General Construction Supervisory Authority Approval/ General Design-Type Approval

Deutsches Institut für Bautechnik

A statutory body jointly sponsored by the German national government and the German federal states

Approval Body for Construction Products and Construction Methods

Date:	Reference No.:
October 2022	I 64-1.34.11-8/21

Approval number:

Z-20.1-53

Period of validity

from: 24 April 2022

to: 24 April 2027

Applicant:

DYWIDAG-Systems International GmbH
Neuhofweg 5
85716 Unterschleiflheim

Subject of Approval:

SUSPA-Rock Anchors

The above mentioned subject of the regulation is hereby generally approved/accepted by the construction authorities.
This Approval consists of 16 pages and three Annexes.

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

I GENERAL PROVISIONS

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7 This Approval refers to the information made available and documents provided by the applicant on the subject of approval. Any change to these materials is not covered by this Approval and must be immediately reported to the German Institute for Building Technology.

II SPECIAL PROVISIONS

1 Subject of the regulation and scope of use or application

1.1 Subject of approval and scope of use

(1) The subject of the Approval are the “SUSPA Rock Anchors” from DYWIDAG Systems International GmbH, consisting of:

- Steel tendons made of 2–22 prestressing strands according to the general construction supervisory authority approval,

– steel anchor heads according to the general construction supervisory authority approval,

– plastic or steel protection caps,

– anchor plates and steel tubes,

– other components of the corrosion protection system consist of plastic sheathing, corrosion protection compounds and inner cement grout.

(2) “SUSPA Rock Anchors” can be used for permanent installation. For this purpose, they must be protected with a corrosion protection system (Annex 1). The corrosion protection system is to be applied over the entire or part of the item at the plant.

(3) “SUSPA Rock Anchors” may be used as per DIN EN 1537 in conjunction with DIN/TS 18537

1.2 Subject of approval and scope of use

(1) The subject of approval are the planning, design and installation of ground anchors according to DIN EN 1537 in conjunction with DIN/TS 18537.

(2) The ground anchors are to be manufactured in accordance with Annex 1 with “SUSPA Rock Anchors” and cement grout.

(3) The ground anchors may be used as permanent anchors with predominantly static loads.

2 Provisions for the construction product

2.1 Properties and composition

In the area of the free steel length L_{tf} and the anchoring length L_{tb} the following corrosion protection system must be arranged and optionally provided by the plant:

– free steel length L_{tf}:
  Plastic sheathing around each individual strand, filled with corrosion protection compound at the factory; entire strand bundle inside a corrugated plastic duct to be injected with inner cement grout in the borehole.
– anchoring length L_{tb}:
  Corrugated plastic sheating, filled with inner cement grout either at the factory or in the borehole (only in case of descending anchors)

2.1.1 Steel tendon

(1) Only general construction supervisory authority approved prestressing steel according to Table 1, consisting of seven cold-drawn, smooth individual wires, may be used as material for the steel tendon.

Table 1: Steel tendon

Prestressing strand type	Steel grade	Diameter	Nominal cross-section
0.6" steel strands	St 1570/1770	15.3 mm	140 mm²
	St 1660/1860		
0.62" steel strands	St 1570/1770	15.7 mm	150 mm²
	St 1660/1860		

(2) Only 2–22 prestressing strands are to be used within a steel tendon as wire strand bundles and only prestressing strands of the same nominal diameter and steel grade.

2.1.2 Anchor head

(1) The steel prestressing strands must be anchored using two-part wedges (round wedges) in the wedge plate according to the general construction supervisory authority approval No. Z-13.8-152.

(2) The wedge plate must have a thread for verification purposes and/or regulation of load, by which the whole wedge plate can be lifted off without releasing the wedges. In addition, the wedge plate is to be marked on the surface located on the top with the inscription “St 1860” when using the strands made of St 1660/1860 grade steel. Wedge plates in which strands with a steel grade St 1570/1770 are anchored, have no markings.

2.1.3 Protection caps, anchor plate, steel tube and corrosion protection coating

2.1.3.1 Protection caps

(1) The internal protection cap with dimensions according to Annex 2 must be made of polyethylene. The sealing of the internal protection cap from the wedge plate / anchor plate should be manufactured with a sealing consisting of Denso binder tape.

(2) The external protection cap with dimensions according to Annex 2 must be made of steel (S235JR) or stainless steel (material no. 1.4301, 1.4541 or 1.4571) and must be sealed against the anchor plate with a sealing washer.

2.1.3.2 Anchor plate and steel tube

(1) Anchor plates must correspond to the provisions of the Approval Z-13.8-152 (load transfer elements).

(2) The steel tube must be made of steel (S235JR) and have dimensions conforming to the number of strands according to Annex 2. At the open-air end they should be connected to the anchor plate, at the earth side they overlap with the corrugated sheathing. A sealing consisting of two sealing rings (polychloroprene, closed cell) should be arranged over the overlapping length.

2.1.3.3 Corrosion protection coating

(1) If not cast completely in concrete, the anchor plate must be provided with a corrosion protection system as defined by DIN EN ISO 12944-5 depending on the determined corrosivity category of the environment and with the protection period “very high (VH)”. The surface must be prepared as specified by DIN EN ISO 12944-4. DIN EN ISO 12944-7 must be observed for the execution of the coating work.

(2) The exposed surfaces of the steel tube and of the outer steel protection cap must also be provided with one of the corrosion protection systems mentioned under item (1). Corrosion protection for these parts may be omitted if they have a wall thickness≥ of ≥6.0 mm or are cast in concrete.

(3) Alternatively, the anchor plate and exposed surfaces or surfaces of steel parts not sufficiently covered with concrete, e.g. steel tube and steel protection cap, where the environment corrosivity category is between C1 and C4 inclusive, must be provided with corrosion protection using hot-dip zinc coating according to DIN EN 14713-1 depending on the determined corrosivity category of the environment with the protection period "very high (VH)". Surfaces must be prepared and treated as prescribed by DIN EN ISO 1461. DASt Guideline 022[1] must be observed.

2.1.4 Corrosion protection system components

2.1.4.1 Corrugated sheathing

(1) The coating of the free steel length or the anchoring length is made in the form of plastic sheathing with a molding compound made either of PVC-U as per DIN EN ISO 21306-1, polyethylene with molding compound as per ISO 17855-PE-HD, E, 44-T022 as per DIN EN ISO 17855-1 or of polypropylene with molding compounds ISO 19069-PP-B, EAGC, 10-16-003 or ISO 19069-PP-H, E, 06-35-012/022 as per DIN EN ISO 19069-1. The sheathing must not contain bubbles and pigment distribution must be even.

(2) The basic dimensions of the corrugated plastic sheathing must correspond to the data provided in Annexes 1 to 2; the minimum wall thickness is specified in DIN EN 1537, Section 6.5.1.4.

(3) In the area of the anchoring length L_{tb}, internal plastic spacers as per Annex 1 are to be arranged to spread the strand bundle. To ensure a ring space of ≥5 mm between the corrugated plastic sheathing and the strand bundle in the area of the anchoring length L_{tb}, a continuous PE-cord (Ø6 mm for 2–12 strands or Ø7 mm for 13–22 strands) must be arranged with a pitch of 0.25 m as an internal spacer.

(4) For sheathing of a single strand and the free steel length L_{tf} at the Applicant's plant, empty pipes made of polyethylene with the above mentioned molding compound Ø19.2 × 1.25 mm (for strands Ø15.3 mm / 0.6") or Ø19.7 × 1.25 mm (for strands Ø15.7 mm / 0.62" should be used.

(5) For end and injection caps, PE caps with a wall thickness ≥1 mm should be used.

2.1.4.2 Heat shrink sleeves

(1) Corrosion protection heat shrink sleeves or fixing heat shrink sleeves should be used as heat shrink sleeves.

(2) Use corrosion protection shrink sleeves as per DIN EN 12068 with the classification Coating EN 12068-C30 (e.g. SATM, CPSM) of radiation-crosslinked polyethylene, which is lined on the inside with a butyl rubber based adhesive with corrosion inhibitors; the amount of adhesive must be at least 700 g/m^2.

(3) Fixing heat shrink sleeves (e.g. CFM, MSTM, MWTM or MOK) are made of polyethylene; the sealing adhesive mass must be a hot melt adhesive.

(4) The heat shrink sleeves are to be shrunk with hot air, infrared radiation or a soft flame of a gas burner; the wall thickness in the shrunken state must be ≥1.5 mm.

2.1.4.3 Corrosion protection compounds

In the area of the free steel length, the void between the strands and the PE sheathings must be filled with Nontribos MP-2 at the Applicant's plant.

2.1.4.4 Inner cement grout

Inner cement grout as per DIN EN 447 should be used. In addition, DIN EN 445 and DIN EN 446 must be observed.

1 DASt Guideline 022:2016-06 Guideline for hot-dip-zinc-coating of prefabricated structural steel components; Deutscher Ausschuss für Stahlbau DASt, Sohnstr. 65, 40237 Düsseldorf

2.2 Production, packaging, storage, transport and marking

2.2.1 Production and corrosion protection of the prefabricated SUSPA rock anchors for installation and grouting

(1) The following works should be carried out at the plant.

(2) The “SUSPA Rock Anchors” are assembled and the corrosion protection system is applied in accordance with the work instructions submitted to the German Institute for Building Technology. Prior to its installation, the prestressing steel must be treated in accordance with the approval provisions for prestressing steel. The prestressing steel must be clean and free of damaging rust. Prestressing steels with a slight rust film may be used. The term “slight rust film” is defined as the uniform initial phase of rust formation which has not yet led to the formation of corrosion pits visible to the naked eye and which in general may be removed by wiping with a dry rag.

2.2.1.1 Prefabrication of the corrosion protection system in the free steel length L_{tf} and the anchoring length L_{tb}

(1) In the area of the free steel length L_{tf}, each individual strand of the strand bundle must be provided with a PE sheathing or a PE single sheathing and plastic corrosion protection compound (single strand); see Annexes 1 and 2. Alternatively, the following methods may be used:

- Prestressing strands that received general construction supervision authority and have a corrosion protection system applied at the prestressing strand manufacturing plant, consisting of corrosion protection compound and PE sheathing, should be used. In the area of the planned anchoring length, the PE sheathing of the strands extruded at the steel plant must be removed; the corrosion protection compound should be washed off with water at approx. 90°C and under a pressure of 70 to 80 bar.
- The free steel length section of the strands is encased in PE sheathings at the Applicant’s plant according to Section 2.1.4.1 (4), with the void between the strand and the sheathing being completely filled with Nontribos MP-2 corrosion inhibitor. The amount of the corrosion protection compound applied per 1 m of length should be at least 42 g/m on average and must not be less than 25 g/m. At the transition point of the free steel length L_{tf} to the anchorage length L_{tb} of the tendon, the ends of the PE-sheathing must be sealed tightly. At the end of the excess tendon L_e, PE-sheathings must be closed with plastic caps and taped with adhesive tape.

(2) As plastic sheathing of the entire strand bundle, corrugated sheathings as per Section 2.1.4.1 are to be used. Individual sections of PVC-U sheathings should be screwed together and glued with a PVC adhesive. As PE or PP sheathing, continuous pipes should be used. It is important to ensure that only straight pipe sections are used.

(3) In the area of the anchoring length L_{tb}, strands are to be spread with spacers according to the data in Annex 1 and bundled together with steel stripes. The strand bundle should we wrapped with a continuous PE-cord as per Section 2.1.4.1 (3) as an internal spacer.

(4) The strand bundle must be grouted over the entire anchor length in a corrugated plastic sheathing. In the case of descending anchors, the grout tube must also be arranged within the strand bundle in case of internal grouting of the corrugated plastic sheathing with inner cement grout in the borehole throughout the entire anchor length in the area of the free steel length.
For horizontal and ascending anchors, the internal grouting of the corrugated plastic sheathing with inner cement grout at the area of the anchoring length is made exclusively at the plant.

(5) The anchor foot side end of the corrugated plastic sheathing at the anchoring length L_{tb} must be closed with an end or injection cap as per Section 2.1.4.1 (5) and additionally sealed with a corrosion protection heat shrink sleeve as per Section 2.1.4.2. The overlap of the cap on the sheathing must be a minimum of 85 mm. The heat shrink sleeve overlaps the end cap and the sheathing by the same length in each case.

(6) The void in the area of the anchoring length between the corrugated plastic sheathing and the strand bundle must be filled with inner cement grout either at the plant or in the borehole according to Section 2.1.4.4. In both cases, the inner cement grout must be injected with an injection speed of no more than 5 m/min. If injected at the plant, the anchors in the area of the bond length must be stored in an inclined manner for this purpose and injected with inner cement grout from the bottom end cap in the upward direction. The grout must be injected until the inner cement grout exits without bubbles from the ventilation opening in the plastic corrugated sheathing. The ventilation opening should be located approx. 300 mm behind the transition point between the free steel length and anchorage length towards the anchor head, so that the ends of PE sheaths of the single strand are covered with grout. Upon completion of grouting, the ventilation opening must be sealed with corrosion protection heat shrink sleeve as per Section 2.1.4.2 and the filling opening of the end or injection cap must be closed with a glued end cap.

2.2.1.2 Prefabrication and corrosion protection of the anchor head

The design of the anchor head is depicted in Annex 2. The following prefabrication measures must be taken at the factory for the anchor head construction:

- Anchor plate and steel tube as per Section 2.1.3.2 should be welded together in a continuous manner. Anchor plates welding contractors must have a welding certificate for the execution class EXC 1 as required by DIN EN 1090-1.
- After their connection, the steel tube (inside and outside) and exposed anchor plates must be provided with a coating according to Section 2.1.3.3.
- If the external protection cap is made of stainless steel as per Approval Z-30.3-6 with the material numbers 1.4301, 1.4541 or 1.4571 (see also Annex 3 and 4), there is no need to apply the corrosion protection system. Steel is classified as per Approval Z-30.3-6, Annex 1 – Table 1 into corrosion resistance classes (CRC) II (material no. 1.4301 and 1.4541) or III (material no. 1.4571). The specifications and provisions made in Approval Z-30.3-6, in particular Section 2.1.6 and Section 4 must be observed.

2.2.2 Transport and storage

(1) The effectiveness of the “SUSPA Rock Anchors” corrosion protection depends on the integrity of the corrosion protection system. Therefore during the storage, transport and installation of prefabricated “SUSPA Rock Anchors”, care must be taken to ensure that the corrosion protection system, in particular the corrugated plastic sheathing, is not damaged through improper handling.

(2) Depending on the temperature, “SUSPA Rock Anchors” may be removed from the assembly bench at the earliest one day after grouting with inner cement grout at the plant. Further transport and installation is allowed not earlier than 3 days after injection with inner cement grout at the plant. The anchors may be installed at a time when the inner cement grout has not yet fully hardened.

(3) The prefabricated “SUSPA Rock Anchors” may not be stored on the ground; avoid especially contamination and soiling of the corrugated pipes. If the prefabricated “SUSPA Rock Anchors” are supported at intervals only, the support points may not be sharp-edged, but must be flat. If the prefabricated “SUSPA Rock Anchors” are stacked, they must lie on top of each other in a parallel manner. If supported at intervals by square timber or adequate spacers, then the weight of the anchors on top may only be carried via the timber or spacers.

(4) Under no circumstances may the “SUSPA Rock Anchors” be thrown or dropped. They must be transported in such a manner (e.g. by hand on the shoulders or by means of carrying straps) that especially the corrugated sheathing will not be damaged. If transported by a crane hook, the anchor must be carried at its stressing end or with carrying straps or placed in ducts.

(5) The prefabricated “SUSPA Rock Anchors” may also be transported wound up in coils and inserted into the borehole from the coil, with the factory grouted bond length tangentially protruding from the coil. During installation and transport of the anchors, the following minimum bending radii R must be observed:

min R = 0.90 m (permanent anchors consisting of 2 to 9 strands),

min R = 1.00 m (permanent anchors consisting of 10 to 12 strands)

min R = 1.25 m (permanent anchors consisting of 13 to 22 strands)

The work instructions submitted to the German Institute for Building Technology must be observed.

2.2.3 Marking

(1) The prefabricated or prepackaged “SUSPA Rock Anchors” and the delivery note thereof must be marked by the manufacturer with the mark of conformity in accordance with the national conformity mark regulations. Such marking is allowed only if the requirements as per Section 2.3 are met.

(2) In particular, the delivery note must include the use for which the “SUSPA Rock Anchors” are intended and the plant in which they were manufactured. One delivery note should only list components for one installation version; the assignment of the “SUSPA Rock Anchors” components must clearly result from the delivery note.

2.3 Conformity confirmation

2.3.1 General

The confirmation of conformity of the anchor components and the SUSPA Rock Anchors prefabricated for installation and grouting with the provisions of the general technical approval covered by the Approval must be provided for each manufacturing plant with a declaration of conformity from the manufacturer based on a plant production control and a certificate of conformity from a recognized certification body and regular external monitoring by a recognized monitoring body in accordance with the following provisions:

Issuing a certificate of conformity and monitoring, including the product tests to be carried out, require from the manufacturer of the anchor components and the prefabricated “SUSPA Rock Anchors” to engage a recognized certification body and a recognized monitoring body.

The manufacturer submits the declaration of conformity by marking the construction products with a conformity mark with reference to the intended use.

The certification body must provide the German Institute for Building Technology with a copy of the certificate of conformity they have issued.

Additionally, a copy of the initial test report must be submitted to the German Institute for Building Technology.

2.3.2 Plant production control

(1) In every manufacturing plant, a plant production control must be set up and carried out. The plant production control is understood as a continuous monitoring of production carried out by the manufacturer, by means of which the manufacturer ensures that the construction products they manufacture meet the provisions of the general construction supervisory authority approval granted under this Approval.

(2) The plant production control shall include at least the measures listed in Annex 3 regarding the incoming goods control and the control during manufacturing.

(5) The results of the plant production control must be recorded and assessed. Such records must contain at least the following information:

– designation of the construction product or the initial material and its components;–

nature of the control or inspection;

– date of manufacturing and inspection of the construction product or the initial material or its components;

– results of the controls and inspections and, if applicable, a comparison with the relevant requirements;

– signature of the person responsible for the plant production control.

(6) The records must be kept for at least five years and presented to the monitoring body responsible for external monitoring. They must be presented to the German Institute for Building Technology and to the competent highest construction supervisory authority on request.

(7) If the inspection result is unsatisfactory, the manufacturer must immediately take the necessary measures to remove the defect. Construction products that do not met the requirements must be handled in such a way so as to exclude confusion with the conforming ones. When the defect is removed, the respective inspection must be repeated immediately – insofar as it is technically possible and necessary to prove that the defect has been removed.

2.3.3 External monitoring

(1) At every manufacturing plant, the plant itself and the plant production control must be controlled through external monitoring on a regular basis, in any case at least twice a year.

(2) Within the external monitoring, an initial test in accordance with Annex 3 must be carried out. Samples are to be taken for spot checks and also the testing tools are to be controlled. The sampling and inspections are the responsibility of the recognized monitoring body.

(3) The results of the certification and external monitoring must be retained for at least five years. They must be presented by the certification body or the monitoring body to the German Institute for Building Technology and to the competent highest construction supervisory authority on request.

3 Provisions for planning, design and installation

3.1 General

(1) The ground anchors must be planned, designed and executed in accordance with technical building specifications, unless otherwise specified below.

(2) For the planning, execution and inspections (suitability and acceptance tests) of ground anchors, the specifications in DIN EN 1537 in conjunction with DIN/TS 18537 must be observed. Dimensioning is based on DIN EN 1997-1 in conjunction with DIN EN 1997-1/NA and DIN 1054, unless otherwise specified below.

(3) The application is limited to the cases where the total load transfer length of the anchor is in rock (see DIN EN 1997-1 in conjunction with DIN EN 1997-1/NA and DIN 1054). Any deviating cases may only be carried out upon the consent of geotechnical experts.

(4) The requirements for the subsoil investigations are covered by DIN EN 1537, Section 5.

(5) The execution planning documentation must include the information resulting from the planning regarding the implementation of the details. It includes in particular the preparation of prefabricated “SUSPA Rock Anchors” for installation, grout composition and grout body manufacturing, as well as the construction details of anchor head construction / anchor head.

3.2 Planning

3.2.1 Borehole

(1) The borehole diameter must be selected in such a way that the anchor with spacers can be inserted without problems and the minimum coverage with grout can be maintained. The minimum borehole diameters are stated in Annex 1; DIN EN 1537 in conjunction with DIN/TS 18537, Section 8.1, applies.

(2) It must be verified that in the area of the free anchor length perpendicular to the borehole axis:

- no fracture displacements is expected if the load transfer length is not limited or
- the expected fracture displacements are smaller than the difference between the sheathing and the borehole diameter if the load transfer length is limited (see Section 3.2.3 (4)).

3.2.2 Anchor preparation

(1) Spacers on prefabricated “SUSPA Rock Anchors” (see Section 2.2.1.1) must be arranged within the area of the anchorage length as per Annex 1. The spacers must be arranged starting at the distance of 0.75 m from the anchor foot and further at maximum distance of 1.20 m on the corrugated sheathing in the anchorage length so that they are secured against displacement.

(2) The inner void between the strand bundle and the plastic corrugated sheathing, which was not filled as planned at the plant, must be filled with inner cement grout as per Section 2.1.4.4 after “SUSPA Rock Anchors” have been installed in the borehole. The corresponding grouting and venting pipes must be planned and provided at the plant. For ascending anchors, the grouting in the area of the free steel length L_{tf} may be omitted.

(3) The injection for the production of the grout body must always be carried out from the lowest point of the grout body, while venting, if required, must always be effected from the highest point. For this purpose, ascending ground anchors must have a packer with the appropriate grouting and venting pipe arranged (see Annex 1).

(4) If postgrouting of the grout body is planned, valve hoses or pipes with grouting hoses with sleeves should be used, which must be taken into account during planning and attached before the anchors are installed.

3.2.3 Grout and grout body

(1) For the manufacturing of the grout body, cement grout should be used.

(2) The starting materials for the cement grout are cements with special properties according to DIN 1164–10 and cements according to EN 197-1 – taking into account the existing exposure classes as per DIN EN 206-1 in conjunction with DIN 1045-2 (Tables 1, F.3.1 and F.3.2), water as per DIN EN 1008 and, if necessary, additives as per EN 934-2 in conjunction with DIN EN 206-1/ DIN 1045-2 or with general construction supervisory authority approval and natural aggregates for concrete with up to 4 mm grain diameter as per EN 12620 – taking into account DIN EN 206-1/DIN 1045-2, Appendix U to be applied.

(3) In the case of an alternative use of inner cement grout, the water/cement ratio must be limited to a maximum of 0.44 pursuant to DIN EN 447.

(4) The load transfer length of the grout body is to be limited by one of the following methods:

a) by flushing out excess cement grout by means of a flushing hose permanently mounted on the sheathing. The flushing hose must be arranged in such a manner that the first lateral discharge openings lie 50 cm above the transition point between the free steel length and the bond length of the tendon. Verification of this value must be confirmed in the record. The flushing pressure applied must amount to approx. 4 bar.

b) by flushing out excess cement grout by means of a flushing lance. The flushing lance closed at the bottom and provided with lateral openings must be inserted up to approx. 1.0m above the transition point L_{tb}/L_{tf}. The flushing pressure applied must amount to approx. 4 bar.

c) by blocking the load transfer length by means of a packer. The suitability of the packer must be verified within the scope of a suitability test.

In the case of downwardly inclined (descending) ground anchors, methods a), b), or c) may be applied. For upwardly inclined (ascending) ground anchors, method c)
must be applied. This procedure must be included in the execution planning documentation.

(5) Limitation of the load transfer length may be omitted if the respective conditions stated in DIN EN 1537 in conjunction with DIN SPEC 18537, Section 8.3.4, are fulfilled.

(6) Post-grouting operations with cement suspension may be carried out in accordance with DIN EN 1537 in conjunction with DIN/TS 18537, Section 8.3.5. The grout body can be burst using water. After post-grouting, if the load transfer length must be limited, the free anchor length must be flushed again.

3.2.4 Anchor head

(1) The anchor head s per Section 2.1.2, other components of the anchor head as per Section 2.1.3 and the prefabrication of the anchor head structure at the plant as per Section 2.2.1.2 must be planned accordingly and specified in the execution planning documentation.

(2) The tendon must be anchored in each direction perpendicular to its axis.

(3) To seal the transition point of the steel tube and the corrugated plastic sheathing, two sealing rings should be provided in accordance with Annex 2 and arranged within the overlapping length.

(4) The wedges are embedded by 6 mm when anchored in the anchor head; the influence of this embedding must be taken into account as slippage when determining the pull-out distances. In the case of the free steel length, $\leq$5 m this slippage must be compensated by lifting the wedge plate off the anchor plate after embedding the wedge, and then inserting washers between the wedge plate and the anchor plate with a total height of 6 mm.

(5) In the area of the steel tube, Nontribos MP-2 or Vaseline “Cox GX” should be used as a corrosion protection compound. If the corrugated plastic sheathing in the free steel length L_{tf} has been filled with inner cement grout and Nontribos MP-2 has been used as a corrosion protection compound, the cement stone contact surfaces must be sealed with SikaCor-299.

(6) The internal protection cap is screwed onto the external thread of the wedge plate and sealed. The void of the internal protection cap must be filled with Vaseline “Cox GX”, Nontribos MP-2, UNIGEL 128 F-1 or with Vaseline FC 284 TP 70. As additional protection, an external protection cap with underlying sealing must be screwed onto the anchor plate. This external protection cap may be omitted if the anchor head is embedded in concrete.

3.3 Design

(1) For anchoring, the anchor plate and the steel or reinforced concrete structure supporting the anchor plate must be verified separately according to the technical building specifications.

(2) The transmission of forces in the structure (e.g. splitting forces) must be verified in each individual case.

(3) It must be verified that the changes of forces (characteristic value) in the steel tendon frequently repeated specified load (including wind) is not greater than 20% of the characteristic load E_k. The verification is only needed if the pulsating load is not covered by the prestressing.

(4) The overall safety of the anchored mountain body is the subject of the rock-mechanical stability verification; the anchor forces required for the stability must be determined by an expert[2]. For anchoring through rock, the design values of the rock pressure (resistance) must be determined by an expert in each individual case, taking into consideration possible structural disturbance directly at the borehole. Necessary intermediate components are to be dimensioned according to relevant standards, taking into consideration the design values of the rock pressure (resistance).

3.4 Installation

3.4.1 General

(1) The “DYWIDAG” soil nailing system, prefabricated or ready-made for installation and grouting, must be inspected by the contractor based on the execution planning documentation and delivery note for completeness of all required components.

(2) Works must be carried out in accordance with the work instructions from DYWIDAG-Systems International GmbH submitted to the German Institute for Building Technology. The work instructions concerning anchor manufacturing at the construction site and the installation of the anchor heads must be available at the construction site.

(3) During the execution of ground anchors using “SUSPA Rock Anchors” and grout, records documenting the proper execution must be kept by the executing company, by the site manager or their representative.

3.4.2 Installation into the borehole

(1) The minimum borehole diameter must be selected in accordance with the execution planning documentation. Before the installation of “SUSPA Rock Anchors”, the boreholes should be tested for any blockages, e.g. with a template.

(2) If transported by a crane hook, the anchor must be carried at its stressing end or with carrying straps or placed in ducts. The anchors wound up in coils may be inserted into the borehole directly from the coil. In the area of the anchoring length, spacers in accordance with the execution planning documentation should be arranged.

(3) If, during the installation of “SUSPA Rock Anchors” protected in a casing. the projecting end of the drill set has an edged internal thread or a sharp-edged pipe end, the prepared “SUSPA Rock Anchors” may not be inserted into the casing 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) The voids between the strand bundles and the corrugated plastic sheathing that were not filled at the plant, are to be filled with grout in the borehole during the manufacturing of the grout body through the grout tube, starting from the lowest point of the area to be filled, with inner cement grout according to the execution planning documentation. The inner cement grout must be injected with an injection speed of no more than 5 m/min. The grouting process may only be ended when grout without bubbles and of the same consistency as provided on the filling side comes out from the corrugated plastic sheathing in case of downward inclined (descending) anchors and from the vent pipe in case of upward inclined (ascending) anchors.

2 In order to determine the static and structural requirements, as well as the characteristic load, experts in geotechnics must be consulted.

3.4.3 Grout body production

(1) The rock surrounding the grout body bust be tight enough to ensure flawless production of the grout body. This should be verified to the required extent using special investigations (e.g. optical borehole inspection, mortar level measurement, water pressure test). The grout composition, injection pressure and the grouting procedure should be determined individually based on the results of the rock probing and water pressure tests, as well as the findings after drilling the boreholes by the executing engineer in collaboration with the expert and with the designing engineer. The planned grouting method must be verified within the scope of a suitability test.

(2) For the production of the grout body, grout (cement grout) in accordance with the execution planning documentation must be used. The cement grout must be machine-mixed. Before filling, no demixing or formation of lumps may occur.

(3) The amount of grout, its composition and the grouting pressure for a ground anchor must be measured and recorded, e.g. using the manufacturing protocol in accordance with DIN/TS 18537, Annex F, Fig. F.1.

(4) For cased boreholes, after filling the borehole with grout and installing the “SUSPA Rock Anchor” and, if applicable, after putting on the grout cap, the pipe should be pulled out slowly and step by step while maintaining the required grouting pressure. The grout must be pressed at least to the transition point from the anchoring length L_{tb} to the free steel length L_{tf}.

(5) For ascending anchors, a packer attached to the outside of the corrugated plastic sheathing at the transition point from the anchoring length L_{tb} to the free steel length L_{tf} must be activated before the beginning of the grouting works (see also Annex 1). The grouting process may only be ended, when the grout without bubbles comes out from the vent tube as provided on the filling or grouting tube.

(6) If the force transmission length of the grout body is limited according to the execution planning documentation, the free anchor length is to be flushed using an appropriate method.

3.4.4 Anchor head installation and corrosion protection measures at the construction site

(1) The prefabricated anchor head structure (anchor plate with steel tubes) is pushed trough the free steel end and the corrugated plastic sheathing. The sealing of the transition point of the steel tube and the corrugated plastic sheathing (two sealing rings in accordance with Annex 2) must be then be inspected for proper seating.

(2) The strand sheathing within the steel tube must be removed, whereby a minimum distance of 5 cm to the existing cement stone surface must be maintained. The void between the strand bundle and the anchor plate / steel tube must be filled with a corrosion protection compound. The corrosion protection compound removed during tensioning must be reintroduced.

(3) After tensioning the ground anchor, the wedge plates and the excess strand must be protected with an internal PE protection cap and the closing external protection cap must be sealed with the anchor plate.

3.4.5 Suitability and acceptance tests, supervision of installation

(1) The suitability tests must be supervised by a surveillance agency for monitoring the installation of ground anchors which is included in the list of inspection, surveillance and certification agencies in keeping with the regional building codes, Part V, as amended from time to time[3]. All necessary documents (installation instructions, design drawings, etc.) must be made available to the monitoring body; this also includes the design drawings of the anchor head.

3 Recently: List of inspection, surveillance and certification agencies in accordance with the regional building codes, edition 2022, as of: 1 March 2022 – Notifications regarding German Institute for Building Technology information, department P4, Recognition and Notification of Third Parties

(2) As part of the monitoring activity for the suitability and acceptance tests, the monitoring body involved must monitor the assembly of permanent anchors at the construction site, in particular the corrosion protection measures carried out at the construction site, e.g. the complete filling of the anchor head area with corrosion protection compound, at least randomly.

(3) If the entire void between the strand bundle and the corrugated plastic sheathing is only filled with inner cement grout in the borehole, the basic functionality must be controlled by the monitoring body; additionally, its careful execution must also be monitored on a random basis. This must be recorded in the test report.

(4) The monitoring body must report to the competent construction supervisory authority, if the facilities and personnel at the construction site do not ensure proper installation. The competent construction supervisory authority must be informed about the beginning of such works.

3.4.6 Declaration of conformity of the installation

(1) The executing company must submit a declaration of conformity as per Article 16a section 5 in conjunction with Article 21 section 2 of the MBO[4] to confirm that the design type conforms to the general design-type approval.

(2) The executing company's declaration of conformity must be drafted in accordance with DIN EN 1537, Section 10 in conjunction with DIN/TS 18537. Additionally, the Approval number must be provided.

(3) Copies of the records must be handed over to the client for incorporation into the construction file and presented to German Institute for Building Technology and to the competent highest construction supervisory authority on request.

4 Provisions for use, maintenance, and service

(1) For re-inspections, DIN EN 1537, Section 9.10 applies, supplemented by DIN/TS 18537.

(2) If necessary, the re-inspection should be carried out by the same monitoring body that was already involved in the suitability tests.

(3) If, as a result of the monitoring tests, the anchors have to be retensioned, it must be ensured that the corrosion protection compound removed during tensioning is reintroduced.

List of standards

EN 197-1:2011-11	Cement – Part 1: Composition, specifications and conformity criteria for common cements; (in Germany replaced with DIN EN 197-1:2011-11)
DIN EN 206-1:2001-07	Concrete – Part 1: Specification, performance, production and conformity; German edition EN 206-1:2000
DIN EN 206-1/A1:2004-10	Concrete – Part 1: Specification, performance, production and conformity; German edition EN 206-1:2000
DIN EN 206-1/A2:2005-09	Concrete – Part 1: Specification, performance, production and conformity; German edition EN 206-1:2000/A2:2005
DIN EN 445:1996-07	Grout for prestressing tendons – Test methods – German edition EN 445:1996
DIN EN 446:1996-07	Grout for prestressing tendons – Grouting procedures – German edition EN 446:1996

4 Model Building Code (Musterbauordnung, MBO) version of November 2002, last changed by the decision of the conference of the minister of construction of 25 September 2020

DIN EN 447:1996-07	Grout for prestressing tendons – Grouting procedures – Requirements for common grouts – German edition EN 447:1996
EN 934-2:2009+A1:2012	Admixtures for concrete, mortar and grout – Part 2: Concrete admixtures – Definitions, requirements, conformity, marking and labelling; (in Germany replaced with DIN EN 934-2:2012-08)
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 edition EN 1008:2002
DIN 1045-2:2008-08	Concrete, reinforced and prestressed concrete structures – Part 2: Specification, performance, production and conformity; Application rules for DIN EN 206-1
DIN 1054:2021-04	Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1
DIN EN 1090-1:2012-02	Design of steel structures and aluminum structures – Part 1: Verification of compliance of structural components; German edition EN 1090-1:2009+A1:2011
DIN 1164-10:2013-03	Special cement – Part 10: Composition, requirements and conformity evaluation for cement with low effective alkali content
DIN EN ISO 1461:2009-10	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461:2009); German edition EN ISO 1461:2009
DIN EN 1537:2014-07	Execution of special geotechnical works – Ground anchors; German edition EN 1537:2013
DIN EN 1997-1:2009-09	Eurocode 7: Geotechnical design – Part 1: General rules; German edition EN 1997-1:2004 + AC:2009
DIN EN 1997-1/NA:2010-12	National Annex – Nationally determined parameters – Eurocode 7: Geotechnical design – Part 1: General rules
DIN EN 10204:2005-01	Metallic products – Types of inspection documents; German edition EN 10204:2004
DIN EN 12068:1999-03	Cathodic protection – External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection – Tapes and shrinkable materials; German edition EN 12068:1998
DIN EN 12620:2008-07	Aggregates for concrete; German edition EN 12620:2002+A1:2008
DIN EN ISO 12944-4:2018-04	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 4: Types of surface and surface preparation (ISO 12944-4:2017); German edition EN ISO 12944-4:2017
DIN EN ISO 12944-5:2020-03	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 5: Protective paint systems (ISO 12944-5:2019); German edition EN ISO 12944-5:2019

DIN EN ISO 12944-7:2018-04	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 7: Execution and supervision of paint work (ISO 12944-7:2017); – German edition EN ISO 12944-7:2017
DIN EN ISO 14713-1:2017-08	Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures – Part 1: General principles of design and corrosion resistance (ISO 14713-1:2017); German edition EN ISO 14713-1:2017
DIN EN ISO 17855-1:2015-02	Plastics – Polyethylene (PE) moulding and extrusion materials – Part 1: Designation system and basis for specifications (ISO 17855-1:2014); German edition EN ISO 17855-1:2014
DIN/TS 18537:2021-05	Supplementary specifications to DIN EN 1537:2014–07, Execution of special geotechnical works – Ground anchors
DIN EN ISO 19069-1:2015-06	Plastics – Polypropylene (PP) moulding and extrusion materials – Part 1: Designation system and basis for specifications (ISO 19069-1:2015); German edition EN ISO 19069-1:2015
DIN EN ISO 21306-1:2019-07	Plastics – Unplasticized poly(vinyl chloride) (PVC-U) moulding and extrusion materials – Part 1: Designation system and basis forspecifications (ISO 21306-1:2019); German edition EN ISO 21306-1:2019

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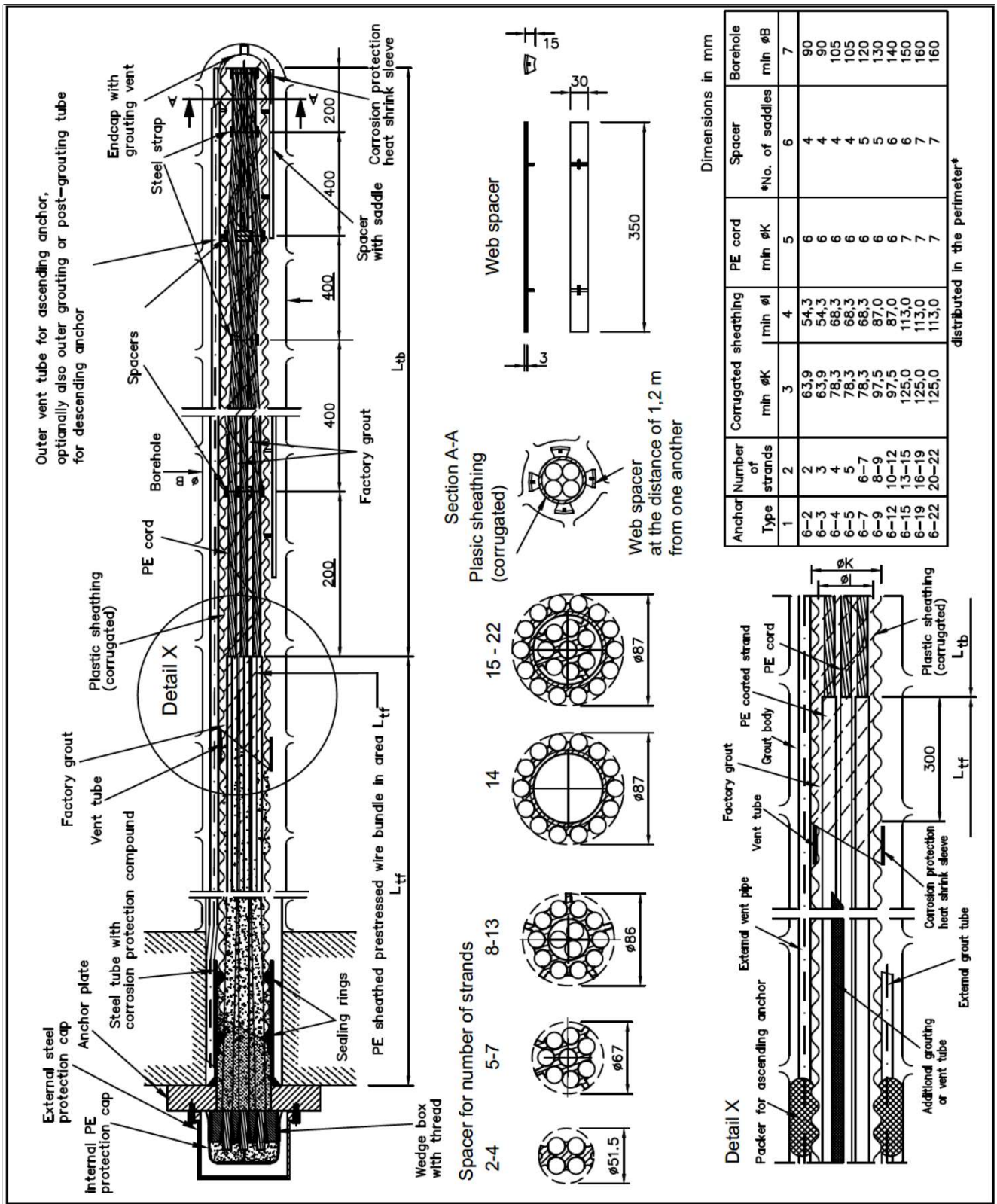


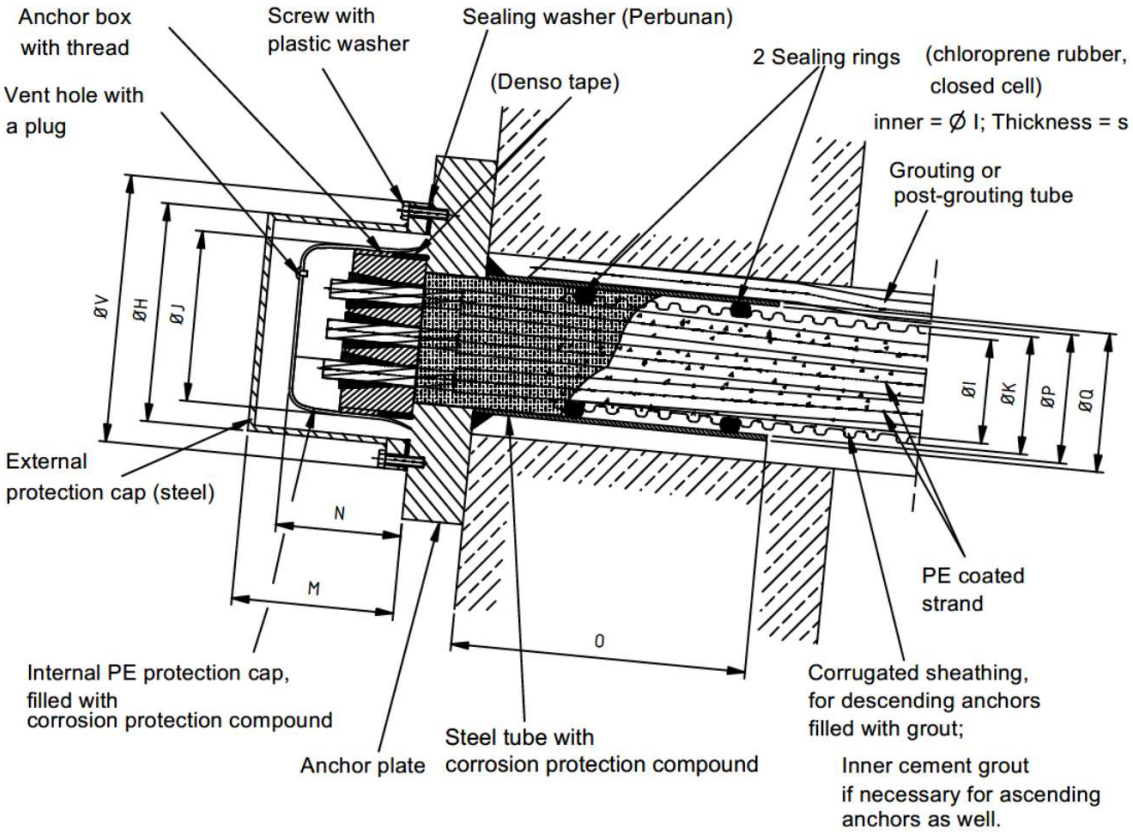
Anchor Type	Number of strands	Corrugated sheathing min øK	Corrugated sheathing min ø	PE cord min øK	Spacer *No. of saddles	Borehole min øB
1	2	3	4	5	6	7
6–2	2	63,9	54,3	6	4	90
6–3	3	63,9	54,3	6	4	90
6–4	4	78,3	68,3	6	4	105
6–5	5	78,3	68,3	6	4	105
6–7	6–7	78,3	68,3	6	5	120
6–9	8–9	97,5	87,0	6	5	130
6–12	10–12	97,5	87,0	6	6	140
6–15	13–15	125,0	113,0	7	6	150
6–19	16–19	125,0	113,0	7	7	160
6–22	20–22	125,0	113,0	7	7	160

*distributed in the perimeter

SUSPA – Rock anchors

Annex 1

Overview – Type 6-2 to 6-22



Anchor Type	Strands Number	External protection cap (steel)			Internal protection cap (PE-HD)		Steel tube			Corrugated sheathing		Sealing ring
		Ø V	Ø H	M	Ø J	N	Ø Q	Ø P	O	Ø K	Ø I	s
1	2	3	4	5	6	7	8	9	10	11	12	13
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
6-2	2	178	133	110	98	95	82,5	75,3	160	63,9	54,3	15
6-3	3	178	133	110	103	95	82,5	75,3	160	63,9	54,3	15
6-4	4	219	178	125	122	100	101,6	93,6	170	78,3	68,3	15
6-5	5	219	178	125	144	110	101,6	93,6	170	78,3	68,3	15
6-7	6-7	229	178	125	144	110	114,3	106,3	290	78,3	68,3	20
6-9	8-9	267	216	140	163	110	133,0	125,8	290	97,5	87,0	20
6-12	10-12	267	216	140	182	120	139,7	128,5	460	97,5	87,0	25
6-15	13-15	305	254	160	209	130	159,0	150,0	650	125,0	113,0	20
6-19	16-19	305	254	160	219	140	191,0	178,4	650	125,0	113,0	35
6-22	20-22	324	273	170	239	150	191,0	178,4	750	125,0	113,0	35

SUSPA – Rock anchors	Annex 2
Anchor heads illustration – Type 6-2 to 6-22	

Inspection		Inspection method	WPK[1]	EP/ FÜ[2]	Value
1 Incoming goods control:					
1.1	Prestressing steel	Conformity mark, delivery	Every shipment	X	According to general construction supervisory
1.2	Wedge plates with external thread, wedges	Conformity mark, delivery	Every shipment	X	According to Z-13.8-152
	Nominal diameter and thread depth of the wedge plate's external thread	Measurement*	Every shipment	X	Plant drawings
1.3	Steel tube				
	Type of steel	DIN EN 10204	Every shipment	X	Plant certificate 2.1
	External and internal diameter	Measurement*	1 every 100 pcs	X	Plant drawings
	Wall thickness, length	Measurement*	1 every 100 pcs	X	Plant drawings, Annex 2
1.4	Sealing rings with steel tubes; sealing washers for anchor caps				
	Diameter (inner and outer in sealing rings), sealing ring thickness	Measurement*	1% of each delivery, at least 5 pcs	X	Plant drawings, Annex 2
1.5	Protection caps (inner and outer)				
	Material and geometry	Delivery note / Measurement*	Every shipment	X	Plant drawings, Annex 2
1.6	Corrugated sheathing, end and injection caps				
	Molding compound	DIN EN 10204	Every shipment	X	Plant certificate 2.1
	Wall thickness (for corrugated sheathing – wall thickness at inner and outer rib and at the side)	Measurement*	1 every 100 pcs	X	DIN EN 1537 and plant drawings
	Inner and outer diameter	Measurement*	1 every 100 pcs	X	Minimum values according to Annexes 1 and 2
1.7	Heat shrink sleeves (fixing heat shrink sleeves [1] and corrosion protection heat shrink sleeves [2])				
	Molding compound ([1] and [2])	DIN EN 10204	Every shipment	X	Plant certificate 2.1
	- Classification [2]: - Amount of adhesive [2]:	EN 12068 Measurement*	1 every 100 pcs 1 every 100 pcs	X X	C30 > 700 g/m2
1.8	Corrosion protection coatings				
	Material properties and coating thickness	DIN EN 10204	5% of the produced amount	X	Acceptance test certificate 3.1

1 Plant production control
2 Initial inspection / external monitoring (2 x yearly)

	Inspection	Inspection method	WPK[1]	EP/ FÜ[2]	Value
2 Control during manufacturing					
2.1	Single strands – amount of corrosion protection compound applied	Weighing	Daily; at least one every 20 anchors	X	Mean value ≥ 42 g/m; individual value ≥ 25 g/m
	Single strands – distribution of corrosion protection compound	Visual	Daily; at least one every 20 anchors	X	Penetrated in every groove, all surfaces connected
2.2	Strands in L_{tb} – free from corrosion protection compound	Visual	Daily	X	Yes
2.3	Steel tubes with sealing rings – test on the function assumed	Visual, sample	5% of the produced amount	X	Yes
2.4	Heat shrink sleeves – wall thickness in shrunk state	Sample and measurement*	1 on each type of anchor and production	X	≥ 1.5 mm
2.5	Inner cement grout	DIN EN 445	DIN EN 446	X	DIN EN 447
2.6	All of the plant-applied corrosion protection measures	Visual	Every load-carrying element	X	Documented procedures
2.7	Packaging of the components	Visual	Every shipment	X	Planning or execution documents

* Inspection plan:

If each individual measured value is equal to or greater than the required minimum value, L_{os} shall be assumed. Other samples may be taken. The same measurements as in the first sample are to be carried out on these samples. The measurement results shall be summarized with the previous measurements. The mean value x and the standard deviation s must be formed from all measured values. If the test parameter (numerical value)

$$z = x - 1.64\ s$$

to be formed therefrom is equal to or greater than the required minimum value, the value L_{os} is to be rejected.

1 Plant production control
2 Initial inspection / external monitoring (2 x yearly)