SUSPA-DSI Geotechnical Systems

SUSPA Rock Anchor

Approval Number
Z-20.1-53

Validity
22 July 1998 - 31 August 2008
General Construction Supervisory Authority Approval

Approval No.: Z-20.1-53

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Subject of Approval: SUSPA Rock Anchor

Valid until: 31 August 2008

The above-mentioned subject of the approval is herewith granted a general construction supervision authority approval.*

This general construction supervision authority approval consists of 14 pages and nine appendices.

Important Notice
This general construction supervision authority approval is the translation of a document originally prepared in the German language which has not been verified and officially authorised by the "Deutsches Institut für Bautechnik" (DIBt; German Institute for Building Technology). In case of doubt in respect to wording and/or interpretation of this approval, the original German version of this document shall prevail exclusively. No liability is therefore assumed for translation errors or inaccuracies.

* This general construction supervision authority approval supersedes the general construction supervision authority approval granted on 22 July 1998, amended as a result of the notification on 4 May 2000.
I. GENERAL REGULATIONS

1 This general construction supervisory authority approval verifies the suitability (fitness for the intended purpose) of the subject of the approval in keeping with the state construction ordinances.

2 The general construction supervisory authority approval does not replace the permission, agreements and certifications required by law for a construction project to be carried out.

3 The general construction supervisory authority approval is granted without prejudicing the rights of third parties, especially private protection rights.

4 Notwithstanding any further regulations in the "Special Provisions" section, the manufacturer and distributor of the object of approval shall provide the user with copies of the certificate of approval; furthermore, they shall inform the user that the certificate of approval must be available at the place of use. Copies of the general construction supervisory authority approval must be made available to involved authorities on request.

5 The general construction supervisory authority approval may only be copied completely. The publication of extracts is subject to approval by the DIBt. Texts and drawings of advertising material may not contradict the 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 checked by the DIBt".

6 The general construction supervisory authority approval is granted, but is revocable. The provisions in the general construction supervisory authority approval can be subsequently supplemented or changed, especially if the latest technical findings give reason for this.
II. SPECIAL REGULATIONS

1 Subject of Approval and Applications

Subject of the following general construction supervisory authority approval is SUSPA-DSI GmbH's "SUSPA Rock Anchor" with steel tendons consisting of 1 to 22 strands St 1570/1770, nominal diameter 15.3 mm (0.6"; nominal cross-section 140 mm²) or 15.7 mm (0.62\"; nominal cross-section 150 mm²).

Unless otherwise stated below, DIN 4125:1990-11 – Ground anchors, temporary anchors and permanent anchors; design, construction and testing – shall be observed with regard to their design, construction and testing.

Depending on the type of design, the ground anchors may either be used as permanent anchors (see Appendices 2 and 3) with steel tendons consisting of 1 to 22 strands or as temporary anchors (see Appendix 7) with steel tendons consisting of 11 to 22 strands.

Their application is limited to those cases in which the entire fixed anchor length of the anchor is located in rock (cf. DIN 1054 and DIN 4022). Deviating cases may only be carried out subject to the permission of an earthwork and foundation engineering expert.

DIN 4125:1990-11, section 5.1, applies with regard to subsoil requirements.

2 Regulations covering the Construction Product

2.1 Features and constituents

2.1.1 General

The ground anchor may be manufactured in the following types:
- Types 6-1 to 6-22 for permanent anchors
  a) Type G with smooth plastic sheathing in the area of \( l_5 \) and corrugated plastic sheathing in the area of \( l_4 \) as shown in Appendix 2,
  b) Type R with continued full-length corrugated plastic sheathing for \( l_5 + l_4 \) as shown in Appendix 3,
- Types 6-12 to 6-22 for temporary anchors.

2.1.2 Steel Tendon

Only generally construction supervisory authority approved strands St 1570/1770, nominal diameter 15.3 mm (0.6"; nominal cross-section 140 mm²) or nominal diameter 15.7 mm (0.62"; nominal cross-section 150 mm²), consisting of seven cold-drawn, smooth individual wires may be used as steel tendon material. Generally construction supervisory authority approved strands coated with a corrosion-protection system shall be used for permanent anchors. The corrosion protection system consisting of an anti-corrosion compound and a PE sheathing shall be applied at the shop where the prestressing steel is produced.

During installation and transportation of the anchors, the following bending radii \( R \) may not fall short of:
- \( \text{min } R = 0.90 \text{ m} \) (Permanent anchors with 1 to 9 strands and temporary anchors with 11 to 15 strands),
- \( \text{min } R = 1.00 \text{ m} \) (Permanent anchors with 10 to 12 strands and temporary anchors with 16 to 19 strands),
- \( \text{min } R = 1.25 \text{ m} \) (Permanent anchors with 13 to 22 strands and temporary anchors with 20 to 22 strands).

2.1.3 Anchor Head

The anchor head shall be designed in compliance with Appendix 4 or 5 (permanent anchor) or Appendix 8 (temporary anchor). Assembly of the anchor head on the construction site shall be carried out in accordance with the description filed with the DBt.

The strands of the steel tendon shall be anchored with wedges in the anchor head. Only strands of the same nominal diameter may be used within one steel tendon. As regards form and material quality, anchor heads and wedges must comply with those in the general construction supervisory authority approvals for "SUSPA Strand Post-Tensioning System
140 mm², approval No. Z-13.1-21, or "SUSPA Strand Post-Tensioning System 150 mm²", approval No. Z-13.1-82. The specifications set forth in Appendix 6 apply to the outer diameter of anchor heads including external thread. To avoid confusion, only generally construction supervisory authority approved wedges may be used on the construction site. For the transfer of load from the anchor head to the structure to be anchored bearing plates as specified in Appendix 6 (permanent anchor) or Appendix 9 (temporary anchor) shall be used. Unless completely cast in concrete, the bearing plate of permanent anchors shall be provided with a corrosion protection system in accordance with DIN EN ISO 12944-5:1998-07, e.g. with the following layers:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Target layer thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer</td>
<td>metal coating by a thermal spraying system</td>
<td>100 µm</td>
</tr>
<tr>
<td>1st coating</td>
<td>epoxy resin</td>
<td>80 µm</td>
</tr>
<tr>
<td>2nd coating</td>
<td>polyurethane</td>
<td>80 µm</td>
</tr>
</tbody>
</table>

Surface preparation Sa 2 ½; total target layer thickness 260 µm.

Further coating examples pursuant to DIN EN ISO 12944-5 are the corrosion protection systems S5.12, S5.13, S5.15, S5.16 and S8.08 (protection systems without metal coating) as well as S9.11, S9.12 and S9.13 (protection systems with galvanized coating).

The exposed surfaces of the anchor trumpet and the steel protection cap of permanent anchors must also be provided with one of these corrosion protection systems. Corrosion protection for these parts may be waived, if they have a wall thickness = 6.0 mm or will be cast in concrete.

If the steel protection cap consists of stainless steel with the material numbers 1.4301, 1.4541 or 1.4571 (see also Appendix 5) in accordance with the general construction supervisory authority approval for "Structural and Connection Elements made of Stainless Steel", approval No. Z-30.3-6, it need not be provided with a corrosion protection system.

As regards corrosion, the steels specified in approval No. Z-30.3-6 are assigned either to resistance class II (material numbers 1.4301 and 1.4541) or III (material number 1.4571). The specifications regarding the corrosion load and typical applications set forth therein shall be observed.

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

To ensure that the anchor head is positioned rectangular to the steel tendon, angular deviations must be compensated (e.g. through wedge plates, mortar bed or similar).

When a prestressing load is applied to the anchor head by a stressing jack, a 6 mm slippage of the wedges (wedge slip) into the conical boreholes must be taken into account.

After stressing the wedges used in temporary anchors must be covered with a wedge locking plate.

The anchor heads have an external thread to restress and verify the anchor force of the permanent anchors. Anchor heads without an external thread may be used for temporary anchors.

2.1.3.1 Air-Side Anchorage via Rock

Permissible rock pressures shall be identified on a case-to-case basis by an expert (cf. annotation 1 on page 10) taking into consideration a possible structural fault in the immediate vicinity of the borehole. Any necessary adapters must be dimensioned pursuant to the relevant standards, taking into account the permissible rock pressures.

2.1.3.2 Air-Side Anchorage via Steel and Reinforced Concrete Structures

DIN 4125 applies to the design of structural elements to be anchored. The support on steel structures must be carried out in compliance with Appendix 6 (permanent anchor) or Appendix 9 (temporary anchor). Adequate load capacity and corrosion protection of the steel transition structure shall be demonstrated or identified respectively for every individual case.

If the bearing plate does not have the dimensions given in Appendix 6 (permanent anchor) or Appendix 9 (temporary anchor), their load capacity must be demonstrated as well.

If anchorage is carried out via a reinforced concrete element in accordance with Type 1 of Appendix 6 (permanent anchor) or Appendix 9 (temporary anchor), the general
construction supervisory authority approvals for the "SUSPA Strand Post-Tensioning System 140 mm²" (approval No. Z-13.1-21) and the "SUSPA Strand Post-Tensioning System 150 mm²" (approval No. Z-13.1-62) may be applied. The additional reinforcement indicated therein must be taken into account. If the dimensions of the bearing plates and the aperture specified for Type 2 in Appendix 6 (permanent anchor) or Appendix 9 (temporary anchor) are observed, the load capacity of the bearing plates need not be demonstrated. The transfer of loads in the structure (e.g. splitting forces) must be verified on a case-to-case basis.

2.1.4 Plastic Pipes
For the sheathing of the tendon free length (permanent and temporary anchors) and the bond length (permanent anchors only) respectively, only plastic pipes may be used which consist of PVC-U as specified by DIN EN ISO 1163-1, polyethylene with a moulding compound pursuant to DIN EN ISO -1872-1 - PE, E, 45 T 022 - or polypropylene with a moulding compound as required by DIN EN ISO 1873-1 - PP - B, EAGC, 10-16-003 or DIN EN ISO 1873-1 - PP - H, E, 06-35-012/022. Only pipes without trapped bubbles and with uniform pigmentation may be used.
If required, the individual segments of the PVC-U sheathings shall be screwed together and glued with PVC glue. Unspliced pipes shall be used as PE or PP sheathings. Care must be taken to ensure that only straight pipes which were also delivered in this condition are used.

2.2 Manufacture, Storage, Transport and Marking
2.2.1 Corrosion Protection and Manufacture of Prefabricated Anchors for Installation and Grouting
2.2.1.1 General
The effectiveness of the corrosion protection depends on the integrity of the corrosion protection components. Therefore special care shall be taken during transport and installation of the readily assembled anchors so that sheathings will not be damaged as a result of improper handling.
Corrosion protection and manufacture must be carried out at the shop in accordance with the description filed with the DIBt.
Prior to its installation, the prestressing steel shall be treated in accordance with the provisions set forth in the general construction supervisory authority approval for the prestressing steel.

2.2.1.2 Permanent Anchor
The PE sheathing of the strands extruded in the steel mill shall be removed within the area of the planned bond length; the anti-corrosive agent is be washed off with water having a temperature of approx. 90 °C and a high pressure of 70 to 80 bar.
The strands shall be centred within a continuous PVC cord with a shore hardness of D = 40 throughout the length of the bonding area. The minimum diameter of the PVC cord is 6 mm, the pitch 25 cm, for anchors consisting of 1 to 12 strands; the minimum diameter of the PVC cord is 7 mm, the pitch 20 cm, for anchors consisting of 13 to 22 strands. The strands shall be spread by spacers every 80 cm and bundled with steel straps between the spacers.
The strands shall be inserted into a corrugated plastic sheathing within the designated bond length for anchors type G and over the entire anchor length for anchors type R; the sheathing shall have a uniform wall thickness = 1 mm. The diameter of the sheathings depends on the number of strands in the tendon (see Appendices 2 and 3). The sheathing shall be closed with a PE end cap with a wall thickness = 1 mm to the rock side, with the PE end cap being connected to the sheathing via a shrink sleeve. The overlap on the sheathing must be at least 85 mm.
As regards anchors type G, the strand bundle in the area of the free tendon length lₕ shall be inserted into a plastic sheathing with a minimum wall thickness = 3 mm. The diameter of the sheathings depends on the number of strands in the tendon (see Appendix 4).
With respect to anchors type G, a steel coupler shall be positioned at the transition point from the bond length to the tendon free length to connect the corrugated and smooth
sheathings; both sheathings are pushed onto the steel coupler to one third of the steel coupler length (see Appendix 2). The transitions of both sheathings on the steel coupler shall be sealed off with a common seamless shrink sleeve made of polymerised polyethylene that is at least 300 mm long.

The polyethylene shrink sleeves shall be shrunk on with hot air, infrared radiation or the soft yellow flame of a propane gas burner; their wall thickness in shrunk condition must be \( t = 1.5 \text{ mm} \). The adhesive compound sealing within the shrink sleeves must be hot-melt-type adhesive.

The hollow space within the bond length area between the corrugated plastic sheathing and the steel tendon shall be injected with cement grout in accordance with DIN EN 447 either at the shop or in the borehole. In addition, DIN EN 445 and DIN EN 446 shall be observed. If grouted at the shop, the anchors in the area of the bond length shall be stored in an inclined manner for this purpose and injected with cement grout from the bottom end cap to top.

As regards anchors of the R type, grouting is to take place until grout exits the ventilation opening located on the corrugated pipe. This ventilation opening shall be arranged so that the ends of the PE sheathings of the monostrands are in about 300 mm depth of the bonding length.

If grouted in the borehole, an inner grouting pipe shall already be built in at the shop. For anchors of the G type to be installed upwardly inclined, also an inner ventilation pipe and a cement grout or bitumen plug shall be built into the steel coupler at the shop (see Appendix 2).

Inner grouting in the borehole is not envisaged for upwardly inclined anchors of the R type.

2.2.1.3 Temporary Anchors
Within the bond length, the strands shall be spread by spacers every 0.8 m; between the spacers the tendon shall be bundled with steel straps. To ensure cement grout coverage spacers including webs shall be positioned within the area of the regular spacers (see Appendix 7).

In the area of the tendon free length the tendon shall be inserted into a smooth plastic pipe. The plastic pipe shall be sealed with a sealing plug made of bitumen, cement grout or 2C-polyurethane (no foam) against the rock side.

2.2.2 Storage
The smooth and corrugated plastic pipes of readily assembled anchors may not rest on sharp-edged bearing surfaces. If anchors are piled up, they must lie on top of each other in a parallel manner. If supported in intervals by square timbers or adequate spacers including webs, the weight of the anchors on top within the area of the plastic pipes may only be transferred via the timbers or spacers. The readily assembled anchors may not be stored on the ground.

2.2.3 Transport
In no case may the anchors be thrown or dropped. They shall be carried (e.g. by hand or on shoulders or by means of carrying straps) so that in particular the plastic pipes will not be damaged. The anchors may also be transported wound up in coils and inserted into the borehole from the coil, with the rigid, shop cement grouted bond length of the permanent anchor tangentially protruding from the coil.

2.2.4 Marking
The delivery note for the preassembled anchor structure must be marked with the conformity mark ("Ü-Zeichen") by the manufacturer in accordance with the Conformity Mark Ordinances of the German Laender. Marking may only be carried out if the requirements according to Section 2.3 have been met.

Among other things, the delivery note must indicate for which ground anchors the components (e.g. bearing plate subject to the intermediate structure selected) are determined and in which shop they have been produced. The delivery note must clearly indicate to which type of ground anchor the components are assigned.
2.3 Evidence of Conformity

2.3.1 General
Each manufacturing plant must confirm that the anchor components and the prefabricated anchors for installation and grouting comply with the provisions in this general construction supervisory authority approval by means of a certificate of conformity based on the plant's own quality control and regular external surveillance, including initial testing, in accordance with the following provisions.

The manufacturer of the anchor components and of the prefabricated anchors must commission a recognised certification authority and a recognised external surveillance authority to issue the certificate of conformity and to carry out an external surveillance, including product testing, respectively.

The certification authority must send a copy of the issued certificate of conformity to the DIBt for information.

In addition, a copy of the initial test report must be forwarded to the DIBt for information.

2.3.2 In-house Quality Control
Each manufacturing plant must set up and also carry out its own quality control. By "in-house quality control" the continuous monitoring of the manufacturing process by the manufacturer is understood which ensures that the manufactured building products comply with the provisions of this general construction supervisory authority approval. The results of the internal quality control shall be recorded and evaluated. The recordings must contain at least the following information:

- Description of the building product or the basic material respectively and its components,
- nature of the control or inspection,
- date of manufacture and date of inspection of the building product or of the basic material respectively or its components,
- results of the controls and inspections and, if applicable, comparison with the requirements,
- a signature from the person responsible for in-house quality controls.

The records shall be kept for at least five years and presented to the external authority assigned with surveillance. They must be submitted to the DIBt and the highest construction supervisory authority in charge on request. If the inspection results are unsatisfactory, the manufacturer must immediately take the necessary actions to remedy the deficit. Construction products which do not meet the stipulated requirements must be handled in a manner that confusion with conforming products will be excluded. Once the deficit has been remedied, the relevant test must be repeated without delay, to the extent technically feasible and in proof of the remedy of the deficit.

The in-house quality control must include at least the following measures:

2.3.2.1 Strands
Only strands may be used for which an evidence of conformity has been produced pursuant to the provisions of the corresponding general construction supervisory authority approvals.

2.3.2.2 Anchor Heads and Wedges
Only anchor heads and wedges may be used for air-side anchorage for which an evidence of conformity has been produced pursuant to the provisions of the general construction supervisory authority approval Z-13.1-21 or Z-13.1-82. The provisions for the incoming inspection set forth therein shall be observed.

2.3.2.3 Plastic Pipes
Composition of the moulding compound shall be attested with the agreement certificate "2.1" as per DIN EN 10 204. The wall thickness and the diameter of the plastic pipes must be measured. As regards corrugated plastic pipes, one corrugated plastic pipe shall be taken per batch (100 pipes) to measure the wall thickness at one internal and one external corrugation and on the flank as well as the diameter of the pipes. The decision whether the batch will be accepted or rejected shall be made in accordance with Section 2.3.2.9.
2.3.2.4 Shrink Sleeves
The material characteristics of the shrink sleeves and the bonding agent shall be attested by agreement certificate “2.1” in accordance with DIN EN 10204. The thickness of the shrink sleeves must be measured in shrunk condition. For this purpose, one sleeve each shall be shrunk on corresponding pipe sections parallel to the manufacture of one anchor type.

2.3.2.5 Lip Seals, Rings and Washers
From each lip seal batch delivered, the diameter of 1% but at least 5 pieces shall be checked with regard to their functioning (e.g. by means of a template) at the shop. At least 5% of the anchor trumpets shall be examined at the shop with regard to the fact whether the lip seal is immovably seated in the anchor trumpet and tightly connected to the designated plastic pipe.
From each roll batch delivered, the diameter of 1% but at least 5 pieces shall be checked with regard to their functioning (e.g. by means of a template) at the shop. At least 5% of the anchor trumpets shall be examined at the shop with regard to the fact whether the rings are tightly connected to the designated plastic pipe.
From each washer batch delivered, 1% but at least 5 pieces shall be checked with regard to their dimensions at the shop. The decision whether the batch will be accepted or rejected shall be made in accordance with Section 2.3.2.9.

2.3.2.6 Bearing Plates
If a bearing plate in accordance with Appendix 6 (permanent anchor) or Appendix 9 (temporary anchor) is used or statically evidenced in an individual case, compliance with the material characteristics shall be attested by agreement certificate “2.2” pursuant to DIN EN 10204. In addition, each bearing plate must be verified with regard to its dimensions and gross faults by means of a yes/no check (no recordings hereof required).

2.3.2.7 Structure of the Strand in the Bond Length
Each strand must be examined by means of an attribute check (yes/no check) to ensure that the bond length is free of anti-corrosion compound (statistical evaluation not required).

2.3.2.8 Anti-Corrosion Coating
Compliance with the layer thickness requirements for the anti-corrosion coating of the steel parts at the anchor head must be verified on 5% of each production batch at the shop.

2.3.2.9 Test Plan
If each individually measured value equals or exceeds the minimum value stipulated, the batch shall be accepted. If not, further samples may be taken. The same measurements as those on the first sample must be carried out on these samples. The measuring results shall be summed with the previous measurements. The mean average value \( \bar{x} \) and the standard deviation \( s \) shall be determined from all values. If the resulting test value (numerical value) \( z = \bar{x} - 1.64 \) \( s \) equals or exceeds the minimum value stipulated, the batch shall be accepted, otherwise rejected.

2.3.3 External Surveillance
The in-house quality control at each manufacturing plant shall be regularly, but at least twice a year, monitored by external surveillance.
An initial inspection shall be carried out as part of the external surveillance. Also samples for sampling tests shall be taken and the testing tools inspected. Samplings and tests are incumbent on the relevant recognised surveillance authority.
The results of the certification and of the external surveillance shall be kept for at least five years. They must be presented to the DIBt and to the highest construction supervisory authority in charge by the certifying body or the surveillance authority on request.

3 Regulations covering Design and Dimensions

3.1 General
Unless stated otherwise below, DIN 4125:1990-11 – Ground anchors, temporary anchors and permanent anchors; design, construction and testing – applies to the planning and design of structures using the SUSPA Rock Anchor.
3.2 Permissible Anchor Load
DIN 4125 applies to the calculation of the permissible anchor load.
When determining the anchor load, evidence must be provided that the change of load in
the steel tendon due to frequently repetitive live loads (including wind) is not larger than
20% of the working load $F_w$.
In addition, the change of force may not exceed the value of 14.0 kN per strand (nominal
strand diameter 15.3 mm) or 15.0 kN per strand (nominal strand diameter 15.7 mm) due to
the dynamic behaviour of the tendon anchorage at the anchor head. Evidence will only be
required if the dynamic load is not covered by the prestressing.

3.3 Rock Anchors
The overall safety of the anchored rock body is the subject matter of rock stability
evidences; the anchor forces required for stability shall be determined by an expert.\footnote{Earthwork and foundation engineering experts shall be consulted to determine the static and constructive requirements and working loads. These experts do not have to belong to the surveillance authorities listed in Appendix 1 hereto.}

4 Regulations covering Execution

4.1 General
The SUSPA Rock Anchor may only be assembled and installed under the responsibility of
the technical supervisor of the applicant.
The applicant shall keep a list of structures secured with permanent anchors according to
this general construction supervision authority approval indicating the structure anchored
and the number of anchors installed.

4.2 Drilling the Boreholes
The drilling method is chosen subject to the specific rock properties.
The minimum borehole diameter must be chosen so that the anchor together with its
spacers including webs can be inserted without any problems.
Furthermore, it must be demonstrated that
- no joint movements will be anticipated, if the annular space between the borehole wall
and the smooth sheathing is injected with cement grout (e.g. if the fixed anchor length is
not limited as per Section 4.4.4), and
- the anticipated joint movements are smaller than the difference between the smooth
sheathing and the borehole diameter, if the annular space between the borehole wall and
the smooth sheathing is not injected with cement grout (e.g. if the fixed anchor length is
limited as per Section 4.4.4)
in the area of the free anchor length perpendicular to the borehole axis.
It is recommended to test the free passage of the boreholes by means of a template.

4.3 Insertion into the Borehole
If in the case of a cased borehole, the projecting end of the drill outfit has an edged
internal thread or a sharp-edged pipe end, the anchors prepared in accordance with
Section 2.2.1 may only be inserted into the borehole when an edge-free inserting trumpet
or a pipe nipple covering the internal thread of the casing completely has been placed onto
the projecting end of the drill outfit. Care must be taken that the corrosion protection is not
damaged when inserting the anchor.
Having injected the borehole with cement grout in accordance with section 4.4.2 and
placed the grout cap, it must be grouted – if necessary - at least up to the transition point
from bond length $l_1$ to tendon free length $l_2$ while pulling out the casings gradually.

4.4 Manufacturing the Ground Anchor
4.4.1 Cement Grout Composition of the Grout Body
The basic materials for the cement grout are cements with particular characteristics in
accordance with DIN 1164:2000-11, the following normal cements indicated in table 1
pursuant to DIN EN 197-1:2001-02, water as defined in DIN EN 447 and, where required,
generally construction supervision authority approved additives and concrete aggregates
in accordance with DIN 4226-1. The water-cement value must range between 0.35 and 0.7
and should be chosen as low as possible. The cement grout must be mixed mechanically, and must not segregate and lump before its injection.

Table 1: Normal cements according to DIN EN 197-1:2001-02

<table>
<thead>
<tr>
<th>Main cement type</th>
<th>Designation of the normal cement type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEM I</td>
<td>Portland cement</td>
</tr>
<tr>
<td>CEM II</td>
<td>Portland slag cement</td>
</tr>
<tr>
<td></td>
<td>CEM II/A-S</td>
</tr>
<tr>
<td></td>
<td>CEM II/B-S</td>
</tr>
<tr>
<td></td>
<td>Portland pozzolanic cement</td>
</tr>
<tr>
<td></td>
<td>CEM II/A-P</td>
</tr>
<tr>
<td></td>
<td>CEM II/B-P</td>
</tr>
<tr>
<td></td>
<td>Portland flue ash cement</td>
</tr>
<tr>
<td></td>
<td>CEM II/A-V</td>
</tr>
<tr>
<td></td>
<td>Portland slate cement</td>
</tr>
<tr>
<td></td>
<td>CEM II/A-T</td>
</tr>
<tr>
<td></td>
<td>CEM II/B-T</td>
</tr>
<tr>
<td></td>
<td>Portland limestone cement</td>
</tr>
<tr>
<td></td>
<td>CEM II/A-LL</td>
</tr>
<tr>
<td></td>
<td>Portland composite cement</td>
</tr>
<tr>
<td></td>
<td>CEM II/B-M (S-V)</td>
</tr>
<tr>
<td>CEM III</td>
<td>Blast furnace slag cement</td>
</tr>
<tr>
<td></td>
<td>CEM III/A</td>
</tr>
<tr>
<td></td>
<td>CEM III/B</td>
</tr>
</tbody>
</table>

If cement grout gets into direct contact with the prestressing strands, cement grout in accordance with DIN EN 447 shall be used. In addition, DIN EN 445 and DIN EN 446 shall be observed. This applies, for example, for temporary anchors or in case the hollow space between the steel tendon and the corrugated plastic pipe is grouted after insertion of the anchor into the borehole.

4.4.2 Manufacturing the Grout Body
The rock must be so compact that perfect manufacturing of the grout body will be ensured. This must be verified by special examinations (e.g. visual borehole inspection, gauge measurement of the grout level, geohydraulic test) to the extent required.

The mortar formula, grouting pressure and grouting operation shall be established in each individual case by the field engineer in consultation with the expert (cf annotation 1 on page 10) and the engineer based on the results of the rock explorations, geohydraulic tests and the findings following the drilling of the boreholes. The designated grouting method must be examined within the scope of the suitability test. The quantity of cement grout required for one anchor, its composition and the grouting pressure must be measured and recorded. It is recommended to use the form provided in Appendix A to DIN 4125.

The grout body shall be manufactured in accordance with DIN 4125, Section 7.3.3. Cement grouting of the borehole of downwardly inclined anchors may be carried out before the anchor is inserted. If cement grouting is carried out after insertion of the anchor into the borehole, grouting shall always be carried out from the deepest point, whereas ventilation shall always be carried out from the highest point of the grout body. The outer grouting pipe is used for grouting, whereas ventilation is provided via an outer ventilation pipe for upwardly inclined anchors. For upwardly inclined anchors the packer mounted outside of the sheathing must first be activated before grouting. To manufacture the grout body cement grout in accordance with DIN EN 447 shall be used. In addition, DIN EN 445 and DIN EN 446 shall be observed, if the hollow space between the steel tendon and the corrugated plastic pipe is grouted after installation of the anchor.

In case of a cased borehole, grouting may be carried out after injection of the casing with cement grout, with the pipes being slowly drawn while maintaining the necessary grouting pressure.

4.4.3 Grouting the Hollow Space within the Sheathings
Grouting shall always be carried out from the deepest point, whereas ventilation shall always be carried out from the highest point of the hollow space. The inner grouting pipe shall be injected with cement grout until bubble free cement grout escapes at the mouth of the borehole (downwardly inclined anchors) or through the inner ventilation pipe (upwardly inclined anchors).
If, in the case of an upwardly inclined anchor, grouting of the hollow space is designated in the area between the steel tendon and the smooth plastic sheathing, a short cement grout spout shall be injected first. After its hardening the remaining part of that hollow space shall be grouted by means of the inner grouting and the inner ventilation pipes.

With respect to permanent anchors with shop grouted, corrugated sheathing in the bond length, the hollow space in the area between the bond length and the anchor head shall still be grouted for downwardly inclined anchors. In case of an upwardly inclined anchor, grouting of that hollow space may be waived.

In respect of permanent anchors where the hollow space within the corrugated sheathing has not already been injected with cement grout at the shop (see Section 2.2.1.2), grouting may be carried out after insertion of the anchor into the borehole in the course of the manufacture of the grout body. This possibility is primarily used, if limited space conditions require a ductile anchor. In case of downwardly inclined anchors, the entire area between the end cap and the anchor head shall be grouted. In case of ascending anchors, the sheathings shall be grouted by means of an inner grouting pipe and in addition by means of an inner ventilation pipe. In case of an upwardly inclined anchor, grouting of the hollow space in the area between the steel tendon and the smooth plastic sheathing may be waived. Cement grout in accordance with DIN EN 447 shall be used both for inner grouting and the manufacture of the grout body for this type of anchor manufacture. In addition, DIN EN 445 and DIN EN 446 shall be observed.

4.4.4 Limitation of the Load Transfer Length

In general, the load transfer length shall be limited by the following methods:

a) by flushing out excess cement grout (e.g. with water or bentonite suspension) by means of a hose tightly mounted on the sheathing. The hose must be arranged so that the first lateral openings are positioned 50 cm above the designated grout body length l. Verification of this value must be confirmed in the protocol. The applied flushing pressure shall amount to about 4 bar.

b) by flushing out excess cement grout by means of a lance. The flushing lance, which is closed at the bottom and provided with side openings, must be inserted up to approx. 1.0 m above the designated grout body length l. The applied flushing pressure shall amount to about 4 bar.

c) by blocking the load transfer length by means of a packer. Suitability of the packer shall be demonstrated within the scope of a suitability test.

Methods a) and b) may also be used for downwardly inclined anchors. Method c) shall be applied for upwardly inclined ground anchors, but may also be used for downwardly inclined anchors. Limitation of the load transfer length may be waived, if conditions are in compliance with DIN 4125, section 7.5.

4.4.5 Post-Grouting

Post-grouting with cement suspension may be carried out in accordance with DIN 4125, Section 7.4.

Subsequently, the free anchor length shall be flushed free, e.g. with water or bentonite suspension.

4.5 Protective Measures against Corrosion on Site

4.5.1 The individual steps for the assembly of the anchor head on the construction site including corrosion protection measures shall be carried out in accordance with the description filed with the DIBt.

The following corrosion protection measures shall be carried out on the anchor head on the construction site.

4.5.2 Permanent Anchors

The area between the bearing plate and the upper end of the smooth plastic sheathing (anchor type G) or of the corrugated plastic sheathing (anchor type R) must be protected by means of a steel tube (anchor trumpet) welded to the bearing plate. For this purpose, the transition to the smooth plastic sheathing must be sealed by means of a lip seal in the case of anchors type G and the transition to the corrugated plastic pipe by means of two rings in the case of anchors type R (see Appendix 5).
The hollow space between the steel tendon and the bearing plate/steel tube shall be
injected with Nontribos MP-2 or vaseline "Cox GX". If the smooth or corrugated plastic
sheathing was injected with cement grout and Nontribos MP-2 was used as the anti-
corrosion compound, then the cement grout surface inside the plastic sheathing shall be
sealed with Icosit 277 beforehand.

After stressing the anchor, the anchor head and the excess protruding prestressing steel
shall be protected by means of an inner PE protection cap that will be screwed onto the
anchor head and whose hollow space shall also be injected with vaseline "Cox GX". The
inner protection cap between the bearing plate shall be sealed by means of a sealing
consisting of a Denso Bandage.

The outer steel protection cap including an underlying washer made of perbunan is
screwed onto the bearing plate as an additional protection measure. If the anchor head is
set in concrete, this outer protection cap may be waived.

If anchors must be restressed, care shall be taken that corrosion protection is properly
executed after restressing again, e.g. through injection of vaseline "Cox GX".

4.5.3 Temporary Anchors

The area between the bearing plate and the upper end of the smooth plastic sheathing
shall be protected by means of a steel tube (anchor trumpet) welded to the bearing plate,
with the transition to the smooth plastic sheathing having to be sealed by means of a lip
seal (see Appendix 8). After stressing the anchor, the anchor head and the excess
protruding prestressing steel shall be protected by means of an inner PE protection cap
that will be pushed onto the anchor head.

4.6 Stressing Operation

After sufficient hardening of the grout body, the anchors may be stressed. For this purpose,
a hollow piston jack is pushed onto the excess protruding strand. This jack is seated on the
anchor head of the anchor.

The 6 mm wedge slip occurring at the anchor head when transferring the stressing force
from the jack to the wedges shall be compensated by overstressing.

After the anchor has been determined and the stressing jack dismantled, the strands shall
be severed about 30 mm outside of the anchor head. The wedges of temporary anchors
are covered by means of a wedge locking plate screwed to the anchor head. The
supplementary corrosion protection measures are described in Section 4.5 hereof.

4.7 Suitability and Acceptance Tests, Supervision of the Installation

Suitability and acceptance tests shall be carried out on every construction site pursuant to
DIN 4125.

The suitability tests for permanent anchors shall be monitored by one of the surveillance
authorities listed in Appendix 1.

In the course of their surveillance activities associated with suitability and acceptance
tests, the commissioned geotechnical surveillance authority shall supervise at least
randomly the assembly of the permanent anchors on the construction site, especially the
corrosion protection measures to be carried out on site, e.g. the complete grouting of the
anchor head area with anti-corrosion compound.

If the annular space between the steel tendon and the corrugated plastic sheathing is only
injected with cement grout in the borehole (see Sections 2.2.1.2 and 4.4.3), the basic
functioning shall be controlled by the surveillance authority. In addition, the proper
execution shall be monitored by random checks. This shall be recorded in the test report.

The surveillance authority shall notify the building supervision authority in charge,
whenever facilities and staff on site do not assure proper installation. The beginning of
such work shall be reported to the building supervision authority in charge.
5 Provisions for Usage, Maintenance and Service

5.1 Restressing and Verifying the Anchor Force
The anchors may be restressed. For this purpose, a jack shall be used that is supported by 
the bearing plate via a stressing chair. The anchor head is lifted off of the bearing plate on 
top of a tensioning sleeve screwed onto its thread without loosening the wedges by means 
of the stressing jack. After the restressing distance has been reached, supporting shells 
(half shells) are inserted at the height of the restressing distance between the anchor head 
and the bearing plate, so that the restressing force is transferred from the anchor head to 
the bearing plate via the supporting shells. The anchor force of the stressed anchor may 
either be verified by the stressing device described for restressing operations or by means 
of a special testing jack that is directly screwed onto the thread of the anchor head. The 
anchor force that occurs in the moment when the anchor head is lifted off of the bearing 
plate (lift-off test) is measured.
Restressing of the anchor including loosening of the wedges is only permissible as a 
variant, if the wedge positions of the wedges resulting from the previous stressing 
operation are shifted by at least 15 mm outwards after restressing and anchoring. However, 
this kind of restressing is only possible, if the strands are sufficiently protruding the anchor 
head. This variant is especially used for temporary anchors where the anchor head 
normally has no external thread.

5.2 Verification
DIN 4125:1990-11, section 13, applies.
If required, verification should be assumed by the surveillance authority which has already 
performed the suitability tests.

Henning
Certified:
W. Faller
One of the following surveillance authorities in soil mechanics shall be commissioned to perform the suitability test:

- Baugrundinstitut Smoltczyk & Partner GmbH, Stuttgart
- Bundesanstalt für Wasserbau, Abteilung Erd- und Grundbau, Karlsruhe
- Deutsche Forschungsgesellschaft für Bodenmechanik (Degebo) Berlin
- Erdbaulaboratorium Essen
- Grundbauingenieure Steinfeld und Partner, Erdbaulaboratorium Hamburg
- Forschungs- und Materialprüfungsanstalt Baden-Württemberg - Otto-Graf-Institut -, Abteilung 4, Geotechnik, Stuttgart
- Institut für Grundbau und Bodenmechanik, TU Hannover
- Institut für Bodenmechanik und Felsmechanik, Universität Karlsruhe
- Versuchsanstalt für Bodenmechanik und Grundbau der TH Darmstadt
- Grundbau-Institut, TU Berlin
- Institut für Grundbau, Bodenmechanik, Felsmechanik und Verkehrswasserbau, TH Aachen
- Lehrstuhl und Prüfamt für Grundbau, Bodenmechanik und Felsmechanik, TU München
- Grundbauinstitut der Landesgewerbeanstalt Bayern, Nürnberg
- Institut für Grundbau und Bodenmechanik der TU Braunschweig
- Lehrstuhl für Grundbau und Bodenmechanik der Ruhr-Universität Bochum
- Lehrstuhl für Grundbau und Bodenmechanik/Geotechnik der TU Cottbus
- Laboratorium für Bodenmechanik, Erd- und Grundbau der Gesamthochschule Wuppertal
- Ingenieurbüro Dr. -Ing. J. Hanisch, Berlin
- Ingenieurbüro für Grundbau und Bodenmechanik Dr.-Ing. Elmiger und Dr.-Ing. Karstedt GmbH Berlin
- GuD Geotechnik und Dynamik Consult GmbH, Berlin
Anchor Head and Plastic Sheathing of the Free Anchor Length

For types 6-15 to 6-22 the anchor trumpet has a reduction piece (steel) for the lip seal.

---

<table>
<thead>
<tr>
<th>Type of anchor</th>
<th>No. of strands</th>
<th>Outer protection cad (steel)</th>
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SUSPA-DSI GmbH
Max-Planck-Ring 1
40764 Langenfeld

SUSPA Permanent Rock Anchor
Anchor head design
Type G 6-1 to 6-22

Annex 4
to the general construction supervising authority approval No. Z-20.1-53
of 25. August 2003
Type R: with continuously corrugated sheathing
Anchor Head and Plastic Sheathing of the Free Anchor Length

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**Diagram Description:***
- **SUSPA anchor head incl. thread**
- **Sealing washer (perban)**
- **Seal (Denso Bandage)**
- **2 rings (chloroprene rubber, closed cell)**
  - Inner diameter = \( \varnothing \ i \)
  - Thickness = \( s \)
- **Grouting or post-grouting pipe**
- **Screws with plastic washers**
- **Ventilation drilling with plug**
- **Outer protection cap**
  - a) Steel S235JR complying with EN 10025
  - b) Stainless steel
    - Material No.: 1.4301
    - or No. 1.4541
    - or No. 1.4571
- **Inner PE protection cap, grouted with anti-corrosive agent**
- **Bearing plate (steel S235JR - complying with DIN EN 10025)**
- **Anchor trumpet**
  - (steel S235 complying with DIN EN 10025),
  - grouted with anti-corrosive agent

---

**Table:***

<table>
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<tr>
<th>Type of anchor</th>
<th>Number of strands</th>
<th>Outer protection cap (steel)</th>
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**Notes:**
- SUSPA-DSI GmbH
- Max-Planck-Ring 1
- 40764 Langenfeld
- SUSPA-Permanent Rock Anchor
- Anchor head design
- Type R 6-1 to 6-22

**Annex 5:**
- to the general construction supervising authority approval No. Z-20.1-53
- of 25. August 2003
The steel transition structure is to be dimensioned based on the evidence provided. In case of deviating support conditions, e.g., enlargement of diameter F or G, the bearing plate is to be dimensioned based on the evidence provided.
Anchor head and plastic duct of the free anchor length

- SUSPA anchor head
- Wedge locking plate
- PE protection cap
- Bearing plate
- Anchor trumpet (steel)
- Lip seal (perbunan) glued with anchor trumpet
- Grouling or post-grouting pipe
- Strands
- Plastic duct

<table>
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<tr>
<th>Type of anchor</th>
<th>Number of strands</th>
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SUSPA Temporary Rock Anchor
Anchor head design
Type 6-12 to 6-22

Annex 8
to the general construction supervising authority approval No. Z-20.1-53
of 25. August 2003
### Type 1
Bearing plate cast in concrete
Anchor head and bearing plate according to the SUSPA Strand Post-Tensioning System

**Bearing plate material:**
Steel S235JR complying with DIN EN 10025

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<th>Number of strands</th>
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<th>ØB</th>
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### Type 2 (incl. aperture)
Bearing plate with support on steel transition structure
Pipe section (inner diameter = G) as steel transition structure
Web (clear distance = G) as steel transition structure

The steel transition structure is to be dimensioned based on the evidence provided.

In case of deviating support conditions, e.g. enlargement of diameter F or G, the bearing plate is to be dimensioned based on the evidence provided.

<table>
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The bearing plate is to be dimensioned based on the evidence provided.
SUSPA temporary rock anchor, type 6-2 to 6-10
The design complies with DIN 4125: 1990-10

Support for anchor head

Type 1
Bearing plate cast in concrete

Type 2 (incl. aperture)
Bearing plate with direct support on concrete

Anchor head design for single duct

- Bearing plate material: steel S235JR complying with DIN 10 025
- In case of deviating support conditions, e.g. enlargement of diameter F, the bearing plate is to be dimensioned based on the evidence provided.

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<th>Anchor type</th>
<th>No. of strands</th>
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Dimensions in mm
### Anchor Head Support Variants for Temporary Anchors

| K1 | Support on ||- belts inclined |
|----|------------|
| K2 | Support on waling anchor head inclined |

#### K3: Anchor head countersunk
(for \( \text{I} = 400 \))

#### K4: Support on \( \text{I} \)- anchor head inclined

#### K5: Anchor head on bored pile - milled bearing surface

#### K6: Anchor head on bored pile - partly milled bearing surface