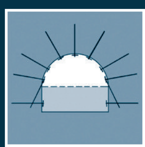


DYWIDAG

GEOTECHNICAL SYSTEMS

Soil Nailing System with DYWI Drill System Hollow Bars

Approval Number Z-34.13-208
Validity 14th August 2018 - 14th August 2023

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
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General Design-Type Approval

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Applicant:
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80796 München

Subject of approval:
Soil Nailing System with DYWIDrill System Hollow Bars

The above-mentioned subject matter is hereby granted general construction supervisory authority accreditation.
This notice comprises 13 pages and 2 annexes.

Important note
This general design-type approval 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.

I GENERAL PROVISIONS

1 This general design-type approval verifies the applicability or fitness for the intended purpose of the subject matter of approval within the meaning of the *Land* building codes ["*Landesbauordnungen*"].

2 This notice does not replace the permissions, approvals and certificates required by law for the realization of building projects.

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

4 Copies of this notice must be made available to the installer of the subject matter of approval without prejudice to more detailed provisions under "Special Provisions". In addition, it must be pointed out to the installer of the subject matter of approval that this notice must be available at the site of installation. Copies hereof must also be made available to the authorities involved on request.

5 This notice may only be reproduced in its entirety. A publication of excerpts is subject to the approval of DIBt. Texts and drawings included in promotional material may not contradict this notice, and translations must include the note "Translation of the German original version not verified by DIBt".

6 This notice is issued subject to revocation. The provisions herein can be subsequently amended or modified, especially if the latest technical findings give reason for this.

7 This notice refers to the information and documents provided by the applicant regarding the subject matter of approval during the approval proceedings. Any amendment of such information and documents is not covered by this notice and must be promptly disclosed to DIBt.

8 The general design-type approval covered by this notice is deemed to be a general construction supervisory authority approval of the design at the same time.

II SPECIAL PROVISIONS

1 Subject of approval, scope of application

1.1 Subject of approval

(1) Subject matter of this general design-type approval is the planning, design and installation of soil nails, consisting of DYWIDrill system steel tendons (hollow bars, nominal diameters of 32mm, 38mm and 51mm) with connections and anchorages according to the general construction supervisory authority approval No. Z-14.4-674 and a 20mm (or a minimum of 15mm in the area of the couplers) thick cement grout covering of the steel tendons, and an facing made from sprayed concrete or precast concrete parts.

(2) The hollow bars serve as drill rods when the boreholes are produced and are spliced with couplers to achieve the required soil nail length.

(3) The soil body must be nailed in the manner shown in Annex 1, 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.

1.2 Scope of application

1.2.1 Construction measures

The soil nailing system with DYWIDrill system hollow bars only applies to a preliminary (≤ 2 years) use and can be used to secure abrupt topographical changes, e.g. excavation and tieback walls, and stabilize load-bearing earth bodies with an arbitrary wall inclination for underpinning works.

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 sulfate 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 sulfate resistance (HS cement) as required by DIN 1164-10[5] is used.

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
	DIN 1054/A2:2015-11	Subsoil - Verification of the safety of earthworks and foundations - Supplementary rules to DIN EN 1997-1:2010; amendment 2015
4	DIN 4030-1:2008-06	Assessment of Waters, Soils and Gases attacking Concrete: Basics and Threshold Values
5	DIN 1164-10:2013-03	Special cement - Part 10: Composition, requirements and conformity evaluation for special common cement

2 Provisions for planning and design

2.1 Planning

2.1.1 Ground 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.

2.1.2 Soil nailing

(1) The maximum distance between the nails is 1.5m in the horizontal and vertical directions and may only be exceeded if spatial verification of the stability has been performed.
(2) The facing does not need to be tied in below the excavation pit bottom.

2.2 Design

2.2.1 General

(1) The technical building regulations, in particular, DIN EN 1997-1[1], DIN EN 1997-1/NA[2] and DIN 1054[3], apply to the planning and design of nailed supporting structures unless otherwise stated in the text below.
(2) Nailed supporting structures must at least be classified as geotechnical category GK 2. It must be verified based on DIN 1054[3], Section A9.1.3 A (4), whether criteria exist which require classification as geotechnical category GK 3.
(3) The verifications to be produced for the limit state of the load capacity, 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.
<u>Table 1:</u> Overview of load capacity verifications for nailed supporting structures

	Verification	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
Outer skin	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.				

2.2.2 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 2.2.6 of this notice).

2.2.3 Nail verification

Sufficient protection from material failure and extraction of a soil nail must be verified in accordance with DIN 1054[3].

2.2.3.1 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 surface protection 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[6] for the limit state GEO-3.

The greater value of the design load is decisive.

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

(1) The design action on the surface protection of the supporting structure must be determined, in the GEO-2 limit state, from the characteristic active earth pressure pursuant to DIN 1054[3] and DIN 4085[7], 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 transfer 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.

6 DIN 4084:2009-01 Subsoil - Calculations of terrain rupture and slope rupture
7 DIN 4085:2011-05 Subsoil - Calculation of earth-pressure

(2) 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:

$e_{ag,k}(z) = e_{ag,k} = E_{ag,k} \bullet \cos(\alpha) / h = \text{constant}$ (2.1)

with α = inclination angle of the wall (as defined by DIN 4085[7])

h = wall height

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

$\text{red } e_{ag,k} = 0.85 \bullet e_{ag,k}$ (2.2)

(4) The earth pressure from variable actions must be specified in accordance with DIN 40857 and may not be reduced. Thus, the resulting design load from earth pressure emerges as:

$e_{a,d}(z) = \text{red } e_{ag,k} \bullet \gamma_G + e_{ap,k}(z) \bullet \gamma_Q$ [kN/m²]

(2.3)

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

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

$E_{E,d} = e_{a,d} \bullet \Delta F$ [kN] (2.4)

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 surface protection can differ for nails in peripheral areas (e.g. top or bottom nail layer) from that of the remaining nails.

(6) The decisive design load $E_{E,d}$ for the load-bearing capacity verification according to Section 2.2.3.3 of this notice is the maximum from all nail forces thus determined.

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

(1) For the determination of the design load from the equilibrium of forces or moments, the safety against terrain rupture must be verified in accordance with DIN 4084[6], 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:

$F_{Ni,d} = T_{m,d} \bullet l_{r,i}$ [kN] (2.5)

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

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

(3) 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:

$E_{N.d} = T_{m,d} \bullet l_{r,max}$ [kN] (2.6)

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

(4) 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 surface protection 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 surface protection allocated to the nail. This is often decisive especially at the lowest nail layers.

2.2.3.2 Design resistance of nails

2.2.3.2.1 Extraction resistance $R_{A,d}$

(1) The length-related characteristic extraction resistance of a soil nail $T_{Pm,k}$ must be determined by in-situ extraction tests (tests as defined in Section 3.7 hereof). The design value of the length-related extraction resistance $T_{Pm,d}$ emerges from the characteristic value as:

$T_{Pm,d} = T_{Pm,k} / \gamma_a$ [kN/m] (2.7)

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

(2) The design value for the greatest extraction resistance of an individual nail then emerges as:

$R_{A,d} = T_{Pm,d} \bullet l_{r,max}$ [kN] (2.8)

(3) 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, $T_{Pm,d}$ is to be reduced by 50%.

2.2.3.2.2 Material resistance $R_{B,d}$

(1) The characteristic axial tensile resistance $R_{B,k}$ of the soil nail for predominantly static loads is determined as:

$R_{B,k} = F_{0.2,k}$ (2.9)

with $F_{0.2,k}$ dependent on the hollow bar type according to approval No. Z-14.1-674

(2) The design value of the material resistance then emerges as:

$R_{B,d} - R_{B,k} / \gamma_M$ [kN] (2.10)

with γ_M =1.15

(3) In the case of predominantly non-static loads, fatigue verification in accordance with approval No. Z-14.1-674, Section 3.3.2, must be performed.

2.2.3.3 Verification of the load-bearing capacity of the nails

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

(a) extraction resistance (ground resistance),

(b) material resistance (component resistance).

It must be verified:

$$R_{A,d} \text{ and/or } R_{B,d} \geq \max \begin{cases} E_{E,d} \\ E_{N,d} \end{cases} \quad (2.11)$$

2.2.4 Surface protection verification (facing)

(1) The facing must be designed in accordance with DIN EN 1992-1-1[8] in conjunction with DIN EN 1992-1-1/NA[9]. 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[8] in conjunction with DIN EN 1992-1-1/NA[9].

(2) The decisive design load emerges, analogue to Section 2.2.3.1 of this notice, either from earth pressure or from the deficit of the equilibrium of forces and/or moments.

2.2.5 Deformations

(1) 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[6], 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.

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.

(2) In addition, the following safe deformation values must be taken into account at the sites of coupling or end anchorages.

- a slip of 0.5mm per site of coupling or end anchorage,
- indentation of the domed plate of 5mm.

2.2.6 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 twisting of the supporting structure, the conditions regarding the location of the bearing pressure resultants must be observed in accordance with DIN 1054[3] Sections A 6.6.5 A (2) and A (3).

3 Provisions for the installation

3.1 General

(1) The delivery note for the nail components must indicate for which soil nails the parts are intended. Only components for one soil nail type to be specified may be delivered on one delivery note.

(2) The provisions of approval No. Z-14.4-674, Section 3.4, regarding the installation must be observed.

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

(4) 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 installation of the soil nailing system in accordance with this general design-type approval.

(5) Spacers must be mounted on the steel tendon in the area of every coupler. The maximum distance between two spacers may not exceed 3m (see Annex 1).

3.2 Drilling

(1) The boreholes are drilled without casing with a sacrificial drill bit, which is screwed onto the steel tendon (see also Annex 1). The minimum borehole diameter depends on the diameter of the steel tendon selected plus a 20mm thick cement grout covering; the boreholes must be drilled with a minimum inclination of 10° to the horizontal. The values for impact energy and torques recommended by the applicant for the installation must be taken from Annex 2.

(2) A water/cement suspension with a water/cement ratio of 0.5 to 0.7 is to be used as the flushing and supporting liquid. The water/cement suspension must be fed into the borehole through the steel tendon (steel pipe). During drilling, the flushing and supporting liquid must exit at the borehole mouth.

(3) If the target depth has been reached, please proceed as stipulated in Section 3.3.3.

8	DIN EN 1992-1-1:2011-01	Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004 + AC:2010
9	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

3.3 Cement grout for injecting boreholes

3.3.1 Composition

The basic materials for the cement grout are cements with particular properties in accordance with DIN 1164-10[5] and cements in line with DIN EN 197-1[10], taking into consideration the present exposition class as defined by DIN EN 206-1[11] in conjunction with DIN 1045-2[12] (Tables 1, F.3.1 and F.3.2), water as stipulated by DIN EN 1008[13] and, where required, additives in accordance with DIN EN 934-2[14] in conjunction with DIN EN 206-1[11]/DIN 1045-2[12] or subject to a general construction supervisory authority approval, and natural aggregates for concrete in compliance with DIN EN 12620[15], taking into account DIN EN 206-1[11]/DIN 1045-2[12].

(2) The water/cement ratio must be between 0.35 and 0.50 and should be chosen as low as possible especially in cohesive soil.

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

3.3.2 Compressive strength

(1) 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.

(2) For the verification of the compressive strength, tests according to DIN EN 12390-3[16] 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.

After the target depth has been reached, injection with cement grout as per Sections 3.3.1 and 3.3.2 must be performed through the hollow bars/drill bit until the grout replaces the supporting liquid from the earth-side end and exits at the borehole mouth.

10	DIN EN 197-1:2011-11	Cement - Part 1: Composition, specifications and conformity criteria for common cements; German version EN 197-1:2011
11	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
12	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
13	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
14	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
15	DIN EN 12620:2008-07	Aggregates for concrete; German version EN 12620:2002+A1:2008
16	DIN EN 12390-3:2009-07	Testing hardened concrete - Part 3: Compressive strength of test specimens German version EN 12390-3:2009

3.3.3 Injecting the boreholes

After the target depth has been reached, injection with cement grout as per Sections 3.3.1 and 3.3.2 must be performed through the hollow bars/drill bit until the grout replaces the supporting liquid from the earth-side end and exits at the borehole mouth.

3.4 Facing

(1) Lined excavated areas must be protected by the facing 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.
(2) 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[17] and DIN 18551[18] apply to the installation and verification.
(3) An adequate drainage must be provided so that water pressure does not build up behind the facing.

3.5 Anchoring soil nails on the facing

(1) The steel tendons must be anchored by steel nuts or domed nuts and related bearing plates according to approval No. Z-14.4-674, Annexes 6 and 8, perpendicular to their axis in each direction. For this purpose, the anchor plates must be laid in fresh sprayed concrete or in a mortar bed perpendicular to the tendon. If there are minor drilling or other construction deviations due to the construction progress, domed nuts with related bearing plates must be used.
(2) 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.

3.6 Splice

The distance between required joints must be at least 1m; the stipulations of approval No. Z-14.4-674 must be observed for the formation of mechanical splices.

3.7 Tests

3.7.1 Load tests

(1) The mathematical design action assumed in the statics 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.
(2) For the load tests, a tensile force is to be applied to the nail head in steps of 20kN up to the maximum test load $P_{P,}$ the 1.40 times design value of the nail load. If, in this process, the force within the hollow bars intended for the nailed soil body exceeds the value of 0.8 $F_{t,k}$ or 0.95 $F_{0.2,k}$ ($F_{t,k}$ or $F_{0.2,k}$ see approval No. Z-14.4-674), then nails of a higher load-bearing capacity, but with the same bonding properties with regard to the soil must be used. 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.

	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
17	DIN EN 14487-1:2006-03	Sprayed concrete - Part 1: Definitions, specifications and conformity; German version EN 14487-1:2005
18	DIN 18551:2010-02	Sprayed concrete - National application rules for series DIN EN 14487 and rules for design of sprayed concrete constructions

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.

(3) The test may only be carried out on nails from a limit depth of $t_g \geq 2.0$m. 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.

(4) Due to the surface friction along the bonding section $l_{v,i}$ (cf. Section 2.2.3), which is assumed to be equally distributed, the mean characteristic axial nail force per lineal meter $T_{Pm,i}$ can be calculated from the maximum test load $P_{max,i}$ achieved in test i.

$$T_{Pm,i} = \frac{P_{max,i}}{l_{V,i}} \qquad [kN/m] \qquad (3.1)$$

(5) 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:

$$T_{Pm,k} = MIN\left(\frac{(T_{Pm,i})_{mitt}}{\xi_1}; \frac{(T_{Pm,i})_{min}}{\xi_2}\right) \qquad [kN/m] \qquad (3.2)$$

(6) 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					

3.7.2 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.

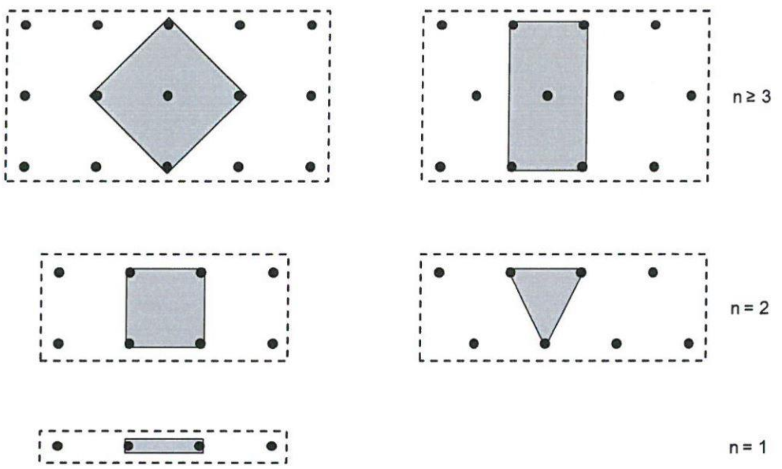

Fig. 1: Arrangement of the test field and minimum number of the nails to be tested in the case of group loads dependent on the number of nail rows n

3.8 Contractor's declaration of conformity

(1) The compliance of the soil nailing system with DYWIDrill system hollow bars with the provisions of this general design-type approval must be confirmed for every installation by means of a declaration of conformity in accordance with Section 16a(5) MBO[19] issued by the contractor.

(2) The contractor's declaration of conformity must at least contain the following information:

- notice number,
- 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.

(3) The declaration of conformity must be handed over to the client for incorporation into the construction file and presented to DIBt and to the highest construction supervisory authority on request.

4 Provisions for usage, support and maintenance

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.

[19] Version of November 2002, last amended by the resolution adopted by the conference of the ministers of construction of 05/13/2016

Bettina Hemme
Section Head

Certified

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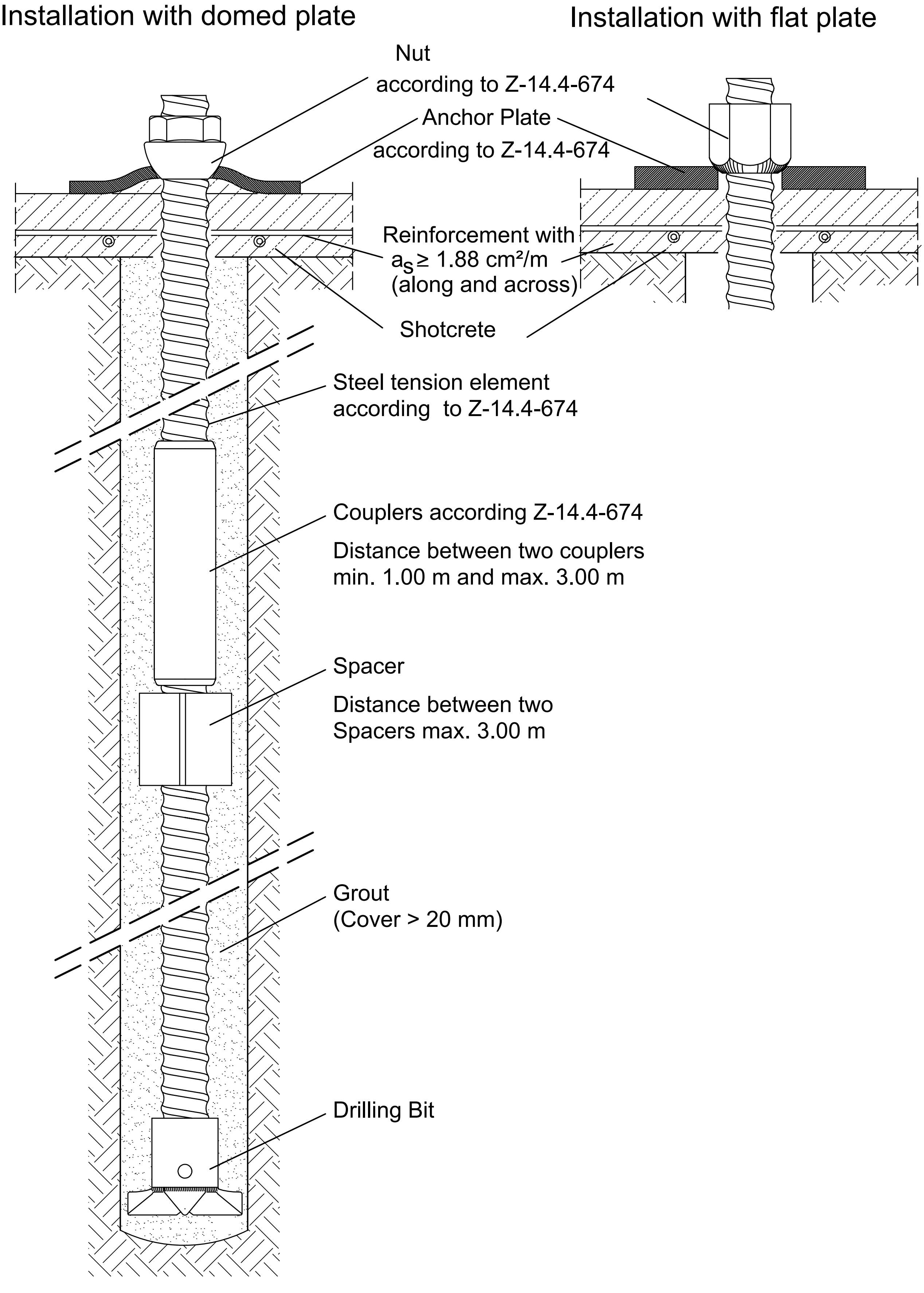
/Bear emblem/
Deutsches Institut
für Bautechnik
11



Soil nailing
with hollow bars System DYWIDrill

System representation of temporary soil nails

Annex 1

Recommended impact energy and torsional moment for installation

Range	Parameter		Type					
			R32-210	R32-250	R32-280	R32-320	R32-360	R32-400
$\frac{E_{S,max}}{2}$	E_S	Joule	70	80	90	110	120	140
	M_t	Nm	440	480	520	570	600	620
$\frac{M_{t,max}}{2}$	E_S	Joule	110	120	140	160	180	200
	M_t	Nm	320	340	370	410	430	450

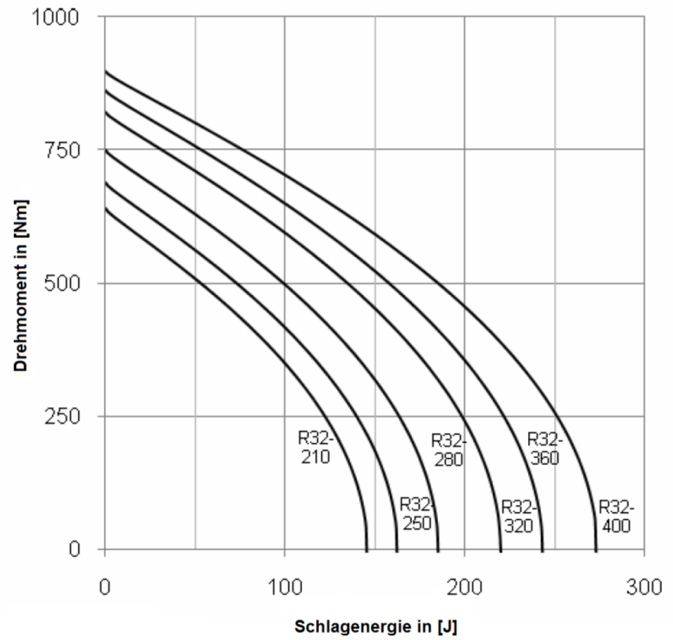
E_S = impact energy M_t = torsional moment

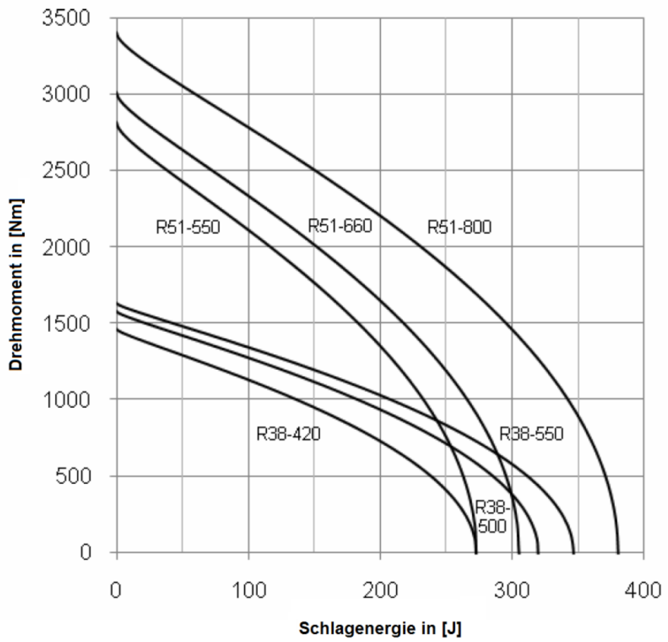
Range	Parameter		Type					
			R38-420	R38-500	R38-550	R51-550	R51-660	R51-800
$\frac{E_{S,max}}{2}$	E_S	Joule	140	160	170	140	150	190
	M_t	Nm	1000	1080	1120	1860	2000	2270
$\frac{M_{t,max}}{2}$	E_S	Joule	200	230	250	190	220	270
	M_t	Nm	730	790	810	1400	1500	1700

E_S = impact energy M_t = torsional moment

The two pair of values always applies to the installation together.

On the other side of these pair of values, the impact energy and the torsional moment may be gathered from the following tables.





Soil nailing with hollow bars System DYWIDrill	Annex 2
Recommended impact energy and full load for the installation	

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