23] and the list of building regulations B Part 1[12], Annex 1/1.3, taking into account DIN EN 206-1[19]/DIN 1045-2[20], Annex U. The water/cement ratio must be between 0.35 and 0.50 and should be chosen as low as possible especially in cohesive soil.

The cement grout must be mixed mechanically, and may not segregate and lump before its injection.

18	DIN 1164-10:2013-03	Special cement - Part 10: Composition, requirements and conformity evaluation for cement with low effective alkali content
19	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
20	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
21	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
22	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
23	DIN EN 12620:2008-07	Aggregates for concrete; German version EN 12620:2002+A1:2008

4.3.2 Compressive strength

After 28 days, the compressive strength of the cement grout must at least correspond to that of concrete of the strength class C25/30 unless otherwise agreed.

For the verification of the compressive strength, tests according to DIN EN 12390-3[24] must be carried out on at least two series of 3 specimens per 7 manufacturing days, however, on at least two series of 3 samples per construction site.

4.3.3 Injecting the boreholes

The boreholes must be filled with the cement grout according to Sections 4.3.1 and 4.3.2 from the earth-side end via the drill casings or via grout tubes. As far as the minimum cover with cement grout and the arrangement of spacers is concerned, please see Sections 2.1.2.1 and 2.1.2.2. Post-grouting is permissible. Once the initial grouting has set or fully hardened, further injections of cement grout can be made. For this purpose, the soil nail must already be equipped with an injection tube provided with grout valves before the installation (see Annexes 1 and 2). The cement grout set can be burst using water; however, post-grouting must be carried out with cement grout.

4.4 Facing

Lined excavated areas must be protected by the outer skin without delay. In the case of strongly sinking soils and/or construction measures where deformations have to be kept to a minimum, wall reinforcements must be put in place in advance prior to the excavation (e.g. piles, pregrouting), if required.

The facing may consist of sprayed concrete or precast concrete parts. The sprayed concrete must at least correspond to the C25/30 strength class. DIN EN 14487-1[25] and DIN 18551[26] apply to the installation and verification.

An adequate drainage must be provided so that water pressure does not build up behind the facing.

4.5 Anchoring soil nails on the facing

To anchor the soil nails on the facing, anchor plates (see Section 2.1.3) must be placed vertical to the tendon in fresh sprayed concrete or in a mortar bed. If a domed plate anchorage according to Annex 4 is used, an angle compensation of ± 15° to the tendon axis is possible. The borehole must be injected up to the front edge of the wall; the remaining hollow space caused by the inclined position of the nail must be filled with sprayed concrete. After the sprayed concrete shell has hardened, the nuts must be fastened by hand. For permanent soil nailing, a sprayed concrete layer of at least 5cm must be applied to the nail heads and reinforced with N 94 welded steel mesh or equivalent. If the facing consists of prefabricated elements, the nail heads must have equivalent protection.

[24]	DIN EN 12390-3:2009-07	Testing hardened concrete - Part 3: Compressive strength of test specimens; German version EN 12390-3:2009
	DIN EN 12390-3 Ber. 1:2011-11	Testing hardened concrete - Part 3: Compressive strength of test specimens; German version EN 12390-3:2009, correction to DIN EN 12390-3:2009-07; German version EN 12390-3:2009/AC:2011
[25]	DIN EN 14487-1:2006-03	Sprayed concrete - Part 1: Definitions, specifications and conformity; German version EN 14487-1:2005
[26]	DIN 18551:2010-02	Sprayed concrete - National application rules for series DIN EN 14487 and rules for design of sprayed concrete constructions

4.6 Splice formation

The distance between the joints must be ≥ 1m. The couplers must always be secured in accordance with Annexes 1 and 2. In the case of permanent soil nails, the free bar ends as well as the internal thread of the couplers must be provided with an anti-corrosion compound coating in such a manner that the interior space of the coupler is completely filled after the assembly. Any hollow space between the grout column and the splice must, as required by DIN 30672[27], be completely filled with the "Densoplast Petrolatum" plastic sealing tape on both sides of the splice, before the shrink sleeve is shrunk on. The petrolatum must be melted on through heating. Subsequently, the site of coupling must be protected with a heat shrink sleeve in accordance with Section 2.1 4 and Annex 2. The heat shrink sleeves must have a minimum wall thickness of 1.5mm in the shrunk condition. The heat shrink sleeves must be shrunk on with hot air, infrared radiation, or the soft flame of a gas burner.

4.7 Certificate of conformity

4.7.1 General

During the construction of the “DYWIDAG” soil nailing system, records regarding the verification of the proper construction must be kept by the construction site manager or their representative.

The conformity of the “DYWIDAG” soil nailing system with the provisions of this general construction supervisory authority approval as set out in Section 2.3.4 must be confirmed for each soil nailing by the contractor by means of a declaration of conformity based on the inspections of the construction and based on the tests set out in Section 4.7.2 hereof. The results of the inspections must be recorded and evaluated.

If the test results are unsatisfactory, the manufacturer must immediately take the measures necessary to eliminate the identified deficiency. Once the deficiency has been eliminated, the test in question must be immediately repeated, provided that this is technically feasible and also required to verify the elimination of the deficiency.

The contractor’s declaration of conformity must at least contain the following information:

- approval No.,
- designation of the building project,
- the date of installation,
- contractor’s name and registered office,
- confirmation that the installation is in compliance with the design documents,
- documentation of the basic materials and delivery notes,
- the nature of the controls or inspections,
- the date of the control or inspection,
- the results of the controls and inspections and, if applicable, a comparison with the relevant requirements,
- particularities,
- name, company and signature of the person in charge of the controls and inspections.

The records must be available on the construction site during the construction period. Following completion of the work, the records must be retained by the company for a minimum of five years.

[27] DIN 30672:2000-12 External organic coatings for the corrosion protection of buried and immersed pipelines for continuous operating temperatures up to 50°C - Tapes and shrinkable materials

Copies of the records must be handed over to the client for incorporation into the construction file and presented to DIBt and to the competent highest construction supervisory authority on request.

4.7.2 Tests

4.7.2.1 Load tests

The pull out resistance of the soil nail assumed in the static calculations must be verified by load tests. The load tests must be performed on at least 3% of all nails or at least on 3 nails per soil type.

For the load tests, a tensile force is to be applied to the nail head in steps of 20kN or in a minimum of 5 load stages up to the maximum test load P_P, the 1.40 times design value of the nail load. If, in this process, the force in the reinforcing bars with thread ribs intended for the nailed soil body exceeds the value of 0.8 R_m (determined with the characteristic value of the tensile strength of the test nail) or 0.95 R_e (determined with the characteristic value of the yield strength of the test nail), then nails with a higher load-bearing capacity, but with the same bonding properties with regard to the soil must be used for the load tests. During the test loading which must be kept constant, the displacements must be read after 1, 2, 5, 10 and 15 minutes. The observation period must be prolonged if the displacement Δs exceeds 0.5mm between 5 and 15 minutes. In these cases, the observation must be continued until Δs is ≤ 2.0mm over a time interval of t_1 to $t_2 = 10\ t_1$. Provided that one of those conditions is fulfilled for all nails tested, a sufficient load-bearing capacity in soil is verified. During the load tests, it must be ensured that the nail is not supported by the facing.

The test may only be carried out on nails from a limit depth of $t_g \geq 2.0$m below ground level. The length of the bonding section l_v of the test nail must be chosen in such a manner that it corresponds to 70% to 90% of the total length of the longest nail. The length of the bonding section should not vary much in a test series.

Due to the surface friction along the bonding section $l_{v,i}$ (cf. Section 3.3), which is assumed to be equally distributed, the mean characteristic axial nail force per lineal meter $T_{Pm,k}$ can be calculated from the maximum test load $P_{max,i}$ achieved in test i.

$$T_{Pm,i} = \frac{P_{max,i}}{I_{V,i}} \qquad [kN/m] \qquad (4.1)$$

From this results the decisive length-related characteristic extraction resistance $T_{Pm,k}$ based on DIN EN 1997-1[1] 7.6.3.2 (5)P as:

$$T_{Pm,k} = MIN\left(\frac{(T_{Pm,i})_{mitt}}{\xi_1}; \frac{(T_{Pm,i})_{min}}{\xi_2}\right) \qquad [kN/m] \qquad (4.2)$$

The distribution coefficients ξ1 and ξ2 must be applied according to Table 2. In the case of n ≥ 8 tests, the minimum value for the calculation of $(T_{Pm,i})_{min}$ may not be taken into account if it significantly deviates downwards. In the case of doubt, an expert in geotechnical engineering must be consulted for the evaluation of the tests.

Table 2: Distribution coefficients to derive characteristic values from nail load tests

n	3	4	5	6	≥ 7
ξ1	1.35	1.25	1.15	1.05	1.00
ξ2	1.35	1.15	1.00	1.00	1.00
n is the number of load tested nails					

4.7.2.2 Group effect

If the distance between the nails is less than 0.8m, a mutual effect due to group loading must be checked. The arrangement of the test field and the minimum number of the nails to be tested can be taken from Figure 1.

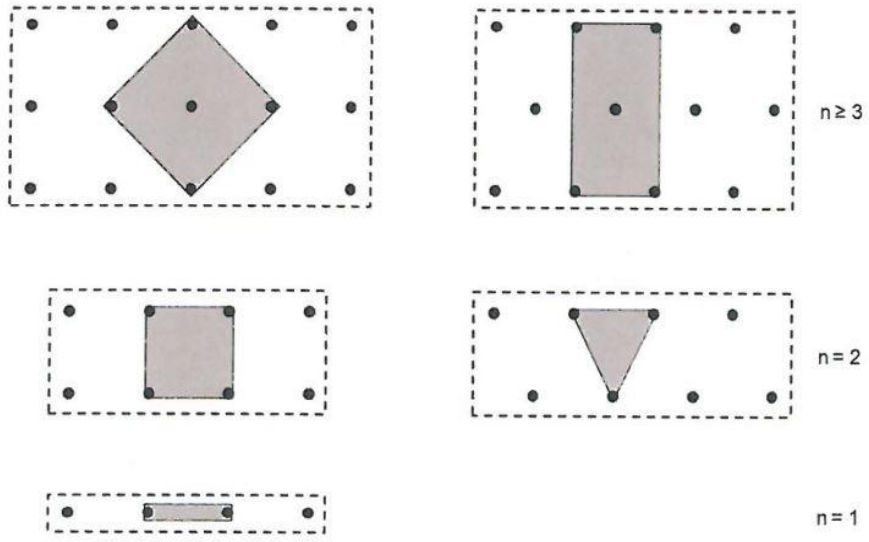


Fig. 1: Arrangement of the test field and minimum number of the nails to be tested in the case of group loads dependent on the number of nail rows n

5 Provisions for usage, maintenance, and service

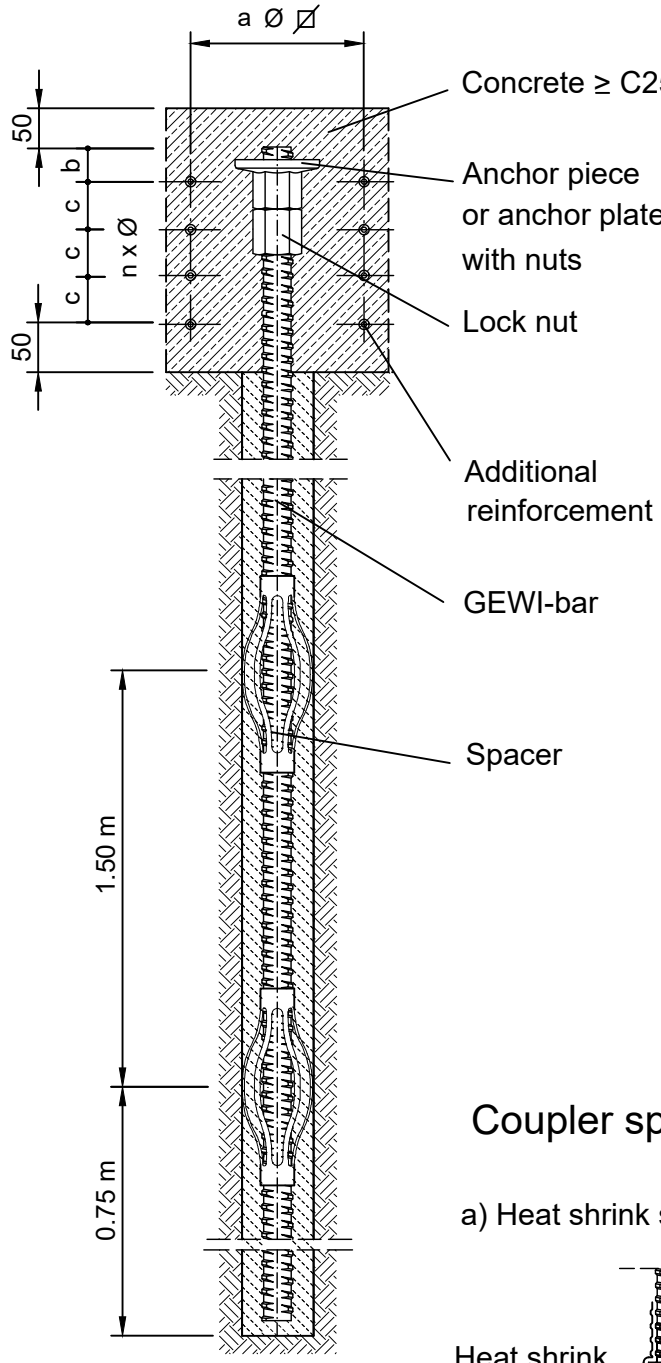
If special requirements are to be imposed on the structure with regard to deformations, re-inspections - deformation measurements - must be carried out after the soil nailing. The necessity for this can be established based on the type of structure and/or the in-situ soil, taking into account public safety and order. The decision regarding the necessity and the scope, the time intervals and the duration of the deformation measurements is to be made based on the design data in consultation with the commissioned expert in geotechnical engineering.

Bettina Hemme
Section Head

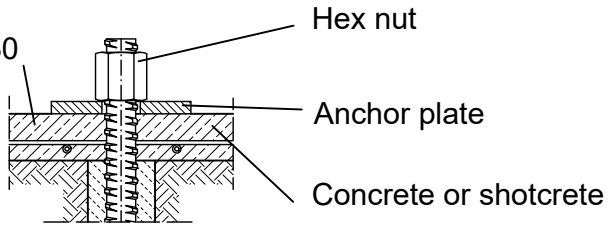
Certified
/signed W. Faller/

/Stamp mark:/
/Bear emblem/
Deutsches Institut
für Bautechnik
11

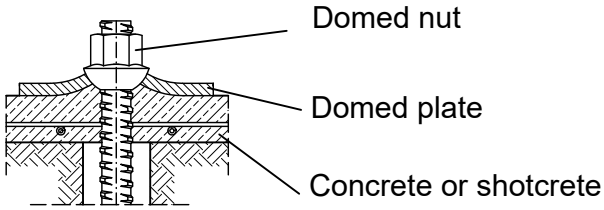
1 GEWI End anchorage



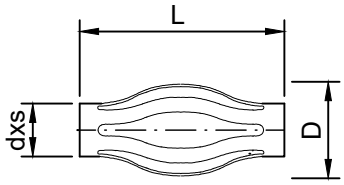
2 Plate anchorage



3 Domed plate anchorage

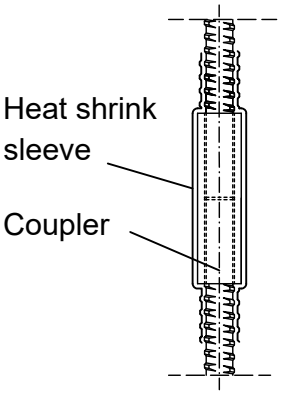


Spring basket spacer

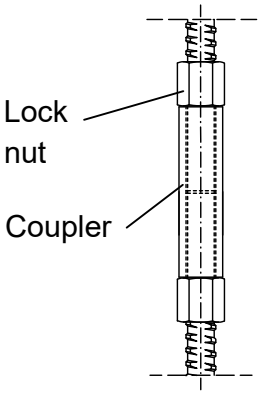


Coupler splice (with optional locking methods)

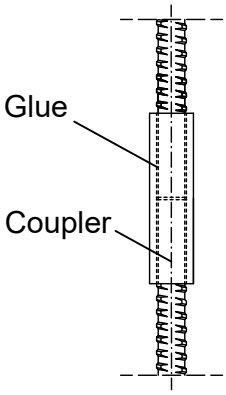
a) Heat shrink sleeve



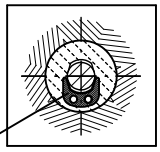
b) Lock nuts



c) Glue



Post-grouting system

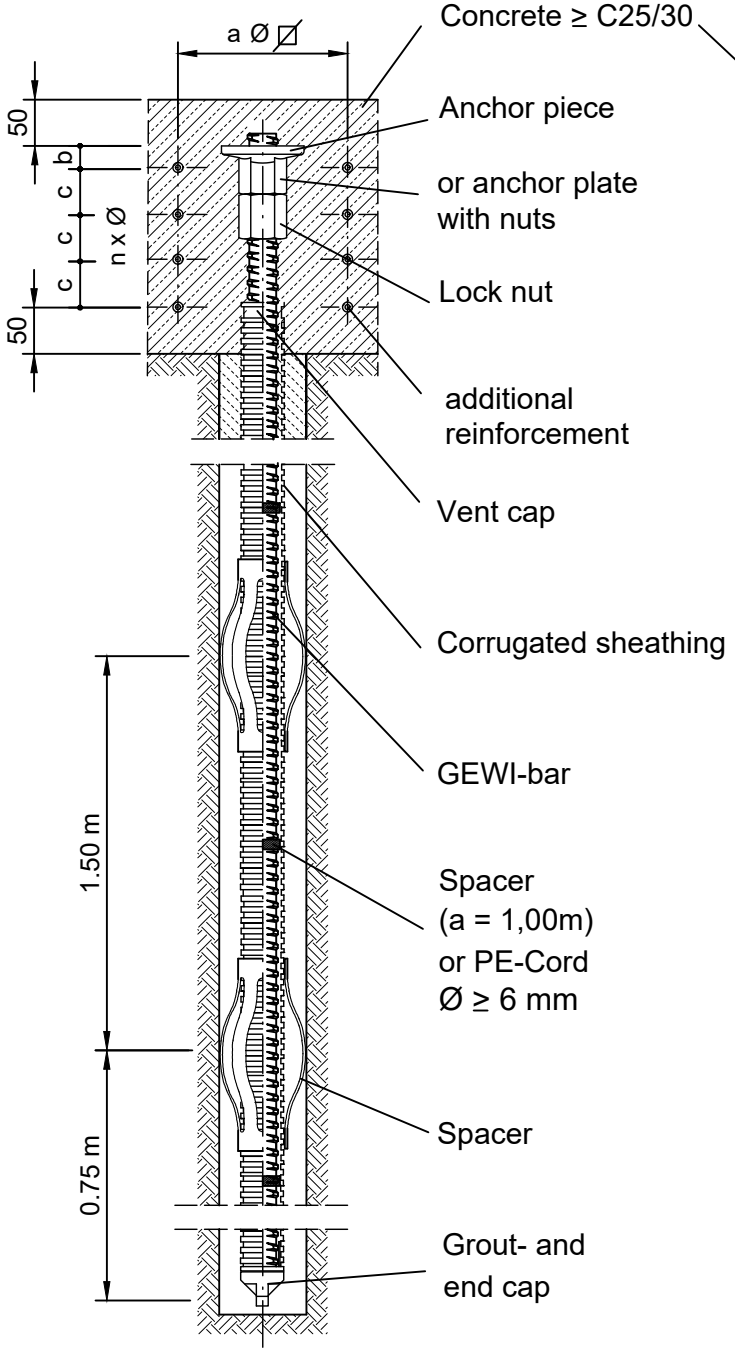


Post-grouting valve

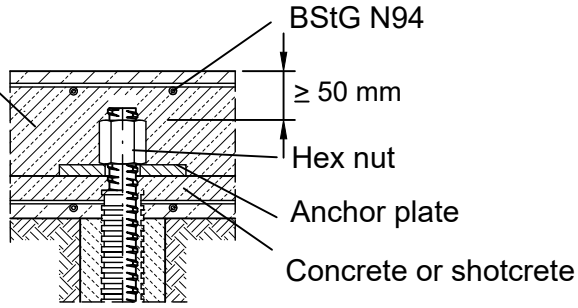
Applicability, references and dimensions acc. to annex 3

DYWIDAG Soil Nailing System	
System design Temporary soil nail	Annex 1

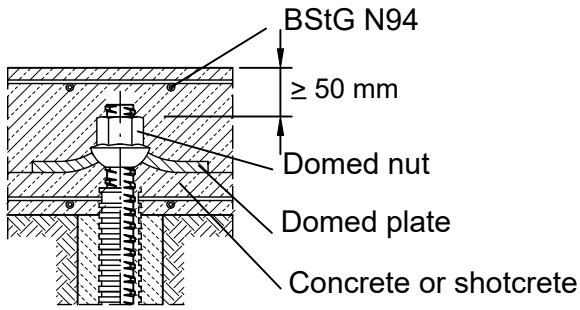
1 GEWI-End anchorage



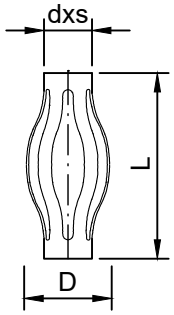
2 Plate anchorage



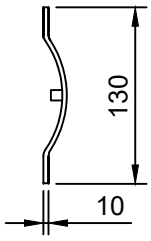
3 Domed plate anchorage



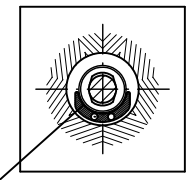
Spring basket spacer



Segment-spacer

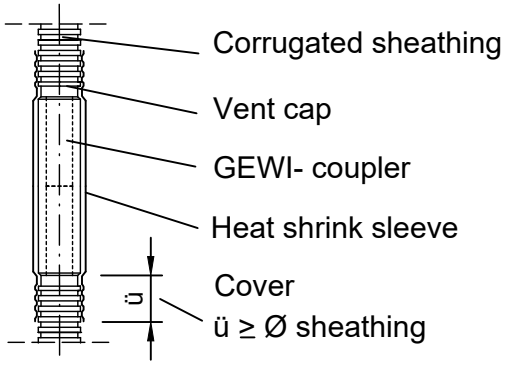


Post-grouting system



Post-grouting valve

Coupler splice



Applicability, references and dimensions acc. to annex 3

DYWIDAG Soil Nailing System	Annex 2
System design Permanent soil nail	

Temporary and Permanent Soil Nails

GEWI steel dia.	16	20	25	28	32	40	50	63.5
Steel grade	B500B							S 555/700
Anchorage								
1 Locked end anchorage	approval Z-1.5-76					approval Z-1.5-149		approval Z-1.5-2
2 Plate anchorage -Anchor nut	based on approval Z-1.5-76					approval Z-1.5-149		approval Z-1.5-2
-Anchor plate (min. dimensions) axa s	80x80 10	90x90 12	110x110 15	120x120 20	120x120 30	150x150 40	190x190 45	245x245 50
3 Domed plate anchorage	see Annex 4					---		---

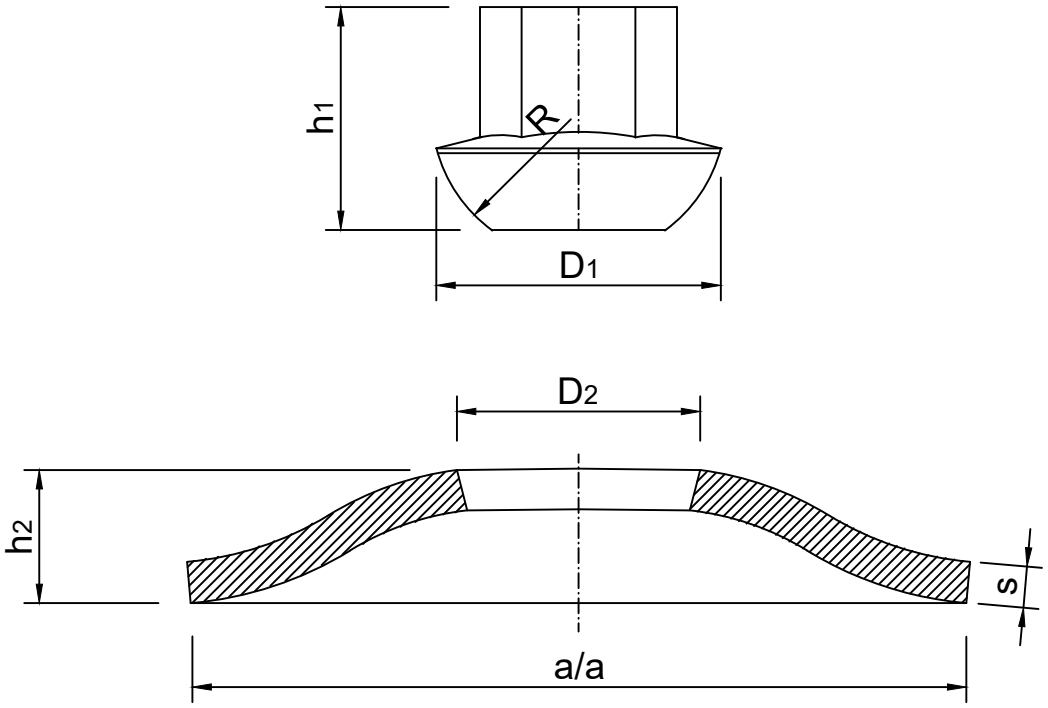
Temporary soil nails

Spring basket spacer dxs	20x1.5	25x1.9	32x2.4	40x3	48x3	63x3	75x3.6
L	210	225	235	280	285	285	285
min. dia.	65	70	80	100	100	125	125
Minimum borehole diameter	56	60	65	68 72	80	90	110
Coupler connection	Approval Z-1.5-76				Approval Z-1.5-149		Approval Z-1.5-2
Anti-rotation device (optional): -locked	Approval Z-1.5-76				Approval Z-1.5-149		Approval Z-1.5-2
- Shrink sleeve Type	Corrosion protection shrink sleeve CPSM						
max/min dia.	35/12	50/16	75/22	95/29	140/42		
- Gluing	Quick hardening glue or adhesive						

Permanent soil nails

Ribbed sheathing (PVC or PE) s	≥ 1mm						
min. dia.o/dia.i	34.5/28	42.5/35	50/44	56/49	65/57	80/71	100/91
Spacer	40x3	48x3	55x3	63x3	75x3.6	90x2.7	110x3.2
- Spring basket spacer dxs	280	285	275	285	285	285	285
L	100	100	125	125	125	140	175
min. dia.							
- Segment spacer L	---	---	---	130			
a	---	---	---	10			
Minimum borehole diameter	55	63	70	76	85	100	120
Coupler connection	Approval Z-1.5-76				Approval Z-1.5-149		Approval Z-1.5-2
Anti-rotation device - Shrink sleeve Type	Corrosion protection shrink sleeve CPSM						
max/min dia.	75/22		95/29				140/42

“DYWIDAG” Soil Nailing System	
Temporary and permanent soil nails References and dimensions	Annex 3



Domed nut:

Bar diameter	Ø	16	20	25	28	32
Hexagon	SW	27	32	37	41	46
Height	h_1	33	35	38	48	57
Spherical collar	D_1	35	49	55	62	70
Radius	R	19	25	28	32	36
Material (Material standard)		G 42 CrMo4 (DIN EN 10293)				

Domed plate:

Bar diameter	Ø	16	20	25	28	32
Dimensions *	a/a	120/120		150/150		200/200
Height	h_2	25	28	31	33	35
Plate thickness	s	5	8	10	10	12
Hole diameter	D_2	28	38	43	47	52
Material (Material standard)		S235JR (DIN EN 10025-2)				

* Minimum dimensions
All measurements in mm

DYWIDAG Soil Nailing System	Annex 4
Domed plate anchorage	

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