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European Assessment Document for

Kits for construction of a rock and soil anchor – Kits with thread bars of steel or prestressing steel

Translation of the EAD title in the following official languages of the European Union

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) № 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The “Kits for construction of a rock and soil anchor – Kits with thread bars of steel or prestressing steel” (in the text designated as “Kit for rock and soil anchor”) is intended to construct rock and soil anchors. An example of a rock and soil anchor is shown in Figure 1.1.1.

The components of the product, "Kit for rock and soil anchor", are put together to assemble anchorages and coupling assemblies, and to apply corrosion protection systems to be incorporated in the construction works. According to the intended use, see Clause 1.2.1, there are three kinds of the Kit for rock and soil anchor:

- Kit for rock and soil anchor for temporary use
- Kit for rock and soil anchor for temporary use with extended working life
- Kit for rock and soil anchor for permanent use.

The components of these kinds of the Kit for rock and soil anchor are:

Components of Kit for rock and soil anchor for temporary use:

Mandatory components:

- Continuously threaded steel bar or continuously threaded prestressing steel bar, see Clause 1.1.1. The continuous thread is provided by ribs, hot rolled over the entire length of the bar – thread bar. The load bearing capacity of the Kit for rock and soil anchor is determined by the thread bar.
- Components for anchorages for load transfer to the structure, see Clause 1.1.2
- Couplers to connect the thread bars in coupling assemblies, see Clause 1.1.3.
- Spacers, see Figure 1.1.1 and Clause 1.1.8, for maintaining a distance between thread bar and drillhole wall. These are considered as ancillary components but are not needed for preforming the tests.
- Injection system for filling the residual void of the drillhole, see Figure 1.1.1. It is considered as ancillary component, see Clause 1.1.8, but not needed for preforming the tests.
- Components for corrosion protection of free length according to EN 1537[1] and the Manufacturer’s Product Installation Instructions, MPII.

Optional components:

- Steel cap, plastic cap, or coating with corrosion protection filling material at the anchorage and corrosion protection filling material for filling voids at the anchorage. These are considered ancillary components, see Clause 1.1.8, but are not needed for preforming the tests. Application of these components is optional as they are related to the condition on site.
- Seal at transition anchorage to free length. Its application is optional as it is related to the condition on site. The seal is not needed for performing the tests.

Product to install the Kit for rock and soil anchor:

- Cement mortar, see Figure 1.1.1 and Clause 1.1.7, for filling the residual void of the drillhole. Cement mortar is provided at the construction site and not subject of EAD.

Components of Kit for rock and soil anchor for temporary use with extended working life:

Mandatory components:

- Thread bar in steel or thread bar in prestressing steel bar, see Clause 1.1.1. The load bearing capacity of the Kit for rock and soil anchor is determined by the thread bar.
- Components for anchorages for load transfer to the structure, see Clause 1.1.2
- Couplers to connect the thread bars in coupling assemblies, see Clause 1.1.3.

[1] All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in chapter 4.

- Spacers, see Figure 1.1.1 and Clause 1.1.8, for maintaining a distance between thread bar and drillhole wall. These are considered as ancillary components but are not needed for preforming the tests.
- Injection system for filling the residual void of the drillhole, see Figure 1.1.1. It is considered as ancillary component, see Clause 1.1.8, but not needed for preforming the tests.
- Components for corrosion protection of free length according to EN 1537 and the MPII.
- Seal at transition anchorage to free length. The seal is not needed for performing the tests.
- Steel cap, plastic cap, or coating with corrosion protection filling material at the anchorage and corrosion protection filling material for filling voids at the anchorage. These are considered ancillary components, see Clause 1.1.8, but are not needed for preforming the tests.

Product to install the Kit for rock and soil anchor:

- Cement mortar, see Figure 1.1.1 and Clause 1.1.7, for filling the residual void of the drillhole. Cement mortar is provided at the construction site and not subject of EAD.

Components of Kit for rock and soil anchor for permanent use:

Mandatory components:

- Thread bar in steel or thread bar in prestressing steel bar, see Clause 1.1.1. The load bearing capacity of the Kit for rock and soil anchor is determined by the thread bar.
- Components for anchorages for load transfer to the structure, see Clause 1.1.2
- Couplers to connect the thread bars in coupling assemblies, see Clause 1.1.3.
- Corrugated plastic sheathing, see Clause 1.1.5, slipped over the thread bar.
- Inside the corrugated plastic sheathing a plastic cord is wound helically around the thread bar, see Figure 1.1.1 and Clause 1.1.5. Alternatively, plastic spacers can be installed.
- Cement grout, i.e., inner grout, see Figure 1.1.1 and Clause 1.1.5, is injected inside the corrugated plastic sheathing.
- Heat shrinking sleeve, see Clause 1.1.6. The heat shrinkable sleeve is shrunk on to protect the coupling assembly.
- Spacers, see Figure 1.1.1 and Clause 1.1.8, for maintaining a distance between thread bar and drillhole wall or corrugated plastic sheathing and drillhole wall. These are considered as ancillary components but are not needed for preforming the tests.
- Injection system for filling the residual void of the drillhole, see Figure 1.1.1. It is considered as ancillary component, see Clause 1.1.8, but not needed for preforming the tests.
- Corrosion protection of free length according to EN 1537 and the MPII.
- Seal at transition anchorage to free length.
- Steel cap, plastic cap, or coating with corrosion protection filling material at the anchorage and corrosion protection filling material for filling voids at the anchorage. These are considered ancillary components, see Clause 1.1.8, but are not needed for preforming the tests.

Product to install the Kit for rock and soil anchor:

- Cement mortar, see Figure 1.1.1 and Clause 1.1.7, for filling the residual void of the drillhole. Cement mortar is provided at the construction site and not subject of EAD.

Regarding cement mortar and inner grout, see Figure 1.1.1, distinction is made between:

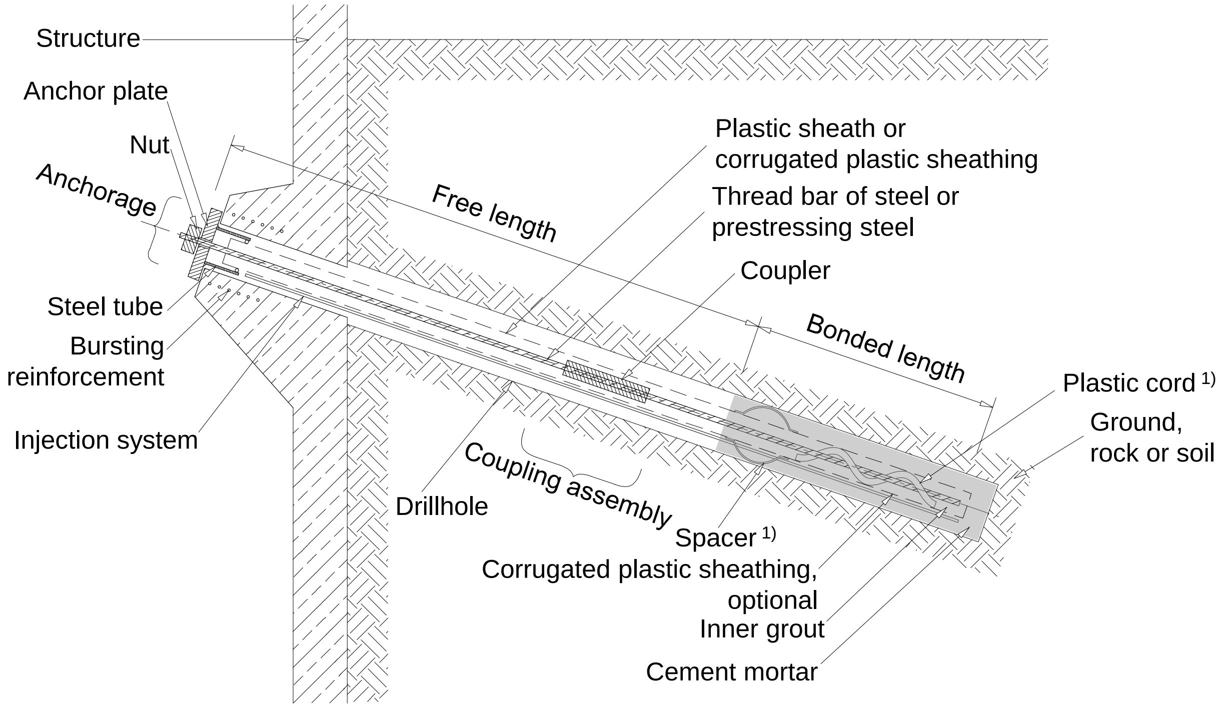
- Inner grout, i.e., cement grout inside a corrugated plastic sheathing, see Clause 1.1.5, and
- Cement mortar filling the residual void of the drillhole, see Clause 1.1.7. Cement mortar is not subject of EAD.

Installation

On site, the Kit for rock and soil anchor is installed by:

- The kit components are delivered to the construction site.

- Thread bars, possibly provided with grouted corrugated plastic sheathing, are jointed with couplers to the intended length of the rock and soil anchor.
- Corrosion protection is applied to the assembled thread bars.
- The assembled thread bars are equipped with spacers and injection system.
- The thread bars, finally assembled, are inserted into a predrilled hole – drillhole.
- With the injection system the drillhole is filled with cement mortar, which acts both as corrosion protection and as load transfer to rock or soil in the bonded length. The cement mortar is provided at the construction site.
- Characteristic to a rock and soil anchor is an unbonded free length according to Figure 1.1.1. For appropriate working of a prestressed rock and soil anchor, the free length is important.
- At the air-side end, the anchorage with corrosion protection is installed.
- The rock and soil anchor is stressed.
- The corrosion protection at the anchorage is completed at the stressed rock and soil anchor.



1) Highly enlarged representations

Figure 1.1.1 Rock and soil anchor with thread bar in steel or prestressing steel – Schematic

The Kit for rock and soil anchor is covered neither by a harmonised European standard (hEN) nor by any other European Assessment Document (EAD) than the present one.

EN 1537 is not a harmonised standard but provides a reference to some methods and criteria for the assessment.

Concerning product packaging, transport, storage, maintenance, replacement, and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on transport, storage, maintenance, replacement, and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer’s instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer’s stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.1.1 Thread bar

1.1.1.1 Thread bar in steel – General

The thread bar in steel is a hot rolled and continuously threaded steel bar and is specifically hot rolled for the Kit for rock and soil anchor. The thread is provided by hot rolled ribs. Reference diameter and reference mechanical characteristics of the thread bar are introduced, see Clause 1.1.1.2. Reference diameters shall be within 15 mm to 80 mm. Within these limits, any series of reference diameters are covered by the EAD. An example of typical series of reference diameters is given in Table 1.1.1.1.1, together with reference mechanical characteristics. These reference values are employed in product assessment.

Table 1.1.1.1.1 Thread bar in steel – Diameters and mechanical characteristics

Example of reference diameters of thread bar $\varnothing_{ref}$	Reference yield strength $R_{e,\,ref}$	Reference tensile strength $R_{m,\,ref}$
mm	MPa	MPa
18 – 22 – 25 – 28 – 30 – 35 – 43 – 50 – 57.5 – 63.5 – 75	≤ 670	≤ 800

1.1.1.2 Thread bar in steel – Reference values

Reference values are either:

- Nominal diameters, nominal yield strength, and nominal tensile strength of the thread bars taken from the MPII.
- If these nominal values are not provided, test specimens available shall be measured and tested according to Annex A to determine the reference values.

Determined are:

- $\varnothing_{ref}$ according to Equation 1.1.1.2.1
- $S_{s,\,ref}$ according to Equation 1.1.1.2.2
- $R_{e,\,ref}$ according to Equation 1.1.1.2.3
- $R_{m,\,ref}$ according to Equation 1.1.1.2.4.

$\varnothing_{ref} = \varnothing_{nom}$ from MPII or
$\varnothing_{ref}$ according to Annex A — Equation 1.1.1.2.1

$$S_{s,\,ref} = \frac{\varnothing_{ref}^2 \cdot \pi}{4}$$ Equation 1.1.1.2.2

$R_{e,\,ref} = R_{e,\,nom}$ from MPII or
$R_{e,\,ref}$ according to Annex A — Equation 1.1.1.2.3

$R_{m,\,ref} = R_{m,\,nom}$ from MPII or
$R_{m,\,ref}$ according to Annex A — Equation 1.1.1.2.4

Where

$S_{s,\,ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel

$\varnothing_{ref}$ .... mm..................... Reference diameter of thread bar in steel

$R_{e,\,nom}$ ....MPa..................... Nominal yield strength of thread bar in steel

$R_{e,\,ref}$..........MPa.................... Reference yield strength of thread bar in steel

$R_{m,\,nom}$........MPa.................... Nominal tensile strength of thread bar in steel

$R_{m,\,ref}$..........MPa.................... Reference tensile strength of thread bar in steel.

1.1.1.3 Thread bar in prestressing steel – General

The thread bar in prestressing steel is a hot rolled and continuously threaded prestressing steel bar and is specifically hot rolled for the Kit for rock and soil anchor. The thread is provided by hot rolled ribs. For purpose of assessment, reference diameter and reference mechanical characteristics of the thread bar are introduced, see Clause 1.1.1.4. Reference diameters shall be within 15 mm to 50 mm. Within these limits, any series of reference diameters are covered by the EAD. An example of typical series of reference diameters is given in Table 1.1.1.3.1, together with reference mechanical characteristics.

Table 1.1.1.3.1 Thread bar in prestressing steel – Diameters and mechanical characteristics

Example of reference diameters of thread bar $\varnothing_{ref}$	Reference yield strength $R_{p0.1,\,ref}$	Reference tensile strength $R_{m,\,ref}$
mm	MPa	MPa
17.5 – 26.5 – 32 – 36 – 40 – 47	≤ 950	≤ 1 050

1.1.1.4 Thread bar in prestressing steel – Reference values

Reference values are either:

– Nominal diameters, nominal yield strength, and nominal tensile strength of the thread bars taken from the MPII.

– If these nominal values are not provided, test specimens available shall be measured and tested according to Annex B to determine the reference values.

Determined are:

– $\varnothing_{ref}$ according to Equation 1.1.1.4.1

– $S_{y,\,ref}$ according to Equation 1.1.1.4.2

– $R_{p0.1,\,ref}$ according to Equation 1.1.1.4.3

– $R_{m,\,ref}$ according to Equation 1.1.1.4.4.

$\varnothing_{ref} = \varnothing_{nom}$ from MPII or
$\varnothing_{ref}$ according to Annex B — Equation 1.1.1.4.1

$$S_{y,\,ref} = \frac{\varnothing_{ref}^2 \cdot \pi}{4}$$ Equation 1.1.1.4.2

$R_{p0.1,\,ref} = R_{p0.1,\,nom}$ from MPII or
$R_{p0.1,\,ref}$ according to Annex B — Equation 1.1.1.4.3

$R_{m,\,ref} = R_{m,\,nom}$ from MPII or
$R_{m,\,ref}$ according to Annex B — Equation 1.1.1.4.4

Calculated with these reference values are:

– $F_{p0.1,\,ref}$ according to Equation 1.1.1.4.5.

– $F_{m,\,ref}$ according to Equation 1.1.1.4.6.

$$F_{p0.1,\,ref} = \frac{R_{p0.1,\,ref} \cdot S_{y,\,ref}}{1\,000}$$ Equation 1.1.1.4.5

$$F_{m,\,ref} = \frac{R_{m,\,ref} \cdot S_{y,\,ref}}{1\,000}$$ Equation 1.1.1.4.6

Where

$S_{y,\,ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in prestressing steel

$\varnothing_{ref}$ .... mm .... Reference diameter of thread bar in prestressing steel

$R_{p0.1,\,nom}$ ...... MPa .... Nominal yield strength of thread bar in prestressing steel

$R_{p0.1,\,ref}$ .... MPa .... Reference yield strength of thread bar in prestressing steel

$R_{m,\,nom}$ .... MPa .... Nominal tensile strength of thread bar in prestressing steel

$R_{m,\,ref}$ .... MPa .... Reference tensile strength of thread bar in prestressing steel

$F_{p0.1,\,ref}$ .... kN .... Reference 0.1 % proof force of thread bar in prestressing steel

$F_{m,\,ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel.

1.1.2 Components for anchorage

The anchorage at the airside end of the rock and soil anchor transfers the load from the rock and soil anchor to the structure. Anchorage components are made of steel and include:

- Kit for rock and soil anchor without bursting reinforcement:
  - Nut for thread bar
  - Anchor plate

    A steel tube is leak tightly welded to the anchor plate for corrosion protection of the transition free length to anchorage.
- Kit for rock and soil anchor with bursting reinforcement:
  - Nut for thread bar
  - Anchor plate

    A steel tube is leak tightly welded to the anchor plate for corrosion protection of the transition free length to anchorage.
  - Bursting reinforcement.

Details on bursting reinforcement and whether the Kit for rock and soil anchor is without bursting reinforcement or the Kit for rock and soil anchor is with bursting reinforcement are given in the MPII.

1.1.3 Coupler

The coupler joints two thread bars in a coupling assembly. The coupler is made of steel.

Included are couplers provided with means to prevent unscrewing, e.g., set screws or heat shrinking sleeve.

1.1.4 Corrosion protection system

Three corrosion protection systems are considered for the Kit for rock and soil anchor, in relation with the categories of intended use, see Clause 1.2.1:

- Temporary corrosion protection
- Temporary corrosion protection with extended working life
- Permanent corrosion protection.

The components that are part of each of the three corrosion protection systems for rock and soil anchors are specified in EN 1537 and the MPII.

1.1.5 Corrugated plastic sheathing – Inner grout

The corrugated plastic sheathing is employed for permanent corrosion protection for the Kit for rock and soil anchor for permanent use. It provides a resistant encapsulation of thread bar and inner grout for corrosion protection and by the corrugation for load transfer from the inner grout to the cement mortar. The corrugated plastic sheathing shall be in accordance with EN 1537.

NOTE See Clause 1.1 and Figure 1.1.1 for the distinction between inner grout and cement mortar.

For Kit for rock and soil anchor for permanent use the encapsulation of the thread bar with the grouted corrugated plastic sheathing is prepared in a workshop or equivalent controlled conditions in accordance with EN 1537. The thread bar is provided with a wound-on plastic cord or plastic spacers to maintain the distance between thread bar and corrugated plastic sheathing. The corrugated plastic sheathing is slipped on the thread bar. At one end of the corrugated plastic sheathing a plastic cap with an inlet and at the other end a vent cap are connected to the corrugated plastic sheathing. The void between thread bar and corrugated plastic sheathing is grouted – inner grout – with the inclined thread bar from bottom to top as specified by EN 446 and EN 1537. Cover of inner grout on thread bar shall be ≥ 5 mm and crack width in inner grout shall be limited. Inner grout serves as corrosion protection and for load transfer from thread bar to corrugated plastic sheathing.

1.1.6 Heat shrinking sleeve

Heat shrinking sleeve provides for corrosion protection of the coupling assembly and comprises:

- A polymeric backing that shrinks once exposed to elevated temperatures. The polymer backing is shaped as sleeve, similar to a flexible hose.
- The inner surface of the polymer backing is provided with an adhesive.

The EAD is only applicable to kits with heat shrinking sleeves, where at least one size of the heat shrinking sleeves can be shrunk on a 100 mm diameter cylinder.

1.1.7 Cement mortar

Cement mortar provides for corrosion protection and for load transfer from thread bar to drillhole wall or corrugated plastic sheathing to drillhole wall. Cement mortar is provided on the construction site and is not subject of assessment within EAD. Cement mortar shall be in accordance with the specifications of EN 1537.

Chemical agents that are aggressive to the cement mortar are considered by the use of cements designated for this aggressiveness.

NOTE 1 Aggressive chemical agents to which cement mortar cannot resist are possible.

NOTE 2 The aggressiveness of the chemical agents can be determined according to EN 206.

1.1.8 Ancillary components

For the outer cover of cement mortar, spacers provide the necessary distance between thread bar and drillhole or between corrugated plastic sheathing and drillhole.

The injection system comprises hoses and valves to fill the residual void of the drillhole.

Steel cap, plastic cap, and corrosion protection filling material are to complete the corrosion protection of the rock and soil anchor at the anchorage and further provide mechanical protection to the installed rock and soil anchor.

1.2 Information on the intended uses of the construction product

1.2.1 Intended uses

The rock and soil anchor constructed with the Kit for rock and soil anchor is intended to stabilise rock and soil by active introduction of prestressing forces. The Kit for rock and soil anchor is intended for the uses of Table 1.2.1.1.

Table 1.2.1.1 Categories of intended use

№	Category of intended use
1	Kit for rock and soil anchor for temporary use
2	Kit for rock and soil anchor for temporary use with extended working life
3	Kit for rock and soil anchor for permanent use

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the Kit for rock and soil anchor for the intended use of up to 2 years for temporary rock and soil anchors, up to 7 years for temporary rock and soil anchors with extended working life, and up to 100 years for permanent rock and soil anchors when installed in the works, provided that the Kit for rock and soil anchor is subject to appropriate installation, see Clause 1.1. These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as defined by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

1.3.1 Temporary rock and soil anchors

Temporary rock and soil anchors are rock and soil anchors that are in use for up to two years. Subject to changes in the corrosion protection system, the working life of temporary rock and soil anchors can be extended by a limited time period. Temporary rock and soil anchors with extended working life are rock and soil anchors which are in use for up to seven years.

NOTE The period of two years is taken from EN 1537.

1.3.2 Permanent rock and soil anchors

Permanent rock and soil anchors are rock and soil anchors that are in use for more than two years.

NOTE The period of two years is taken from EN 1537.

1.3.3 MPII

MPII are the Manufacturer's Product Installation Instructions.

[2] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

1.3.4 Symbols

1.3.4.1 Reference values

- $\varnothing_{ref}$ .... mm .... Reference diameter of thread bar in steel or prestressing steel
- $F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel
- $F_{p0.1, ref}$ .... kN .... Reference 0.1 % proof force of thread bar in prestressing steel
- $R_{e, nom}$ .... MPa .... Nominal yield strength of thread bar in steel
- $R_{e, ref}$ .... MPa .... Reference yield strength of thread bar in steel
- $R_{m, nom}$ .... MPa .... Nominal tensile strength of thread bar in steel or prestressing steel
- $R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar in steel or prestressing steel
- $R_{p0.1, nom}$ ...... MPa .... Nominal yield strength of thread bar in prestressing steel
- $R_{p0.1, ref}$ .... MPa .... Reference yield strength of thread bar in prestressing steel
- $S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel
- $S_{y, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in prestressing steel.

1.3.4.2 Resistance to static load

- Δs .... mm .... Displacement between thread bar and coupler or anchorage
- $F_{m, act}$ .... kN .... Actual maximum force of thread bar in prestressing steel
- $F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel
- F_{Tu} .... kN .... Maximum force in static load test
- $R_{m, act}$ .... MPa .... Actual tensile strength of thread bar in steel
- $R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar in steel
- r_{ta}, r_{tn} ....—...................... Ratios
- $S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel.

1.3.4.3 Resistance to fatigue

- $2 \cdot \sigma_a$ .... MPa .... Stress range in fatigue test, i.e., two times the stress amplitude
- $F_{m, act}$ .... kN .... Actual maximum force, determined in tensile test according to EN ISO 15630-3 on a specimen adjacent to the specimen for the fatigue test
- $F_{m, ref}$ .... kN .... Reference maximum force of thread bar
- F_{max} .... kN .... Upper force in fatigue test
- F_r .... kN .... Force range in fatigue test
- F_{up} .... kN .... Upper force in fatigue test
- $R_{e, ref}$ .... MPa .... Reference yield strength of the thread bar in steel
- $R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar in steel
- $S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel
- $S_{y, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in prestressing steel.

1.3.4.4 Load transfer to the structure

- $F_{u, br, s}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in steel
- $F_{u, 0, s}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in steel
- $F_{u, br, y}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in prestressing steel

$F_{u, 0, y}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in prestressing steel

$R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar in steel

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel

$F_{m, ref}$ .... kN .... Reference maximum force of thread bar

$f_{cm, e}$ .... MPa .... Concrete compressive strength at time of end of load transfer test

$f_{cm, 0}$ .... MPa .... Reference concrete compressive strength

$r_{LT, br, s}$ .... — .... Ratio for specimen with bursting reinforcement for thread bar in steel

$r_{LT, 0, s}$ .... — .... Ratio for specimen without bursting reinforcement for thread bar in steel

$r_{LT, br, y}$ .... — .... Ratio for specimen with bursting reinforcement for thread bar in prestressing steel

$r_{LT, 0, y}$ .... — .... Ratio for specimen without bursting reinforcement for thread bar in prestressing steel.

1.3.4.5 Heat shrinking sleeve

A_0 .... N/mm .... Peel strength to steel surface at ambient temperature prior to burial in soil

A_6 .... N/mm .... Peel strength to steel surface at ambient temperature after 6 months buried in soil

A_{70} .... N/mm .... Peel strength to steel surface at 23 °C after 70 days ageing as arithmetic mean of three results

A_{100} .... N/mm .... Peel strength to steel surface at 23 °C after 100 days ageing as arithmetic mean of three results

A_T .... N/mm .... Peel strength to steel surface at 23 °C without artificial ageing

E_0 .... % .... Elongation at break at ambient temperature prior to burial in soil and at ambient temperature without artificial ageing

E_6 .... % .... Elongation at break at ambient temperature after 6 months buried in soil

E_{70} .... % .... Elongation at break at ambient temperature after 70 days ageing

E_{100} .... % .... Elongation at break at ambient temperature after 100 days ageing

P_{70} .... N/mm .... Peel strength layer to layer at 23 °C after 70 days ageing as arithmetic mean of three results

P_{100} .... N/mm .... Peel strength layer to layer at 23 °C after 100 days ageing as arithmetic mean of three results

P_T .... N/mm .... Peel strength layer to layer at 23 °C without artificial ageing

S_0 .... N/mm .... Tensile strength at ambient temperature prior to burial in soil and at ambient temperature without artificial ageing

S_6 .... N/mm .... Tensile strength at ambient temperature after 6 months buried in soil

S_{70} .... N/mm .... Tensile strength at ambient temperature after 70 days ageing

S_{100} .... N/mm .... Tensile strength at ambient temperature after 100 days ageing

T_{max} .... °C .... Maximum continuous operating temperature.

1.3.4.6 Crack width in inner grout

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel

$R_{e, ref}$ .... MPa .... Reference yield strength of the thread bar in steel

$R_{m, ref}$ .... MPa .... Reference tensile strength of the thread bar in steel

$F_{p0.1, ref}$ .... kN .... Reference 0.1 % proof force of thread bar in prestressing steel

$F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel.

1.3.4.7 Mass per metre – Thread bar in steel

$S_{s, ref}$ .... mm² .... Reference cross-sectional area of thread bar in steel
m_{ref} .... kg/m .... Reference mass per metre of thread bar in steel
m .... kg/m .... Actual mass per metre of thread bar in steel
ρ .... kg/m³ .... Density, 7 850 kg/m³, for hot rolled thread bar.

1.3.4.8 Mass per metre – Thread bar in prestressing steel

M .... kg/m .... Actual mass per metre of thread bar in prestressing steel
M_{ref} .... kg/m .... Reference mass per metre of thread bar in prestressing steel
ρ .... kg/m³ .... Density, 7 850 kg/m³, for the hot rolled thread bar
$S_{y, ref}$ .... mm² .... Reference cross-sectional area of thread bar in prestressing steel.

1.3.4.9 Surface geometry – Thread bar in steel

$a_{1/4}$ .... mm .... Rib height at quarter-point
a_m .... mm .... Rib height at mid-point
$a_{3/4}$ .... mm .... Rib height at three-quarters-point
β .... ° .... Rib inclination
b .... mm .... Width of rib
c .... mm .... Rib spacing
Σe_i .... mm .... Part of the circumference without ribs
f_R .... — .... Relative rib area.

1.3.4.10 Surface geometry – Thread bar in prestressing steel

$a_{1/4}$ .... mm .... Rib height at quarter-point
a_m .... mm .... Rib height at mid-point
$a_{3/4}$ .... mm .... Rib height at three-quarters-point
β .... ° .... Rib inclination
b .... mm .... Width of rib
c .... mm .... Rib spacing
Σe_i .... mm .... Part of the circumference without ribs
f_R .... — .... Relative rib area.

1.3.4.11 Bond strength – Thread bar in steel

$F_{mean, d}$ .... N .... Mean value of all F_{mean} of reference diameter d
$F_{0.01}$ .... N .... Force in pull-out test at a slip of 0.01 mm
$F_{0.1}$ .... N .... Force in pull-out test at a slip of 0.1 mm
F_1 .... N .... Force in pull-out test at a slip of 1 mm
τ_{dk} .... MPa .... Characteristic bond strength for reference diameter d
d .... mm .... Reference diameter of thread bar in steel
l .... mm .... Length of bonded section in pull-out test
$f_{cm, 0}$ .... MPa .... Reference compressive strength of concrete
$f_{cm, e}$ .... MPa .... Actual mean compressive strength of concrete at end of test.

1.3.4.12 Strength characteristics – Thread bar in steel

R_m/R_e .... — .... Ratio tensile strength to yield strength

A_{gt} ....% .... Elongation at maximum force in tensile test
E ....MPa .... Modulus of elasticity
$(R_m/R_e)_k$........—....................... Characteristic value of the ratio tensile strength to yield strength
R_e..............MPa .... Yield strength in tensile test
$R_{e,\ k}$ ....MPa .... Characteristic value of yield strength
$R_{e,\ ref}$...........MPa .... Reference yield strength of thread bar in steel
R_m ....MPa .... Tensile strength in tensile test
$R_{m,\ k}$............MPa .... Characteristic value of tensile strength
$R_{m,\ ref}$ ....MPa .... Reference tensile strength of thread bar in steel
$S_{s,\ ref}$ ....mm^2 .... Reference cross-sectional area of thread bar in steel
r_{Rm}, r_{Re}..........—....................... Ratios.

1.3.4.13 Strength characteristics – Thread bar in prestressing steel

A_{gt} ....% .... Elongation at maximum force in tensile test
E ....MPa .... Modulus of elasticity
$F_{p0.1}$............ kN .... 0.1 % proof force in tensile test
$F_{p0.1,\ k}$ .... kN .... Characteristic value of 0.1 % proof force
$F_{p0.1,\ ref}$......... kN .... Reference 0.1 % proof force of thread bar
F_m................ kN .... Maximum force in tensile test
$F_{m,\ k}$ .... kN .... Characteristic value of maximum force
$F_{m,\ ref}$ .... kN .... Reference maximum force of thread bar
r_{Fm}, r_{Fp} ....—....................... Ratios.

1.3.4.14 Modulus of elasticity – Thread bar in steel

E ....MPa .... Modulus of elasticity
$R_{m,\ ref}$ ....MPa .... Reference tensile strength of thread bar
ε_{50} ....% .... Extension at 0.50 · $R_{m,\ ref}$ in force-extension diagram
ε_{20} ....% .... Extension at 0.20 · $R_{m,\ ref}$ in force-extension diagram
$S_{s,\ ref}$ ....mm^2 .... Reference cross-sectional area of thread bar in steel.

1.3.4.15 Modulus of elasticity – Thread bar in prestressing steel

E ....MPa .... Modulus of elasticity
$S_{y,\ ref}$ ....mm^2 .... Reference cross-sectional area of thread bar in prestressing steel.

1.3.4.16 Elongation at maximum force – Thread bar in steel

$A_{gt,\ k}$..............% .... Characteristic value of elongation at maximum force.

1.3.4.17 Stress relaxation – Thread bar in prestressing steel

$\overline{F}_m$................ kN .... Mean maximum force, determined in tensile tests on specimens according to EN ISO 15630-3.

1.3.4.18 Stress corrosion resistance – Thread bar in prestressing steel

$\overline{F}_m$................ kN .... Actual maximum force, mean value determined in tensile tests on 2 specimens adjacent to specimens for the stress corrosion test.

1.3.4.19 Thread bar in steel – Determination of reference values

ρ................kg/m^3 .... Density, 7 850 kg/m^3, for hot rolled thread bar

$\varnothing_{ref}$ .... mm .... Reference diameter of the group
d_{act} .... mm .... Actual diameter of specimen
m_{act} .... kg/m .... Actual mass per metre of specimen
$R_{e, act}$ .... MPa .... Actual yield strength of specimen
$R_{e, mean}$ .... MPa .... Arithmetic mean of actual yield strengths of all specimens of the group
$R_{e, ref}$ .... MPa .... Reference yield strength of the group
$R_{m, act}$ .... MPa .... Actual tensile strength of specimen
$R_{m, mean}$ .... MPa .... Arithmetic mean of actual tensile strengths of all specimens of the group
$R_{m, ref}$ .... MPa .... Reference tensile strength of the group
$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of the group.

1.3.4.20 Thread bar in prestressing steel – Determination of reference values

ρ .... kg/m^3 .... Density, 7 850 kg/m^3, for hot rolled thread bar
$\varnothing_{ref}$ .... mm .... Reference diameter of the group
d_{act} .... mm .... Actual diameter of specimen
d_{mean} .... mm .... Arithmetic mean diameter of all specimens of the group
$F_{m, ref}$ .... kN .... Reference maximum force of the group
$F_{p0.1, ref}$ .... kN .... Reference 0.1 % proof force of the group
M_{act} .... kg/m .... Actual mass per metre of specimen
$R_{m, act}$ .... MPa .... Actual tensile strength of specimen
$R_{m, mean}$ .... MPa .... Arithmetic mean of actual tensile strengths of all specimens of the group
$R_{m, ref}$ .... MPa .... Reference tensile strength of the group
$R_{p0.1, act}$ .... MPa .... Actual yield strength of specimen
$R_{p0.1, mean}$ .... MPa .... Arithmetic mean of actual yield strengths of all specimens of the group
$R_{p0.1, ref}$ .... MPa .... Reference yield strength of the group
$S_{y, ref}$ .... mm^2 .... Reference cross-sectional area of the group.

1.3.4.21 Calculation of 5 % fractile

i .... i^{th} observation, i = 1, 2, ..., n
n .... Number of all observations to be evaluated
x_i .... i^{th} observed value
$\bar{x}$ .... Arithmetic mean of all observations
s .... Standard deviation of all observations
V .... Coefficient of variation
k .... Factor in dependence of n
$x_{5\,\%}$ .... 5 % fractile.

1.3.4.22 Static load test

Δr .... mm .... Displacement between anchorage components
Δs .... mm .... Displacement between thread bar and coupler or anchorage
ε_{Tu} .... % .... Elongation of thread bar at maximum load in static load test
$F_{m, act}$ .... kN .... Actual maximum force of thread bar in prestressing steel
$F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel
F_{Tu} .... kN .... Maximum force in static load test

$R_{m,\ act}$ .... MPa .... Actual tensile strength of thread bar in steel

$R_{m,\ ref}$ .... MPa .... Reference tensile strength of thread bar in steel

$S_{s,\ ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel.

1.3.4.23 Fatigue test

Δr .... mm .... Displacement between anchorage components

Δs .... mm .... Displacement between thread bar and coupler or anchorage

$2 \cdot \sigma_a$ .... MPa .... Stress range in fatigue test, i.e., two times the stress amplitude

F_f .... kN .... Force in fatigue test

$F_{m,\ ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel

F_{max} .... kN .... Upper force in fatigue test

$R_{m,\ ref}$ .... MPa .... Reference tensile strength of thread bar in steel

$S_{s,\ ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel

$S_{y,\ ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in prestressing steel.

1.3.4.24 Load transfer test

w_5, w_7, w_9, w_{n-8}, w_{n-6}, w_{n-4}, w_{n-2}, w_n .... mm .... Crack width, measured at specific readings.

e_x, e_y .... mm .... Edge distance in x- and y-direction respectively

x, y .... mm .... Minimum specified centre spacing in x- and y-direction

a, b .... mm .... Side lengths of test specimen

ε_5, ε_7, ε_9, ε_{n-8}, ε_{n-6}, ε_{n-4}, ε_{n-2}, ε_n .... mm/m .... Strain, measured at specific readings.

ε .... mm/m .... Strain

ε_t .... mm/m .... Strain, measured perpendicular to loading direction – transversal strain

ε_v .... mm/m .... Strain, measured parallel to loading direction – longitudinal strain

A_c .... mm^2 .... Gross cross-sectional concrete area of specimen

c .... mm .... Concrete cover of reinforcement

F .... kN .... Force in load transfer test

$f_{cm,\ 0}$ .... MPa .... Reference concrete compressive strength for load transfer test

$f_{cm,\ e}$ .... MPa .... Concrete compressive strength at time of end of load transfer test

$F_{m,\ ref}$ .... kN .... Reference maximum force of thread bar

$F_{u,\ br,\ s}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in steel

$F_{u, 0, s}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in steel

$F_{u, br, y}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in prestressing steel

$F_{u, 0, y}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in prestressing steel

h................. mm...................... Height of specimen

m..................—....................... Number of load cycles

n...................—....................... Number of readings for measurements

$R_{m, ref}$ ....MPa..................... Reference tensile strength of thread bar in steel

$S_{s, ref}$ ....mm^2..................... Reference cross-sectional area of thread bar in steel

w .... mm...................... Crack width

w_{max}............ mm...................... Maximum crack width.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of Kit for rock and soil anchor is assessed in relation to the essential characteristics. In Table I.1.1 and Table I.2.1 (Annex I) the essential characteristics relevant for the categories of intended use of Table 1.2.1.1 are listed.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

№	Essential characteristic	Assessment method	Type of expression of product performance
Basic requirement for construction works 1: Mechanical resistance and stability			
1	Resistance to static load	2.2.1	Level
2	Resistance to fatigue	2.2.2	Level
3	Load transfer to the structure	2.2.3	Level and description
4	Corrosion protection of temporary rock and soil anchor	2.2.4	Level and description
5	Corrosion protection of temporary rock and soil anchor with extended working life	2.2.5	Level and description
6	Corrosion protection of permanent rock and soil anchor	2.2.6	Level and description
7	Transition anchorage to free length – Tightness	2.2.7	Level
8	Crack width in inner grout	2.2.8	Level
9	Mass per metre – Thread bar in steel	2.2.9	Level
10	Mass per metre – Thread bar in prestressing steel	2.2.10	Level
11	Bond strength – Thread bar in steel	2.2.11	Level and description
12	Surface geometry – Thread bar in prestressing steel	2.2.12	Level and description
13	Strength characteristics – Thread bar in steel	2.2.13	Level
14	Strength characteristics – Thread bar in prestressing steel	2.2.14	Level
15	Modulus of elasticity – Thread bar in steel	2.2.15	Level
16	Modulus of elasticity – Thread bar in prestressing steel	2.2.16	Level
17	Elongation at maximum force – Thread bar in steel	2.2.17	Level
18	Elongation at maximum force – Thread bar in prestressing steel	2.2.18	Level
19	Constriction at break – Thread bar in prestressing steel	2.2.19	Level
20	Stress relaxation – Thread bar in prestressing steel	2.2.20	Level
21	Stress corrosion resistance – Thread bar in prestressing steel	2.2.21	Level

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

The assessment of the Kit for rock and soil anchor shall be carried out by means of the assessment of anchorages, coupling assemblies, thread bars, and corrosion protection that are representative for the performance of the Kit for rock and soil anchor.

2.2.1 Resistance to static load

Purpose of the assessment

To assess resistance to static load of anchorage and coupling assembly.

Assessment method

Resistance to static load including measurement of displacements, Δs, of anchorage and coupling assembly shall be tested according to Annex D.

With maximum force of the test, F_{Tu}, ratios shall be calculated:

– For thread bar in steel:

Ratio according to Equation 2.2.1.1 for actual tensile strength of thread bar, $R_{m,\,act} \cdot S_{s,\,ref}$.

$$r_{ta} = \frac{1\,000 \cdot F_{Tu}}{0.95 \cdot R_{m,\,act} \cdot S_{s,\,ref}} \qquad \text{Equation 2.2.1.1}$$

Ratio according to Equation 2.2.1.2 reference tensile strength of thread bar, $R_{m,\,ref} \cdot S_{s,\,ref}$.

$$r_{tn} = \frac{1\,000 \cdot F_{Tu}}{0.95 \cdot R_{m,\,ref} \cdot S_{s,\,ref}} \qquad \text{Equation 2.2.1.2}$$

– For thread bar in prestressing steel:

Ratio according to Equation 2.2.1.3 for actual maximum force of thread bar, $F_{m,\,act}$.

$$r_{ta} = \frac{F_{Tu}}{0.95 \cdot F_{m,\,act}} \qquad \text{Equation 2.2.1.3}$$

Ratio according to Equation 2.2.1.4 reference maximum force of thread bar, $F_{m,\,ref}$.

$$r_{tn} = \frac{F_{Tu}}{0.95 \cdot F_{m,\,ref}} \qquad \text{Equation 2.2.1.4}$$

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

F_{Tu} .... kN .... Maximum force in static load test, see Clause D.4

$R_{m,\,act}$ .... MPa .... Actual tensile strength of thread bar in steel, see Clause D.1

$R_{m,\,ref}$ .... MPa .... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2

$S_{s,\,ref}$ .... mm² .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$F_{m,\,act}$ .... kN .... Actual maximum force of thread bar in prestressing steel, see Clause D.1

$F_{m,\,ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel, see Clause 1.1.1.4

Δs .... mm .... Displacement between thread bar and coupler or anchorage, see Clause D.4

r_{ta}, r_{tn} ....—...................... Ratios.

Expression of results

– Reference tensile strength times reference cross-sectional area, $\frac{R_{m,\,ref} \cdot S_{s,\,ref}}{1\,000}$ in kN, of thread bar in steel or reference maximum force, $F_{m,\,ref}$, of thread bar in prestressing steel,
– Minimum value of ratio r_{ta},
– Minimum value of ratio r_{tn}, and
– Maximum displacement Δs

shall be given in the ETA.

2.2.2 Resistance to fatigue

The assessment of resistance to fatigue shall be carried out by means of assessment of resistance to fatigue of anchorage, coupling assembly, and thread bar that are representative of this essential characteristic for the Kit for rock and soil anchor.

2.2.2.1 Resistance to fatigue of anchorage and coupling assembly

Purpose of the assessment

To assess resistance to fatigue of anchorage and coupling assembly.

Assessment method

Resistance to fatigue of anchorage and coupling assembly shall be tested according to Annex E.

Following test conditions shall be taken into account:

– Upper force according to Equation 2.2.2.1.1 for thread bar in steel.

$$F_{max} = 0.65 \cdot \frac{R_{m,\,ref} \cdot S_{s,\,ref}}{1\,000} \qquad \text{Equation 2.2.2.1.1}$$

– Upper force according to Equation 2.2.2.1.2 for thread bar in prestressing steel.

$$F_{max} = 0.65 \cdot F_{m,\,ref} \qquad \text{Equation 2.2.2.1.2}$$

– Stress range $2 \cdot \sigma_a$
– Continue the fatigue test until failure of the specimen. The fatigue test shall be terminated once $2 \cdot 10^6$ load cycles have been attained.

Stress shall be calculated with the reference cross-sectional area of the thread bar, $S_{s,\,ref}$ or $S_{y,\,ref}$. The stress range is taken from the MPII. If the stress range is not available in the MPII, a series of pre-tests shall be carried out to determine the stress range. The pre-tests shall be performed according to Annex E with the largest thread bar. Once two consecutive pre-tests with the same stress range attain $2 \cdot 10^6$ load cycles, that stress range shall be taken.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$R_{m,\,ref}$ .... MPa .... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2

$F_{m, ref}$ .... kN .... Reference maximum force of thread bar, see Clause 1.1.1.4

F_{max} .... kN .... Upper force in fatigue test

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$S_{y, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in prestressing steel, see Clause 1.1.1.4

$2 \cdot \sigma_a$ .... MPa .... Stress range in fatigue test, i.e., two times the stress amplitude.

Expression of results

- Stress range, $2 \cdot \sigma_a$, and reference cross-sectional area, $S_{s, ref}$ or $S_{y, ref}$, and
- Number of load cycles attained

shall be given in the ETA.

2.2.2.2 Resistance to fatigue of thread bar in steel

Purpose of the assessment

To assess resistance to fatigue of thread bar in steel.

Assessment method

Specimens of thread bar shall be tested according to EN 10080, clause 7.2.5. The thread bar shall be subjected to a fatigue test according to EN ISO 15630-1, clause 8. The following parameters apply in relation to EN ISO 15630-1, clause 8:

- Upper force, F_{up}, according to Equation 2.2.2.2.1.
- Stress range $2 \cdot \sigma_a$, i.e., a force range, F_r, according to Equation 2.2.2.2.2.
- The fatigue test shall be continued until failure of the thread bar. The fatigue test shall be terminated once $2 \cdot 10^6$ load cycles have been attained.

Stress shall be calculated based on the reference cross-sectional area of the thread bar, $S_{s, ref}$. The stress range is taken from the MPII. If the stress range is not available in the MPII, a series of pre-tests shall be carried out to determine the stress range. The pre-tests shall be performed according to EN ISO 15630-1, clause 8, as given above with the largest thread bar. Once two consecutive pre-tests with the same stress range attain $2 \cdot 10^6$ load cycles, that stress range shall be taken.

$$F_{up} = 0.7 \cdot \frac{R_{e, ref} \cdot S_{s, ref}}{1\,000} \qquad \text{Equation 2.2.2.2.1}$$

$$F_r = \frac{2 \cdot \sigma_a \cdot S_{s, ref}}{1\,000} \qquad \text{Equation 2.2.2.2.2}$$

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

F_{up} .... kN .... Upper force in fatigue test

$2 \cdot \sigma_a$ .... MPa .... Stress range in fatigue test, i.e., two times the stress amplitude

F_r .... kN .... Force range in fatigue test, see EN ISO 15630-1, clause 8.1

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$R_{e, ref}$ .... MPa .... Reference yield strength of the thread bar in steel, see Clause 1.1.1.2.

Expression of results

- Stress range, $2 \cdot \sigma_a$, and reference cross-sectional area, $S_{s, ref}$, and
- Number of load cycles attained

shall be given in the ETA.

2.2.2.3 Resistance to fatigue of thread bar in prestressing steel

Purpose of the assessment

To assess resistance to fatigue of thread bar in prestressing steel.

Assessment method

Resistance to fatigue of thread bar shall be tested according to EN ISO 15630-3, clause 10. The following parameters apply in relation to EN ISO 15630-3, clause 10:

- With an upper force $F_{up} = 0.7 \cdot F_{m, act}$
- With a stress range of $2 \cdot \sigma_a$, i.e., a force range, F_r, according to Equation 2.2.2.3.1.
- The fatigue test shall be continued until failure of the thread bar. The fatigue test shall be terminated once $2 \cdot 10^6$ load cycles have been attained.

Stress shall be calculated based on the reference cross-sectional area of the thread bar, $S_{y, ref}$. The stress range is taken from the MPII. .If the stress range is not available in the MPII, a series of pre-tests shall be carried out to determine the stress range. The pre-tests shall be performed according to EN ISO 15630-3, clause 10, as given above with the largest thread bar. Once two consecutive pre-tests with the same stress range attain $2 \cdot 10^6$ load cycles, that stress range shall be taken.

$$F_r = \frac{2 \cdot \sigma_a \cdot S_{y, ref}}{1\,000}$$ Equation 2.2.2.3.1

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

F_{up}	kN	Upper force in fatigue test
$F_{m, act}$	kN	Actual maximum force, determined in tensile test according to EN ISO 15630-3 on a specimen adjacent to the specimen for the fatigue test
F_r	kN	Force range in fatigue test, see EN ISO 15630-3, clause 10.1
$2 \cdot \sigma_a$	MPa	Stress range in fatigue test, i.e., two times the stress amplitude
$S_{y, ref}$	mm²	Reference cross-sectional area of thread bar in prestressing steel, see Clause 1.1.1.4.

Expression of results

- Stress range, $2 \cdot \sigma_a$, and reference cross-sectional area, $S_{y, ref}$, and
- Number of load cycles attained

shall be given in the ETA.

2.2.3 Load transfer to the structure

Purpose of the assessment

To assess load transfer to the structure of anchorage.

Assessment method

Load transfer to the structure of anchorage shall be tested according to Annex F.

- For thread bar in steel:

  The maximum force[3], $F_{u, br, s}$, measured in load transfer test on a specimen with bursting reinforcement shall be at least as by Equation 2.2.3.1.

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[3] The required performance on maximum force originates from EAD 160004-00-0301.

$$F_{u,\,br,\,s} \geq 1.1 \cdot \frac{R_{m,\,ref} \cdot S_{s,\,ref}}{1\,000} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}} \qquad \text{Equation 2.2.3.1}$$

The maximum force[3], $F_{u,\,0,\,s}$, measured in the load transfer test on a specimen without bursting reinforcement shall be at least as by Equation 2.2.3.2.

$$F_{u,\,0,\,s} \geq 1.3 \cdot \frac{R_{m,\,ref} \cdot S_{s,\,ref}}{1\,000} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}} \qquad \text{Equation 2.2.3.2}$$

With maximum force, $F_{u,\,br,\,s}$, measured in load transfer test on a specimen with bursting reinforcement, the ratio, $r_{LT,\,br,\,s}$, shall be calculated by Equation 2.2.3.3.

$$r_{LT,\,br,\,s} = \frac{1\,000 \cdot F_{u,\,br,\,s}}{R_{m,\,ref} \cdot S_{s,\,ref} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}}} \qquad \text{Equation 2.2.3.3}$$

With maximum force, $F_{u,\,0,\,s}$, measured in load transfer test on a specimen without bursting reinforcement, the ratio, $r_{LT,\,0,\,s}$, shall be calculated by Equation 2.2.3.4.

$$r_{LT,\,0,\,s} = \frac{1\,000 \cdot F_{u,\,0,\,s}}{R_{m,\,ref} \cdot S_{s,\,ref} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}}} \qquad \text{Equation 2.2.3.4}$$

– For thread bar in prestressing steel:

The maximum force[3], $F_{u,\,br,\,y}$, measured in load transfer test on a specimen with bursting reinforcement shall be at least as by Equation 2.2.3.5.

$$F_{u,\,br,\,y} \geq 1.1 \cdot F_{m,\,ref} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}} \qquad \text{Equation 2.2.3.5}$$

The maximum force[3], $F_{u,\,0,\,y}$, measured in the load transfer test on a specimen without bursting reinforcement shall be at least as by Equation 2.2.3.6.

$$F_{u,\,0,\,y} \geq 1.3 \cdot F_{m,\,ref} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}} \qquad \text{Equation 2.2.3.6}$$

With maximum force, $F_{u,\,br,\,y}$, measured in load transfer test on a specimen with bursting reinforcement, the ratio, $r_{LT,\,br,\,y}$, shall be calculated by Equation 2.2.3.7.

$$r_{LT,\,br,\,y} = \frac{F_{u,\,br,\,y}}{F_{m,\,ref} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}}} \qquad \text{Equation 2.2.3.7}$$

With maximum force, $F_{u,\,0,\,y}$, measured in load transfer test on a specimen without bursting reinforcement, the ratio, $r_{LT,\,0,\,y}$, shall be calculated by Equation 2.2.3.8.

$$r_{LT,\,0,\,y} = \frac{F_{u,\,0,\,y}}{F_{m,\,ref} \cdot \frac{f_{cm,\,e}}{f_{cm,\,0}}} \qquad \text{Equation 2.2.3.8}$$

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$F_{u,\,br,\,s}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in steel, see Annex F

$F_{u, 0, s}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in steel, see Annex F

$F_{u, br, y}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in prestressing steel, see Annex F

$F_{u, 0, y}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in prestressing steel, see Annex F

$R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel, see Clause 1.1.1.4

$f_{cm, e}$ .... MPa .... Concrete compressive strength at time of end of load transfer test

$f_{cm, 0}$ .... MPa .... Reference concrete compressive strength, see Table F.1.1

$r_{LT, br, s}$ .... — .... Ratio for specimen with bursting reinforcement for thread bar in steel

$r_{LT, 0, s}$ .... — .... Ratio for specimen without bursting reinforcement for thread bar in steel

$r_{LT, br, y}$ .... — .... Ratio for specimen with bursting reinforcement for thread bar in prestressing steel

$r_{LT, 0, y}$ .... — .... Ratio for specimen without bursting reinforcement for thread bar in prestressing steel.

Expression of results

- Where the MPII explicitly excludes installation options different from the MPII, it shall be stated that the performance applies only to the options specified in the MPII.
- Description of bursting reinforcement or the conclusion no bursting reinforcement and
- Minimum value of ratio $r_{LT, br, s}$ or minimum value of ratio $r_{LT, 0, s}$ and reference tensile strength times reference cross-sectional area, $\frac{R_{m, ref} \cdot S_{s, ref}}{1\,000}$ in kN, of thread bar in steel

  or
- Minimum value of ratio $r_{LT, br, y}$ or minimum value of ratio $r_{LT, 0, y}$ and reference maximum force, $F_{m, ref}$, of thread bar in prestressing steel

shall be given in the ETA.

2.2.4 Corrosion protection of temporary rock and soil anchor

2.2.4.1 Corrosion protection

Purpose of the assessment

To assess corrosion protection of the Kit for rock and soil anchor to construct a temporary rock and soil anchor.

Assessment method

The Kit for rock and soil anchor to construct a temporary rock and soil anchor is assessed for the following established criteria and corrosion protection details of the Kit for rock and soil anchor:

NOTE 1 For corrosion protection criteria take EN 1537, clauses 6.1.4, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.3.3, 6.2.3.4, 6.2.5.2, 6.2.5.3, 6.3.1.3, 6.3.2.2, 6.4.1.1 to 6.4.1.3, 6.4.1.6 to 6.4.1.9, 6.4.1.12, 6.5.1.1 to 6.5.1.3, 6.5.5.2, 6.6.3.1, 6.6.3.2, 6.6.3.8, 6.6.3.10, 6.6.3.11, and table C.1 into account.

- Anchor bonded length

  ≥ 10 mm cover of cement mortar provides sufficient corrosion protection for 2 years in non-aggressive ground conditions. Basis of cover of cement mortar to drillhole diameter are the thread bar dimensions according to Clause 2.2.4.2.
- Anchor free length

A smooth plastic sheath with wall thickness of ≥ 1.5 mm is slipped over the thread bar. The ends of the plastic sheath are sealed against the thread bar to prevent ingress of water. The sheathed thread bar provides sufficient corrosion protection for 2 years in non-aggressive ground conditions.

– Transition anchorage to free length

The smooth plastic sheath of the thread bar overlaps the steel tube welded to the anchor plate. The overlap provides sufficient corrosion protection for 2 years in non-aggressive ground conditions and non-aggressive outer environmental conditions.

A seal is placed between smooth plastic sheath of thread bar and steel tube welded to the anchor plate. The sealed overlap provides sufficient corrosion protection for 2 years in non-aggressive ground conditions, and non-aggressive and aggressive outer environmental conditions.

NOTE 2 The assessment according to Clause 2.2.7 is not relevant for temporary rock and soil anchors.

– Anchorage

The anchorage without corrosion protection provides sufficient corrosion protection for ≥ 2 years in non-aggressive ground conditions, non-aggressive outer environmental conditions and absent of mechanical impact.

Filling the void between thread bar and steel tube welded to the anchor plate with corrosion protection filling material, providing the protruding parts of anchorage with corrosion protection, and placing a steel cap or plastic cap provides sufficient corrosion protection for 2 years in non-aggressive ground conditions, non-aggressive and aggressive outer environmental conditions, and mechanical impact.

NOTE 3 For aesthetic reasons steel cap or plastic cap to cover the anchorage and corrosion protection of exposed steel parts may be required.

– Coupler assembly

Within bonded length ≥ 10 mm cover of cement mortar provides sufficient corrosion protection for 2 years in non-aggressive ground conditions. Basis of cover of cement mortar to drillhole diameter are the coupler dimensions according to Clause 2.2.4.3.

Within free length a smooth plastic coupler tube with wall thickness according to EN 1537, clause 6.5.1.5, is slipped over the coupler. The ends of the plastic coupler tube are sealed against the plastic sheath of the thread bar to prevent ingress of water. The sealed coupler tube provides sufficient corrosion protection for 2 years in non-aggressive ground conditions.

Expression of results

The results of the assessment regarding the corrosion protection aspects

– Anchor bonded length
– Anchor free length
– Transition anchorage to free length
– Anchorage
– Coupler assemblage

shall be described in the ETA.

It shall be described whether or not 2 years working life are attained and

– Reference diameter in mm, core diameter in mm, and height of ribs in mm of thread bar, and
– Main dimensions of coupler in mm

shall be given in the ETA.

2.2.4.2 Thread bar

Dimensions relevant for mortar cover are:

– Reference diameter of thread bar
– Core diameter of thread bar, i.e., diameter of thread bar between ribs
– Height of ribs.

The core diameter shall be measured with an instrument of a resolution of at least 0.1 mm. The core diameter shall be measured between the ribs, approximately in rib middle, see Figure 2.2.4.2.1.

For measurement of height of ribs see Clause 2.2.11 for thread bar in steel and Clause 2.2.12 for thread bar in prestressing steel. The relevant height shall be height in approximately rib middle, see Figure 2.2.4.2.1.

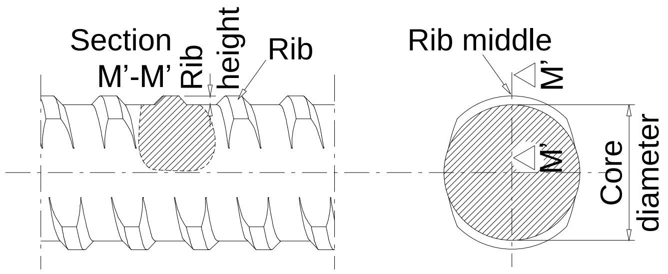


Figure 2.2.4.2.1 Dimensions – Schematic

Mean of core diameters of all specimens and mean of height of ribs of all specimens shall be calculated.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

2.2.4.3 Coupler

Shape and external dimensions of the coupler are relevant for mortar cover.

External dimensions of the coupler shall be measured with a calliper of a resolution of at least 0.1 mm. Relevant external dimensions shall be identified on workshop drawings and measured.

Mean of external dimensions shall be calculated for all specimens.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

2.2.5 Corrosion protection of temporary rock and soil anchor with extended working life

2.2.5.1 Corrosion protection

Purpose of the assessment

To assess corrosion protection of the Kit for rock and soil anchor to construct a temporary rock and soil anchor with extended working life.

Assessment method

The Kit for rock and soil anchor to construct a temporary rock and soil anchor with extended working life is assessed for the following established criteria and corrosion protection details of the Kit for rock and soil anchor:

NOTE 1 For corrosion protection criteria take EN 1537, clauses 6.1.4, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.3.3, 6.2.3.4, 6.2.5.2, 6.2.5.3, 6.3.1.3, 6.3.2.2, 6.4.1.1 to 6.4.1.3, 6.4.1.6 to 6.4.1.9, 6.4.1.12, 6.5.1.1 to 6.5.1.3, 6.5.5.2, 6.5.4.2, 6.5.4.3, 6.5.5.2, 6.6.3.1, 6.6.3.2, 6.6.3.4, 6.6.3.8, 6.6.3.10, 6.6.3.11, and table C.1 into account.

- Anchor bonded length

  ≥ 10 mm cover of cement mortar provides sufficient corrosion protection for 7 years in non-aggressive ground conditions. Basis of cover of cement mortar to drillhole diameter are the thread bar dimensions according to Clause 2.2.5.2.

- Anchor free length

  The thread bar is coated with corrosion protection filling material. A smooth plastic sheath with wall thickness of ≥ 1.5 mm is slipped over the thread bar. The ends of the plastic sheath are sealed against the thread bar to prevent ingress of water. The coated and sheathed thread bar provides sufficient corrosion protection for 7 years in non-aggressive ground conditions.

– Transition anchorage to free length

The smooth plastic sheath of the thread bar overlaps the steel tube welded to the anchor plate. A seal is placed between smooth plastic sheath of thread bar and steel tube welded to the anchor plate. The sealed overlap provides sufficient corrosion protection for 7 years in non-aggressive ground conditions and non-aggressive and aggressive outer environmental conditions.

NOTE 2 The assessment according to Clause 2.2.7 is not relevant for temporary rock and soil anchors with extended working life.

– Anchorage

Filling the void between thread bar and steel tube welded to the anchor plate with corrosion protection filling material, providing the protruding parts of anchorage with corrosion protection, placing a steel cap or plastic cap, and providing exposed steel parts with corrosion protection provides sufficient corrosion protection for 7 years in non-aggressive ground conditions, non-aggressive and aggressive outer environmental conditions, and mechanical impact.

– Coupler assembly

Within bonded length ≥ 10 mm cover of cement mortar provides sufficient corrosion protection for 7 years in non-aggressive ground conditions. Basis of cover of cement mortar to drillhole diameter are the coupler dimensions according to Clause 2.2.5.3.

Within free length a smooth plastic coupler tube with wall thickness according to EN 1537, clause 6.5.1.5, is slipped over the coupler. The plastic coupler tube is filled with corrosion protection filling material and the ends of the plastic coupler tube are sealed against the plastic sheath of the thread bar to prevent ingress of water. The filled and sealed coupler tube provides sufficient corrosion protection for 7 years in non-aggressive ground conditions.

Expression of results

The results of the assessment regarding the corrosion protection aspects

– Anchor bonded length
– Anchor free length
– Transition anchorage to free length
– Anchorage
– Coupler assemblage

shall be described in the ETA.

It shall be described whether or not 7 years working life are attained and

– Reference diameter in mm, core diameter in mm, and height of ribs in mm of thread bar, and
– Main dimensions of coupler in mm

shall be given in the ETA.

2.2.5.2 Thread bar

Dimensions relevant for mortar cover are:

– Reference diameter of thread bar
– Core diameter of thread bar, i.e., diameter of thread bar between ribs
– Height of ribs.

The core diameter shall be measured with an instrument of a resolution of at least 0.1 mm. The core diameter shall be measured between the ribs, approximately in rib middle, see Figure 2.2.4.2.1.

For measurement of height of ribs see Clause 2.2.11 for thread bar in steel and Clause 2.2.12 for thread bar in prestressing steel. The relevant height shall be height in approximately rib middle, see Figure 2.2.4.2.1.

Mean of core diameters of all specimens and mean of height of ribs of all specimens shall be calculated.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

2.2.5.3 Coupler

Shape and external dimensions of the coupler are relevant for mortar cover.

External dimensions of the coupler shall be measured with a calliper of a resolution of at least 0.1 mm. Relevant external dimensions shall be identified on workshop drawings and measured.

Mean of external dimensions shall be calculated for all specimens.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

2.2.6 Corrosion protection of permanent rock and soil anchor

2.2.6.1 Corrosion protection

Purpose of the assessment

To assess corrosion protection of the Kit for rock and soil anchor to construct a permanent rock and soil anchor.

Assessment method

The Kit for rock and soil anchor to construct a permanent rock and soil anchor is assessed for the following established criteria and corrosion protection details of the Kit for rock and soil anchor:

NOTE 1 For corrosion protection criteria take EN 1537, clauses 6.1.4, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.3.3, 6.2.3.4, 6.2.5.2 to 6.2.5.4, 6.3.3.1, 6.4.2.1, 6.4.2.3, 6.4.2.4, 6.4.3.1 to 6.4.3.5, 6.5.1.1 to 6.5.1.4, 6.5.1.7 to 6.5.1.9, 6.5.1.12, 6.5.3, 6.5.4.2, 6.5.5.2, 6.5.6.3, 6.5.7.1, 6.6.2.3, 6.6.2.4, 6.6.2.6, 6.6.3.1 to 6.6.3.4, 6.6.3.8 to 6.6.3.11, 6.7.3, 6.7.5, 6.7.6, 6.7.8 to 6.7.10, 6.7.12, 6.7.13 and table C.2 into account.

– Anchor bonded length and anchor free length

  A corrugated plastic sheathing with wall thickness according to EN 1537, clause 6.5.1.4, and an inner diameter for a cover of ≥ 5 mm of grout – inner grout – on the thread bar is slipped over the thread bar. The thread bar with corrugated plastic sheathing is pre-grouted, see Clause 2.2.6.2 for inner grout. By the layer of inner grout, the steel surface is passivated, provided crack widths are limited. The sheathed and grouted thread bar provides sufficient corrosion protection for 100 years in non-aggressive and aggressive ground conditions.

  NOTE 2 Crack width is assessed according to Clause 2.2.8.

– Transition anchorage to free length

  The sheathed and grouted thread bar overlaps the steel tube welded to the anchor plate. A seal is placed between corrugated plastic sheathing of thread bar and steel tube welded to the anchor plate. The sealed overlap provides sufficient corrosion protection for 100 years in non-aggressive and aggressive ground conditions, and non-aggressive and aggressive outer environmental conditions.

  NOTE 3 The assessment according to Clause 2.2.7 is relevant for permanent rock and soil anchors.

– Anchorage

  Filling the void between thread bar and steel tube welded to the anchor plate with corrosion protection filling material, placing a steel cap or plastic cap filled with corrosion protection filling material on the protruding parts of anchorage, and providing exposed steel parts with corrosion protection provides sufficient corrosion protection for 100 years in non-aggressive and aggressive ground conditions, non-aggressive and aggressive outer environmental conditions, and mechanical impact.

– Coupler assembly

  Within bonded length and free length, the coupling assembly is provided with a heat shrinking sleeve, see Clause 2.2.6.3. The heat shrinking sleeve overlaps the adjacent sheathed and grouted thread bars. The coupler assembly with heat shrinking sleeve provides sufficient corrosion protection for 100 years in non-aggressive and aggressive ground conditions.

Expression of results

The results of the assessment regarding the corrosion protection aspects

- Anchor bonded length
- Anchor free length
- Transition anchorage to free length
- Anchorage
- Coupler assemblage

shall be described in the ETA. It shall be described in the ETA whether or not 100 years working life is attained.

2.2.6.2 Inner grout

Purpose of the assessment

To assess corrosion protection by cover of inner grout of permanent rock and soil anchor.

Assessment method

The assessment shall be performed by testing the inner grout according to EN 445 for the following items:

- Content of aggressive components, i.e., chloride (Cl^-), sulphate (SO_3^{2-}), and sulphide-ions (S^{2-}) content of cement grout shall be determined according to EN 196-2:
  - Cl^- according to EN 196-2, clause 4.5.16
  - SO_3^{2-} according to EN 196-2, clause 4.4.2
  - S^{2-} according to EN 196-2, clause 4.4.5.
- Sieve test of cement grout shall be performed according to EN 445, clause 4.2.
- Fluidity of cement grout shall be determined according to the cone method of EN 445, clause 4.3.1.
- Fluidity of cement grout shall be determined according to the grout spread method of EN 445, clause 4.3.2.
- Bleeding of cement grout shall be determined by the wick-induced method according to EN 445, clause 4.5.
- Bleeding of cement grout shall be determined by the inclined tube test method according to EN 445, clause 4.4.
- Volume change of cement grout shall be determined according to EN 445, clause 4.5.
- Compressive strength of cement grout shall be determined according to EN 445, clause 4.6.
- Setting time of cement grout shall be determined as initial setting time and as final setting time according to EN 196-3, clause 6.
- Fluid density of cement grout shall be determined according to EN 445, clause 4.7.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in EN 447.

Expression of results

Content of aggressive components in %, residue on sieve, fluidity in s, spread diameter in mm, wick-induced bleeding in %, bleeding in inclined tube in %, volume change in %, compressive strength in MPa, initial setting time in h, final setting time in h, and fluid density in kg/m³ of inner grout shall be given in the ETA.

2.2.6.3 Heat shrinking sleeve

Purpose of the assessment

To assess corrosion protection by heat shrinking sleeve, see Clause 1.1.6. Heat shrinking sleeve provides the corrosion protection of the coupling assembly.

Assessment method and Expression of results

Unless otherwise specified by the manufacturer, the maximum operating temperature is T_{max} = 30 °C. Then the tests at T_{max} given below are omitted and only tests at 23 °C shall be performed. Heat shrinking sleeve shall be tested according to EN 12068 for the following items:

- Thickness of heat shrinking sleeve shall be determined after shrinking onto a circular steel bar or steel tube according to EN ISO 3126. The following parameters apply in relation to EN ISO 3126:
  - Measuring device shall be contact instrument according to EN ISO 3126, clause 4.2.1.8 and clause 5.2.1, as measurement of coating thickness with magnetic method.
  - Thickness shall be determined according to EN ISO 3126, clause 5.1, where the measurements according to EN ISO 3126, clause 5.2.3, are taken in about the middle of the shrunk-on heat shrinking sleeve.
  - Mean wall thickness shall be calculated according to EN ISO 3126, clause 5.2.3.

  The tests shall be performed in the numbers given in Annex H.

  Minimum wall thickness in mm shall be given in the ETA.
- Mass of adhesive of heat shrinking sleeve shall be determined by weighing a specimen of 50 mm × 100 mm of the heat shrinking sleeve before and after removing the adhesive. The adhesive shall be removed from the backing by mechanical working. The backing shall be thoroughly cleaned of adhesive residues with a solvent. Mass of adhesive shall be defined by mass per unit area of heat shrinking sleeve before shrinking.

  The tests shall be performed in the numbers given in Annex H.

  Minimum mass of adhesive per unit area in g/m^2 shall be given in the ETA.
- Tensile strength of heat shrinking sleeve shall be determined according to EN 12068, Annex A. For sizes of heat shrinking sleeve where the specimens according to EN 12068, clause A.3.1.2, cannot be taken, the tensile tests shall be performed with the small specimens according to EN 60811-501.

  The tests shall be performed in the numbers given in Annex H.

  Mean tensile strength in N/mm shall be given in the ETA.
- Elongation at break of heat shrinking sleeve shall be determined according to EN 12068, Annex A. For sizes of heat shrinking sleeve where the specimens according to EN 12068, clause A.3.1.2, cannot be taken, the tensile tests shall be performed with the small specimens according to EN 60811-501. Elongation at break and tensile strength can be tested in one combined test.

  The tests shall be performed in the numbers given in Annex H.

  Mean elongation at break in % shall be given in the ETA.
- Peel strength layer to layer of heat shrinking sleeve shall be determined at 23 °C and at T_{max} according to EN 12068, Annex B. The specimens shall be prepared according to EN 12068, clause B.3.2.

  NOTE Instructions for tapes do not apply.

  The tests shall be performed in the numbers given in Annex H.

  - Mean peel strength layer to layer in N/mm at 23 °C,
  - Mean peel strength layer to layer in N/mm at T_{max}, and
  - T_{max} in °C

  shall be given in the ETA.
- Peel strength to steel surface of heat shrinking sleeve shall be determined at 23 °C and at T_{max} according to EN 12068, Annex C. The specimens shall be prepared according to EN 12068, clause C.3.

  NOTE Instructions for tapes do not apply.

  The tests shall be performed in the numbers given in Annex H.

  - Mean peel strength to steel surface in N/mm at 23 °C,
  - Mean peel strength to steel surface in N/mm at T_{max}, and
  - T_{max} in °C

  shall be given in the ETA.
- Thermal ageing of heat shrinking sleeve shall be determined at 23 °C or at T_{max} according to EN 12068, Annex E, by means of tensile strength, elongation at break, peel strength layer to layer, and peel

strength to steel surface. For thermal ageing by means of tensile strength and elongation at break the following applies in relation to EN 12068:

- Apparatus for ageing shall be according to EN 12068, clause E.1.2.
- Pieces of heat shrinking sleeve to take specimens for tensile strength and elongation at break shall be prepared according to EN 12068, clause E.1.3. Tensile strength and elongation at break can be tested in one combined test.
- Ageing shall be carried out according to EN 12068, clause E.1.4.
- After ageing the specimens for tensile strength and elongation at break shall be taken according to EN 12068, clause A.3.1.2. For sizes of heat shrinking sleeve where the specimens according to EN 12068, clause A.3.1.2, cannot be taken, the tensile tests shall be performed with the small specimens according to EN 60811-501.
- Conditioning, testing in tensile test, and expression of results shall be according to EN 12068, clause A.4.1 and EN 12068, clause A.5.
- From the test results, the ratios S_{100}/S_0, E_{100}/E_0, S_{100}/S_{70}, and E_{100}/E_{70}, shall be calculated according to EN 12068, clause E.1.5.

For thermal ageing by means of peel strength layer to layer the following applies in relation to EN 12068:

- Apparatus for ageing shall be according to EN 12068, clause E.1.2.
- Specimens for peel strength layer to layer shall be prepared according to EN 12068, clause E.2.3 and EN 12068, clause B.3.2.
- Ageing shall be carried out according to EN 12068, clause E.2.4.
- After ageing, conditioning, testing, and expression of results shall be according to EN 12068, clause B.4 and EN 12068, clause B.5.

  NOTE Instructions for tapes do not apply.

- From the test results, the ratios P_{100}/P_T and P_{100}/P_{70} shall be calculated according to EN 12068, clause E.2.5.

For thermal ageing by means of peel strength to steel surface the following applies in relation to EN 12068:

- Apparatus for ageing shall be according to EN 12068, clause E.1.2.
- Specimens for peel strength to steel surface shall be prepared according to EN 12068, clause E.3.3 and EN 12068, clause C.3.

  NOTE Instructions for tapes do not apply.

- Ageing shall be carried out according to EN 12068, clause E.3.4.
- After ageing, conditioning, testing, and expression of results shall be according to EN 12068, clause E.3.4, EN 12068, clause C.4, and EN 12068, clause C.5.
- From the test results, the ratios A_{100}/A_T and A_{100}/A_{70} shall be calculated according to EN 12068, clause E.3.5.

The tests shall be performed in the numbers given in Annex H.

- The minimum value of ratios S_{100}/S_0, E_{100}/E_0, P_{100}/P_T, A_{100}/A_T, S_{100}/S_{70}, E_{100}/E_{70}, P_{100}/P_{70}, and A_{100}/A_{70}, and
- T_{max} in °C

shall be given in the ETA. The ratios are dimensionless values.

- Indentation resistance pressure of heat shrinking sleeve shall be determined at 23 °C and at T_{max} according to EN 12068, Annex G.

  The tests shall be performed in the numbers given in Annex H.

  - Minimum residual wall thickness in mm determined at 23 °C,
  - Minimum residual wall thickness in mm determined at T_{max},

  - Rating of the mechanical resistance according to EN 12068, Table 1, and
  - T_{max} in °C

  shall be given in the ETA.

- Impact resistance of heat shrinking sleeve shall be determined at 23 °C according to EN 12068, Annex H.

  The tests shall be performed in the numbers given in Annex H – EAD.

  Rating of the mechanical resistance according to EN 12068, Table 1 shall be given in the ETA.

- Saponification value of adhesive shall be determined according to EN 12068, Annex L.

  The tests shall be performed in the numbers given in Annex H.

  The mean saponification value in mg KHO/g shall be given in the ETA.

- Microbiological resistance of heat shrinking sleeve shall be determined according to EN 12068, Annex M, by means of tensile strength, elongation at break, and peel strength to steel surface. The specimens according to EN 12068, Annex M, shall be buried according to EN 12225. The following parameters apply in relation to EN 12225:

  - Test soil shall be according to EN 12225, clause 5.1, with biological activity according to EN 12225, clause 8.1.
  - The specimens according to EN 12068, Annex M, shall be buried according to EN 12225, clause 8.2.1 and EN 12225, clause 8.2.2. Test duration shall be 6 months.
  - After recovery of the specimens, testing shall be according to EN 12068, Annex M, for tensile strength, elongation at break, and peel strength to steel surface.

  For testing microbiological resistance by means of tensile strength and elongation at break the following applies in relation to EN 12068:

  - The specimens shall be prepared according to EN 12068, clause A.3.1.2. For sizes of heat shrinking sleeve where the specimens according to EN 12068, clause A.3.1.2, cannot be taken, the tensile tests shall be performed with the small specimens according to EN 60811-501. One set of specimens for testing prior to burial and a second set of specimens for testing after burial shall be prepared. Tensile strength and elongation at break can be tested in one combined test.
  - Prior to burial of the specimens, conditioning, testing in tensile test, and expression of results of one set of specimens shall be according to EN 12068, clause A.4.1 and EN 12068, clause A.5.
  - The second set of specimens shall be buried for 6 months.
  - After burial of the specimens, conditioning, testing in tensile test, and expression of results shall be according to EN 12068, clause M.5, EN 12068, clause A.4.1, and EN 12068, clause A.5.
  - From the test results, the ratios S_6/S_0 and E_6/E_0 shall be calculated EN 12068, clause M.6.

  For testing microbiological resistance by means of peel strength to steel surface the following applies in relation to EN 12068:

  - Specimens for peel strength to steel surface shall be prepared according to EN 12068, clause M.4 and EN 12068, clause C.3. One set of specimens for testing prior to burial and a second set of specimens for testing after burial of 6 months shall be prepared.

    NOTE Instructions for tapes do not apply.

  - Prior to burial of the specimens, conditioning, testing, and expression of results shall be according to EN 12068, clause M.5, EN 12068, clause C.4, and EN 12068, clause C.5.
  - The second set of specimens shall be buried for 6 months.
  - After burial of the specimens, conditioning, testing, and expression of results shall be according to EN 12068, clause M.5, EN 12068, clause C.4, and EN 12068, clause C.5.
  - From the test results, the ratios A_6/A_0 shall be calculated according to EN 12068, clause M.6.

  The tests shall be performed in the numbers given in Annex H.

  The minimum value of ratios S_6/S_0, E_6/E_0, and A_6/A_0 shall be given in the ETA. The ratios are dimensionless values.

- Water absorption of the specimens shall be determined according to EN ISO 62. The following parameters apply in relation to EN ISO 62:
  - Apparatuses according to EN ISO 62, clause 4.
  - Specimens of 50 mm × 100 mm shall be punched out from the heat shrinking sleeve.
  - EN ISO 62, clause 6.3, method 1 shall be applied.

  The tests shall be performed in the numbers given in Annex H.

  Mean water absorption in % shall be given in the ETA.
- Softening point of adhesive of heat shrinking sleeve shall be determined according to EN 1238. The adhesive for testing shall be removed from the backing of the heat shrinking sleeve by mechanical working and placed on the ring of the testing apparatus.

  The tests shall be performed in the numbers given in Annex H.

  Mean softening point in °C shall be given in the ETA.
- Oxygen stability of adhesive of heat shrinking sleeve shall be determined according to EN ISO 11357-6. The following parameters apply in relation to EN ISO 11357-6:
  - The adhesive for testing shall be removed from the backing of the heat shrinking sleeve by mechanical working.
  - For an adhesive that can be cut, a specimen with thickness of (650 ± 100) µm shall be cut.
  - For an adhesive that cannot be cut, a specimen with a mass of (15 ± 2) mg shall be placed directly on the crucible. The top of the specimen need not to be flat.
  - Testing temperature shall be 100 °C.
  - Heating of specimen shall be under nitrogen flow.
  - Testing shall be under oxygen flow.

  The tests shall be performed in the numbers given in Annex H.

  Oxidation induction time in min shall be given in the ETA.
- Resistance to salt spray of adhesive shall be determined according to EN ISO 9227 with NSS test procedure at (35 ± 2) °C and for 168 hours. Specimen shall be a smooth structural steel plate. The plate shall be covered with a layer of adhesive, corresponding to the mass per unit area of adhesive of the heat shrinking sleeve.

  Once salt spray is completed, the specimen shall be inspected for signs of corrosion.

  The tests shall be performed in the numbers given in Annex H.

  Description of signs of corrosion or the conclusion no corrosion present shall be given in the ETA.
- Aggressive components[4] in adhesive of heat shrinking sleeve shall be determined by ion chromatography method.

  The adhesive shall be subjected to the extraction method according to Annex G.

  Cl^- shall be determined[4] according to EN ISO 10304-4.
  - $Cl^- \leq 50$ ppm

  NO_3^-, NO_2^-, and SO_4^{2-} shall be determined[4] according to EN ISO 10304-1.
  - $NO_3^- \leq 50$ ppm
  - $NO_2^- \leq 10$ ppm
  - $SO_4^{2-} \leq 100$ ppm

  S^{2-} shall be determined[4] by a common ion chromatography method.
  - $S^{2-} \leq 50$ ppm

[4] The required performance regarding aggressive components originates from EAD 160027-00-0301.

The tests shall be performed in the numbers given in Annex H.

Content of Cl^-, NO_3^-, NO_2^-, SO_4^{2-}, and S^{2-} in ppm shall be given in the ETA.

Record measurements and observations in accordance with Annex J.

Where

A_0 ....N/mm.................... Peel strength to steel surface at ambient temperature prior to burial in soil

A_6 ....N/mm.................... Peel strength to steel surface at ambient temperature after 6 months buried in soil

A_{70} ....N/mm.................... Peel strength to steel surface at 23 °C after 70 days ageing as arithmetic mean of three results

A_{100} ....N/mm.................... Peel strength to steel surface at 23 °C after 100 days ageing as arithmetic mean of three results

A_T ....N/mm.................... Peel strength to steel surface at 23 °C without artificial ageing

E_0 ....%....................... Elongation at break at ambient temperature prior to burial in soil and at ambient temperature without artificial ageing

E_6 ....%....................... Elongation at break at ambient temperature after 6 months buried in soil

E_{70} ....%....................... Elongation at break at ambient temperature after 70 days ageing

E_{100} ....%....................... Elongation at break at ambient temperature after 100 days ageing

P_{70} ....N/mm.................... Peel strength layer to layer at 23 °C after 70 days ageing as arithmetic mean of three results

P_{100} ....N/mm.................... Peel strength layer to layer at 23 °C after 100 days ageing as arithmetic mean of three results

P_T ....N/mm.................... Peel strength layer to layer at 23 °C without artificial ageing

S_0 ....N/mm.................... Tensile strength at ambient temperature prior to burial in soil and at ambient temperature without artificial ageing

S_6 ....N/mm.................... Tensile strength at ambient temperature after 6 months buried in soil

S_{70} ....N/mm.................... Tensile strength at ambient temperature after 70 days ageing

S_{100} ....N/mm.................... Tensile strength at ambient temperature after 100 days ageing

T_{max} .... °C....................... Maximum continuous operating temperature.

2.2.7 Transition anchorage to free length – Tightness

Purpose of the assessment

To assess the joint between steel tube, welded to the anchor plate of the anchorage, and corrugated plastic sheathing of the free length for water tightness.

NOTE Assessment of tightness is only relevant for corrosion protection of a permanent rock and soil anchor, see Clause 2.2.6.1.

Assessment method

The joint between steel tube, welded to the anchor plate of the anchorage, and corrugated plastic sheathing of the free length shall be tested for water tightness.

Specimen

The specimen, see Figure 2.2.7.1, shall comprise steel tube, corrugated plastic sheathing, and seals that are components as used in the rock and soil anchor. The steel tube shall be provided with a nozzle to attach a water supply.

The corrugated plastic sheathing shall be completely filled with mortar or a similar rigid material while it is kept straight. Once setting and hardening of the mortar is completed, seals shall be placed on the corrugated plastic sheathing and the steel tube shall be slipped over.

Test procedure

At the nozzle of the specimen, a water supply provided with a pressure gauge and a valve shall be attached. The specimen in filled with tap water up to a pressure of 0.1 MPa and the valve shall be closed. After 5 minutes holding time, the pressure shall be increased by 0.05 MPa, followed by again 5 minutes holding time. During the holding time of pressure steps, the specimen shall be inspected for leakage and loss of water pressure. Leakage, if any, and pressure loss during holding time shall be recorded. Steps with an increase of 0.05 MPa and a holding time of 5 minutes shall be continued up to failure of the specimen. The test may be terminated at a pressure step of 0.3 MPa.

After the last pressure step and holding time, the water shall be drained off and the specimen disassembled and inspected for damage or leakage.

Each sheathing nominal diameter shall be tested with one specimen including two seals.

Expression of results

Maximum pressure step in MPa without failure shall be given in the ETA.

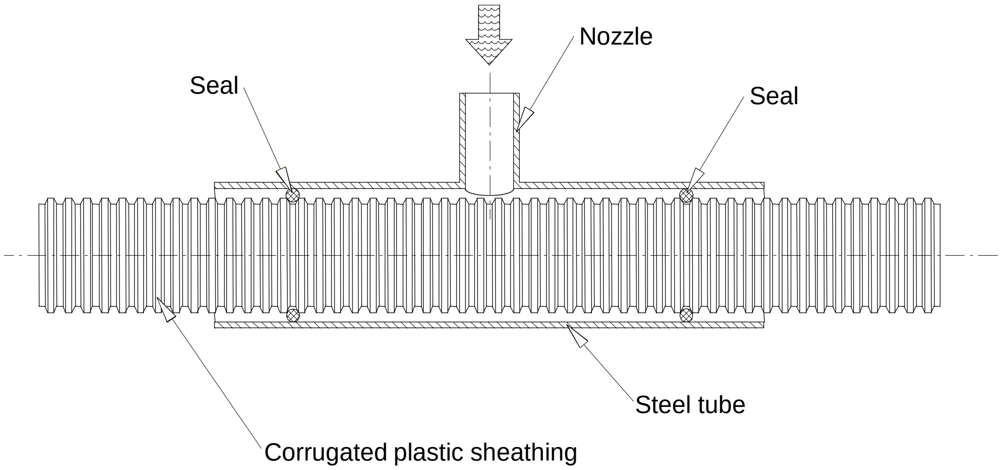


Figure 2.2.7.1 Tightness test – Schematic

2.2.8 Crack width in inner grout

Purpose of the assessment

To assess crack width of inner grout.

Assessment method

Crack width of inner grout shall be tested following EN 1537, Annex A, test A and test B.

The forces referred to in EN 1537, Annex A, are:

- As maximum load the force $\geq \min \begin{cases} 0.95 \cdot R_{e,\,ref} \cdot S_{s,\,ref} \\ 0.80 \cdot R_{m,\,ref} \cdot S_{s,\,ref} \end{cases}$ shall be applied for thread bar in steel.
- As lock-off load the force $\geq 0.60 \cdot R_{m,\,ref} \cdot S_{s,\,ref}$ shall be applied for thread bar in steel.
- As maximum load the force $\geq \min \begin{cases} 0.95 \cdot F_{p0.1,\,ref} \\ 0.80 \cdot F_{m,\,ref} \end{cases}$ shall be applied for thread bar in prestressing steel.
- As lock-off load the force $\geq 0.60 \cdot F_{m,\,ref}$ shall be applied for thread bar in prestressing steel.

NOTE For the term lock-off load see EN 1537, clause 3.1.17.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in EN 1537, clause 6.7.13.

Where

$S_{s,\,ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$R_{e,\,ref}$ .... MPa .... Reference yield strength of the thread bar in steel, see Clause 1.1.1.2

$R_{m, ref}$ .... MPa .... Reference tensile strength of the thread bar in steel, see Clause 1.1.1.2

$F_{p0.1, ref}$ .... kN .... Reference 0.1 % proof force of thread bar in prestressing steel, see Clause 1.1.1.4

$F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel, see Clause 1.1.1.4.

Expression of results

Maximum of crack width in mm determined in test A and test B shall be given in the ETA.

2.2.9 Mass per metre – Thread bar in steel

Purpose of the assessment

To assess reference mass per metre and deviation of reference mass per metre of thread bar in steel.

Assessment method

Reference mass shall be calculated by Equation 2.2.9.1.

$$m_{ref} = \frac{S_{s, ref} \cdot \rho}{10^6}$$ Equation 2.2.9.1

Actual mass per metre of thread bar shall be determined according to EN ISO 15630-1, clause 12. The actual mass per metre, m, shall be calculated as the quotient of the specimen mass in kg, divided by the specimen length in m.

Deviation of reference mass in % shall be determined by Equation 2.2.9.2.

$$\left(\frac{m}{m_{ref}} - 1\right) \cdot 100$$ Equation 2.2.9.2

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

m_{ref} .... kg/m .... Reference mass per metre of thread bar in steel

m .... kg/m .... Actual mass per metre of thread bar in steel

ρ .... kg/m^3 .... Density, 7 850 kg/m^3, for hot rolled thread bar.

Expression of results

Range of deviation of reference mass in % and reference mass per metre, m_{ref}, shall be given in the ETA.

2.2.10 Mass per metre – Thread bar in prestressing steel

Purpose of the assessment

To assess reference mass per metre and deviation of reference mass per metre of thread bar in prestressing steel.

Assessment method

Reference mass shall be calculated by Equation 2.2.10.1.

$$M_{ref} = \frac{S_{y, ref} \cdot \rho}{10^6} \cdot 1.035$$ Equation 2.2.10.1

NOTE The factor 1.035 accounts for 3.5 % non-bearing portion of the ribs.

Actual mass per metre of thread bar shall be determined according to EN ISO 15630-3, clause 16. The actual mass per metre, M, shall be calculated as the quotient of the specimen mass in kg, divided by the specimen length in m.

Deviation of reference mass in % shall be determined by Equation 2.2.10.2.

$$\left(\frac{M}{M_{ref}} - 1\right) \cdot 100$$ Equation 2.2.10.2

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

M ....kg/m..................... Actual mass per metre of thread bar in prestressing steel

M_{ref} ....kg/m..................... Reference mass per metre of thread bar in prestressing steel

ρ ....kg/m^3 .... Density, 7 850 kg/m^3, for the hot rolled thread bar

$S_{y, ref}$ ....mm^2 .... Reference cross-sectional area of thread bar in prestressing steel, see Clause 1.1.1.4.

Expression of results

Range of deviation of reference mass in % and reference mass per metre, M_{ref}, shall be given in the ETA.

2.2.11 Bond strength – Thread bar in steel

The assessment of bond strength shall be carried out by means of assessment of surface geometry and by pull-out tests that are representative of this essential characteristic for the Kit for rock and soil anchor. Reference method is bond strength determined in pull-out tests, see Clause 2.2.11.2.

2.2.11.1 Surface geometry – Thread bar in steel

Purpose of the assessment

To assess surface geometry of thread bar in steel.

Assessment method

Properties subject to testing shall be taken from EN 10080, clause 7.4.2. Measurement of surface geometry dimensions as well as determination of relative rib area shall be carried out in accordance with EN ISO 15630-1, clause 10 and clause 11:

- According to EN ISO 15630-1, clause 10, whereby the clauses for rib measurement apply:
  - Test piece and test equipment according to EN ISO 15630-1, clause 10.1 and clause 10.2.
  - Rib height according to EN ISO 15630-1, clause 10.3.1.2, at quarter-point, $a_{1/4}$, mid-point, a_m, and three-quarters-point, $a_{3/4}$.
  - Rib spacing, c, according to EN ISO 15630-1, clause 10.3.3.
  - Rib inclination angle, β, according to EN ISO 15630-1, clause 10.3.6.
  - Width of rib, b, according to EN ISO 15630-1, clause 10.3.8.
- According to EN ISO 15630-1, clause 11, for relative rib area applies:
  - Measure part of the circumference without ribs, Σe_i, according to EN ISO 15630-1, clause 10.3.5.
  - Calculation of relative rib area, f_R, according to EN ISO 15630-1, clause 11.3.1.
  - Consider that ribs are thread ribs.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$a_{1/4}$ .... mm...................... Rib height at quarter-point

a_m .... mm...................... Rib height at mid-point

$a_{3/4}$ .... mm...................... Rib height at three-quarters-point

β ....°........................ Rib inclination

b .... mm .... Width of rib

c .... mm .... Rib spacing

Σe_i .... mm .... Part of the circumference without ribs

f_R ....—...................... Relative rib area.

Expression of results

- Description of surface geometry in representations like outline drawings,
- Dimensions of surface geometry, a_m, b, c, Σe_i, and β, and
- Relative rib area f_R

shall be given in the ETA.

2.2.11.2 Bond strength – Thread bar in steel

Purpose of the assessment

To assess bond strength of thread bar in steel.

Assessment method

Specimens with thread bar shall be subjected to pull-out test following EN 10080, Annex D, to determine the bond behaviour. External dimensions of the concrete part of the specimen may be larger than 10 · d for pull out as failure mode.

The characteristics as defined in EN 10080, Annex D, shall be determined.

The bond strength shall be evaluated from the results of the pull-out tests by Equation 2.2.11.2.1 and Equation 2.2.11.2.2.

$$F_{mean} = \frac{F_{0.01} + F_{0.1} + F_1}{3} \qquad \text{Equation 2.2.11.2.1}$$

$$\tau_{dk} = \frac{F_{mean,\,d}}{d \cdot \pi \cdot l} \cdot \frac{\sqrt[3]{f_{cm,\,0}^2}}{\sqrt[3]{f_{cm,\,e}^2}} \cdot 0.7 \qquad \text{Equation 2.2.11.2.2}$$

NOTE The coefficient 0.7 is applied in the absence of a more in-depth statistical evaluation.

Characteristic bond strength for reference diameters not tested may be interpolated.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$F_{mean,\,d}$ .... N .... Mean value of all F_{mean} of reference diameter d

$F_{0.01}$ .... N .... Force in pull-out test at a slip of 0.01 mm

$F_{0.1}$ .... N .... Force in pull-out test at a slip of 0.1 mm

F_1 .... N .... Force in pull-out test at a slip of 1 mm

τ_{dk} ....MPa..................... Characteristic bond strength for reference diameter d

d .... mm...................... Reference diameter of thread bar in steel, see Clause 1.1.1.2

l .... mm...................... Length of bonded section in pull-out test

$f_{cm,\,0}$ ....MPa..................... Reference compressive strength of concrete

$f_{cm,\,e}$ ....MPa..................... Actual mean compressive strength of concrete at end of test.

Expression of results

Characteristic bond strength, τ_{dk}, shall be given in the ETA.

2.2.12 Surface geometry – Thread bar in prestressing steel

Purpose of the assessment

To assess surface geometry of thread bar in prestressing steel.

Assessment method

Measurement of surface geometry dimensions as well as determination of relative rib area shall be carried out in accordance with EN ISO 15630-3, clauses 14 and 15:

- According to EN ISO 15630-3, clause 14, whereby the clauses for rib measurement apply:
  - Test piece and test equipment according to EN ISO 15630-3, clause 14.1 and clause 14.2.
  - Rib height according to EN ISO 15630-3, clause 14.3.1.2, at quarter-point, $a_{1/4}$, mid-point, a_m, and three-quarters-point, $a_{3/4}$.
  - Rib spacing, c, according to EN ISO 15630-3, clause 14.3.1.3.
  - Rib inclination angle, β, according to EN ISO 15630-3, clause 14.3.1.5.
  - Width of rib, b, according to EN ISO 15630-3, clause 14.3.1.6.
- According to EN ISO 15630-3, clause 15, for relative rib area applies:
  - Measure part of the circumference without ribs, Σe_i, according to EN ISO 15630-3, clause 14.3.1.4.
  - Calculation of relative rib area, f_R, according to EN ISO 15630-3, clause 15.2.1.
  - Consider that ribs are thread ribs.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$a_{1/4}$ .... mm...................... Rib height at quarter-point

a_m .... mm...................... Rib height at mid-point

$a_{3/4}$ .... mm...................... Rib height at three-quarters-point

β.................... ° .... Rib inclination

b................. mm...................... Width of rib

c................. mm...................... Rib spacing

Σe_i .... mm...................... Part of the circumference without ribs

f_R ....—....................... Relative rib area.

Expression of results

- Description of surface geometry in representations like outline drawings,
- Dimensions of surface geometry, a_m, b, c, Σe_i, and β, and
- Relative rib area f_R

shall be given in the ETA.

2.2.13 Strength characteristics – Thread bar in steel

Purpose of the assessment

To assess strength characteristics of thread bar in steel.

Assessment method

Strength characteristics shall be determined in tension. The stress values shall be calculated based on the reference cross-sectional area, $S_{s, ref}$. Relevant characteristics in tensile test, see also EN 10080, clause 7.2.3, are:

- Tensile strength, R_m
- Yield strength, R_e

– Ratio tensile strength to yield strength, R_m/R_e
– Elongation at maximum force, A_{gt}
– Modulus of elasticity, E, shall be determined with the force-extension diagram of the tensile test.

The tensile test on specimen of thread bar shall be carried out in accordance with EN ISO 15630-1, clause 5. The following parameters and procedures apply in relation to EN ISO 15630-1:

– Specimen shall be according to EN ISO 15630-1, clause 4, without artificial ageing and according to EN ISO 15630-1, clause 5.1.

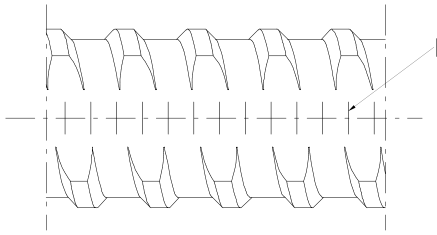


Figure 2.2.13.1 Thread bar with applied marks for elongation measurement – Schematic

– Test equipment shall be according to EN ISO 15630-1, clause 5.2.
– Tensile test shall be performed at room temperature.
– EN ISO 6892-1, clauses 10.1 and 10.2 apply.
– Force-extension diagram shall be recorded.
– Testing rate shall be according to EN ISO 6892-1, clauses 10.3.3.1, 10.3.3.2.1, 10.3.3.2.4, 10.3.3.2.5, and 10.3.3.3, whereby the crosshead separation rate applies.
– Determination of R_e shall be according to EN ISO 6892-1, clauses 11 and 13, or EN ISO 15630-1, clause 5.3. These procedures are considered as equivalent. Reference procedure for proof strength is EN ISO 15630-1, clause 5.3, second method.
– Determination of R_m shall be with the maximum force in tensile test, considering EN ISO 15630-1, clause 5.3.
– Determination of A_{gt} shall be according to EN ISO 15630-1, clause 5.3, and EN ISO 6892-1, clause 3.4. Reference procedure is the manual method.
– From yield strength, R_e, and tensile strength, R_m, the ratio tensile strength to yield strength, R_m/R_e, shall be calculated according to Equation 2.2.13.1.

$$R_m/R_e = \frac{R_m}{R_e}$$ Equation 2.2.13.1

Characteristic values shall be calculated according to EN 10080, clause 8.5.2:

– Tensile strength with 5 % fractile as characteristic value, $R_{m,\,k}$.
– Yield strength with 5 % fractile as characteristic value, $R_{e,\,k}$.
– Ratio tensile strength to yield strength with 10 % fractile as characteristic value, $(R_m/R_e)_k$.

With characteristic values and reference values of tensile strength and yield strength, ratios according to Equation 2.2.13.2 and Equation 2.2.13.3 shall be calculated.

$$r_{Rm} = \frac{R_{m,\,k}}{R_{m,\,ref}}$$ Equation 2.2.13.2

$$r_{Re} = \frac{R_{e,\,k}}{R_{e,\,ref}}$$ Equation 2.2.13.3

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

R_m/R_e .... — .... Ratio tensile strength to yield strength
A_{gt} .... % .... Elongation at maximum force in tensile test
E .... MPa .... Modulus of elasticity
$(R_m/R_e)_k$ .... — .... Characteristic value of the ratio tensile strength to yield strength
R_e .... MPa .... Yield strength in tensile test
$R_{e,\,k}$ .... MPa .... Characteristic value of yield strength
$R_{e,\,ref}$ .... MPa .... Reference yield strength of thread bar in steel, see Clause 1.1.1.2
R_m .... MPa .... Tensile strength in tensile test
$R_{m,\,k}$ .... MPa .... Characteristic value of tensile strength
$R_{m,\,ref}$ .... MPa .... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2
$S_{s,\,ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2
r_{Rm}, r_{Re} .... — .... Ratios.

Expression of results

- Minimum ratio r_{Re} and reference yield strength, $R_{e,\,ref}$,
- Minimum ratio r_{Rm} and reference tensile strength, $R_{m,\,ref}$, and
- Characteristic ratio tensile strength to yield strength, $(R_m/R_e)_k$,

shall be given in the ETA.

2.2.14 Strength characteristics – Thread bar in prestressing steel

Purpose of the assessment

To assess strength characteristics of thread bar in prestressing steel.

Assessment method

Strength characteristics shall be determined in tension. Relevant characteristics in tensile test are:

- Maximum force, F_m
- 0.1 % proof force, $F_{p0.1}$
- Total elongation at maximum force, A_{gt}
- Modulus of elasticity, E
- Constriction at break.

The tensile test on specimen of thread bar shall be carried out in accordance with EN ISO 15630-3, clause 5. The following parameters and procedures apply in relation to EN ISO 15630-3:

- Specimen shall be according to EN ISO 15630-3, clause 4 and clause 5.1.

  See Figure 2.2.13.1 for marks for elongation measurement.
- Test equipment shall be according to EN ISO 15630-3, clause 5.2.
- Tensile test shall be performed at room temperature.
- EN ISO 6892-1, clauses 10.1 and 10.2 apply.
- Force-extension diagram shall be recorded.
- Testing rate shall be according to EN ISO 6892-1, clauses 10.3.3.1, 10.3.3.2.4, 10.3.3.2.5, and 10.3.3.3, whereby the crosshead separation rate applies.
- Determination of $F_{p0.1}$ shall be according to EN ISO 6892-1, clause 13.
- Determination of F_m shall be with the maximum force in tensile test, considering EN ISO 15630-3, clause 5.3.

- Determination of A_{gt} shall be according to EN ISO 15630-3, clause 5.3, and EN ISO 6892-1, clause 3.4. Reference procedure is the manual method.

Characteristic values shall be calculated according to Annex C:

- Maximum force, F_m, with 5 % fractile as characteristic value
- 0.1 % proof force, $F_{p0.1}$, with 5 % fractile as characteristic value

With characteristic values and reference values of maximum force, $F_{m,\,k}$, and of 0.1 % proof force, $F_{p0.1,\,k}$, ratios according to Equation 2.2.14.1 and Equation 2.2.14.2 shall be calculated.

$$r_{Fm} = \frac{F_{m,\,k}}{F_{m,\,ref}} \qquad \text{Equation 2.2.14.1}$$

$$r_{Fp} = \frac{F_{p0.1,\,k}}{F_{p0.1,\,ref}} \qquad \text{Equation 2.2.14.2}$$

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

A_{gt} ....% .... Elongation at maximum force in tensile test
E ....MPa .... Modulus of elasticity
$F_{p0.1}$ .... kN .... 0.1 % proof force in tensile test
$F_{p0.1,\,k}$ .... kN .... Characteristic value of 0.1 % proof force
$F_{p0.1,\,ref}$ .... kN .... Reference 0.1 % proof force of thread bar, see Clause 1.1.1.4
F_m................ kN .... Maximum force in tensile test
$F_{m,\,k}$ .... kN .... Characteristic value of maximum force
$F_{m,\,ref}$ .... kN .... Reference maximum force of thread bar, see Clause 1.1.1.4
r_{Fm}, r_{Fp} ....—....................... Ratios.

<u>Expression of results</u>

- Minimum ratio r_{Fp} and reference 0.1 % proof force, $F_{p0.1,\,ref}$, and
- Minimum ratio r_{Fm} and reference maximum force, $F_{m,\,ref}$

shall be given in the ETA.

2.2.15 Modulus of elasticity – Thread bar in steel

<u>Purpose of the assessment</u>

To assess modulus of elasticity of thread bar in steel.

<u>Assessment method</u>

The modulus of elasticity shall be calculated as secant modulus in the force-extension diagram, see Clause 2.2.13, between $0.20 \cdot R_{m,\,ref} \cdot S_{s,\,ref}$ and $0.50 \cdot R_{m,\,ref} \cdot S_{s,\,ref}$ by Equation 2.2.15.1. Modulus of elasticity and strength characteristics can be tested in one combined test.

$$E = \frac{0.50 \cdot R_{m,\,ref} - 0.20 \cdot R_{m,\,ref}}{\varepsilon_{50} - \varepsilon_{20}} \cdot 100 \qquad \text{Equation 2.2.15.1}$$

The mean value shall be calculated for modulus of elasticity.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

E ....MPa .... Modulus of elasticity

$R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar, see Clause 1.1.1.2

ε_{50} .... % .... Extension at 0.50 · $R_{m, ref}$ in force-extension diagram

ε_{20} .... % .... Extension at 0.20 · $R_{m, ref}$ in force-extension diagram

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2.

Expression of results

Arithmetic mean of modulus of elasticity, E, and reference cross-sectional area, $S_{s, ref}$, shall be given in the ETA.

2.2.16 Modulus of elasticity – Thread bar in prestressing steel

Purpose of the assessment

To assess modulus of elasticity of thread bar in prestressing steel.

Assessment method

Modulus of elasticity, E, shall be determined according to Clause 2.2.14 and EN ISO 15630-3, clause 5.3.2 by applying the method given for hot rolled bars. Modulus of elasticity and strength characteristics can be tested in one combined test. Stresses shall be calculated based on the reference cross-sectional area of the thread bar, $S_{y, ref}$.

The mean value shall be calculated for modulus of elasticity.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

E .... MPa .... Modulus of elasticity

$S_{y, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in prestressing steel, see Clause 1.1.1.4.

Expression of results

Arithmetic mean of modulus of elasticity, E, and reference cross-sectional area, $S_{y, ref}$, shall be given in the ETA.

2.2.17 Elongation at maximum force – Thread bar in steel

Purpose of the assessment

To assess elongation at maximum force of thread bar in steel.

Assessment method

Elongation at maximum force shall be determined according to Clause 2.2.14. Elongation at maximum force and strength characteristics can be tested in one combined test.

Characteristic values of elongation at maximum force shall be calculated according to EN 10080, clause 8.5.2:

– Elongation at maximum force with 10 % fractile as characteristic value, $A_{gt, k}$.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$A_{gt, k}$ .... % .... Characteristic value of elongation at maximum force.

Expression of results

Characteristic elongation at maximum force, $A_{gt, k}$, shall be given in the ETA.

2.2.18 Elongation at maximum force – Thread bar in prestressing steel

Purpose of the assessment

To assess elongation at maximum force of thread bar in prestressing steel.

Assessment method

Elongation at maximum force shall be determined according to Clause 2.2.14. Elongation at maximum force and strength characteristics can be tested in one combined test.

Minimum value of elongation of maximum force shall be determined.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Expression of results

Minimum value of elongation at maximum force in % shall be given in the ETA.

2.2.19 Constriction at break – Thread bar in prestressing steel

Purpose of the assessment

To assess constriction at break of thread bar in prestressing steel.

Assessment method

Constriction at break shall be determined in tensile test according to Clause 2.2.14. Constriction at break and strength characteristics can be tested in one combined test.

After fracture of the specimen, the tensile test fracture shall be visually examined to assess for necking. Thereby, the two pieces of the fractured specimen shall be fitted together at the fracture surface with their axes coinciding in a common straight line. Necking occurs where there is a constriction of the specimen around the fracture in radial direction visible to the unaided eye.

The specimens shall be counted:

- Specimens with necking shall be counted.
- Specimens without necking shall be counted.

The number of specimens with necking shall be divided by the total number of specimens and given in %.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Expression of results

The percentage of specimens with necking shall be given in the ETA.

2.2.20 Stress relaxation – Thread bar in prestressing steel

Purpose of the assessment

To assess stress relaxation of thread bar in prestressing steel.

Assessment method

The thread bar shall be subjected to an isothermal stress relaxation test according to EN ISO 15630-3, clause 9. The following parameters apply in relation to EN ISO 15630-3, clause 9:

- The specimen shall be according to EN ISO 15630-3, clause 9.2.

  NOTE 1 Length of specimen shall be appropriate for the relaxation test frame including length for gripping.

- Gauge length shall be according to EN ISO 15630-3, clause 9.3.3.

  NOTE 2 Details for strands are not relevant.

- Initial force of 0.7 · $\overline{F}_m$
- Temperature according to EN ISO 15630-3, clause 9.1 and clause 9.4.6.
- Duration 1 000 hours.

Relaxation is the loss in force after 1 000 hours duration of test and expressed as a percentage of the initial force.

NOTE 3 This test requires measurement of small quantities with high resolution. The principle behind these series of measurements according to EN ISO 15630-3, clause 9.4.7, is to gain information in case the test or the performance evolves as inappropriate. In tests that extend over a period of time like this, it is common sense to have such in-between measurements. It is clearly not recommended to omit these in between measurements.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$\overline{F}_m$................ kN .... Mean maximum force, determined in tensile tests on specimens according to EN ISO 15630-3, clause 9.2 and clause 5.1.

NOTE 4 In tensile testing, it is sufficient to determine the maximum force for $\overline{F}_m$. Elongation does not need to be measured.

Expression of results

Relaxation after 1 000 hours duration of test in % shall be given in the ETA.

2.2.21 Stress corrosion resistance – Thread bar in prestressing steel

Purpose of the assessment

To assess stress corrosion resistance of thread bar in prestressing steel.

Assessment method

The thread bar shall be subjected to a stress corrosion test according to EN ISO 15630-3, clause 11. The following parameters apply in relation to EN ISO 15630-3, clause 11:

- With a force of $0.8 \cdot \overline{F}_m$
- With test solution A
- Temperature shall be according to EN ISO 15630-3, clause 11.4.3 and clause 11.4.4.
- Until failure of the thread bar. The stress corrosion test may be terminated once 400 hours without fracture have been attained.

Stress corrosion resistance is median time until failure according to EN ISO 15630-3, clause 11.4.6, and minimum time until failure of the individual specimens.

Record measurements and observations in accordance with Annex J.

The tests shall be performed in the numbers given in Annex H.

Where

$\overline{F}_m$................ kN .... Actual maximum force, mean value determined in tensile tests on 2 specimens adjacent to specimens for the stress corrosion test, see EN ISO 15630-3, clause 11.2 and clause 5.1.

NOTE In tensile testing, it is sufficient to determine the maximum force for $\overline{F}_m$. Elongation does not need to be measured.

Expression of results

- Median time to failure in hours and
- Minimum time to failure in hours

shall be given in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System of assessment and verification of constancy of performance to be applied

For the product covered by the EAD, the applicable European legal act is Commission Decision 98/456/EC.

The system is 1+.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

The manufacturer (regarding the components he buys from the market with DoP) shall take into account the Declaration of Performance issued by the manufacturer of that component. No retesting is necessary.

Table 3.2.1 Control plan for the manufacturer – Cornerstones

№	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples 1)	Minimum frequency of control 1)
Factory production control (FPC), including testing of samples taken at the factory in accordance with a prescribed test plan					
1	Static load test of anchorage	2.2.1	2)	0.2 % 3), 4) ≥ 2 4)	per year
2	Static load test of coupling assembly	2.2.1	2)	0.2 % 3), 4) ≥ 2 4)	per year
3	Resistance to fatigue of anchorage	2.2.2.1	2)	1 4)	per year
4	Resistance to fatigue of coupling assembly	2.2.2.1	2)	1 4)	per year
5	Thread bar in steel				
	Cross-sectional area, mass per metre, tolerance on mass per metre	2.2.9	2)	≥ 3	6)
	Surface geometry 5)	2.2.11.1	2)	≥ 3	6)
	Strength characteristics 5) $\varnothing_{ref}$ < 57.5 mm $\varnothing_{ref}$ ≥ 57.5 mm	2.2.13	2)	≥ 3 ≥ 1	6) 7)
	Elongation at maximum force 5) $\varnothing_{ref}$ < 57.5 mm $\varnothing_{ref}$ ≥ 57.5 mm	2.2.17	2)	≥ 3 ≥ 1	6) 7)
	Resistance to fatigue	2.2.2.2	2)	≥ 5 8)	per year
	Visual inspection 9)	10)	2)	all	per year
6	Thread bar in prestressing steel				
	Cross-sectional area, mass per metre	2.2.10	2)		
	Surface geometry	2.2.12	2)		
	Strength characteristics 11)	2.2.14	2)	} 1 ≥ 3	} 12) 13)
	Elongation at maximum force	2.2.18	2)		
	Constriction at break	2.2.19	2)		
	Visual inspection 9)	10)		All	per year

№	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples [1]	Minimum frequency of control [1]
7	Nuts, couplers, and anchor plates				per year
	Dimensions of simple anchor plate	[2]	[2]	3 % [14), 15)] ≥ 2 [14), 15)]	
	Dimensions of nut and coupler	[2]	[2]	5 % [14), 15)] ≥ 2 [14), 15)]	
	Strength of nut and coupler [16]	[2]	[2]	0.5 % [14] ≥ 2 [14]	
	Material of simple anchor plates	[13]	[2]	All	
	Material of nut and coupler	[14]	[2]	All	
	Visual inspection [9]	[10]	[2]	All	
8	Inner grout	EN 445	EN 447	EN 446	EN 446
9	Dimensions of heat shrinking sleeve	[2]	[2]	0.5 % [19] ≥ 1 [19]	per year
10	Material of heat shrinking sleeve	[20]	[2]	100 %	per year
11	Thickness of heat shrinking sleeve after shrinking	2.2.6.3	[2]	0.5 % [19] ≥ 1 [19]	per year
12	Bond to steel surface of heat shrinking sleeve	[21]	[2]	0.5 % [19] ≥ 1 [19]	per year
13	Dimensions of corrugated plastic sheathing	[2]	[2]	0.1 % [22] ≥ 2 [22]	per year
14	Material of corrugated plastic sheathing	[18]	[2]	All	per year
15	Visual inspection [9] of corrugated plastic sheathing	[10]	[2]	All	per year

1) For two specified numbers of samples or frequencies, the higher number or frequency applies.
2) According to the control plan.
3) Percentage of produced anchorages or coupling assemblies per reference thread bar diameter. After 5 years of successful testing, the frequency may be reduced to 0.1 %.
4) For at least 1 reference thread bar diameter. In case of a production of less than 20 anchorages or coupling assemblies of 1 reference thread bar diameter per year, testing that reference thread bar diameter is not required. However, all reference thread bar diameters shall be tested within 5 years.
5) Assessment of long-term quality level according to EN 10080, clause 8.5.
6) Per reference thread bar diameter and rolling batch, at least however, as specified in EN 10080, clause 8.1.
7) Per reference thread bar diameter and rolling batch, at least however, as specified in EN 10080, clause 8.1, with 1 specimen instead of 3 specimens.
8) Of one reference diameter. Reference diameters < 57.5 mm are all tested within 5 years. Reference diameters ≥ 57.5 mm are represented by one of these reference diameters, rotating for every 5 years. However, in case of failure, all of these reference diameters are tested.
9) Successful visual inspection does not need to be documented.
10) Visual inspection means e.g., main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, corrosion, porosities, blisters, according to the component's specification.
11) Assessment of long-term quality level according to the control plan.
12) Per reference thread bar diameter and 15 tons.
13) Per reference thread bar diameter and heat.
14) Percentage of produced component or minimum number of specimens per reference thread bar diameter and batch of component.

[15] In case of a continuous manufacture without retooling of at least 1 000 parts, the frequency may be reduced to 1 % with at least 1 specimen per shift. The stability of the process of the continuous manufacture shall be verified.
[16] Strength determined by means of hardness.
[17] Test report type “2.2” according to EN 10204 for simple anchor plates.
[18] Inspection certificate type “3.1” according to EN 10204.
[19] Percentage or minimum number for at least 1 size of heat shrinking sleeve per year. All sizes of heat shrinking sleeve shall be tested within 5 years.
[20] Control by means of a test report type “2.2” according to EN 10204.
[21] Detailed visual inspection of work samples. Applied heat shrinking sleeve with all-over adherence to steel surface, free of entrapped air, and free of bond defects.
[22] Percentage or minimum number per nominal diameter of corrugated plastic sheathing. In case of less than 20 applications of a nominal diameter of corrugated plastic sheathing per year, testing that nominal diameter of corrugated plastic sheathing is not required. However, all nominal diameters of corrugated plastic sheathing shall be testes within 5 years.

Regarding traceability of components applies:

– Full traceability of each anchorage component, splice component, and thread bar to its raw material.
– Full traceability of the heat shrinking sleeve to its raw material.

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for Kit for rock and soil anchor are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body – Cornerstones

№	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the Kit for rock and soil anchor.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer.	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control					
1	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1.	According to Control plan	According to Control plan	1/year [1] 2/year for thread bar
Audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities					
1	Thread bar in steel Resistance to static load of anchorage and coupling assembly	2.2.1	[2]	1 [3]	Once per year
2	Thread bar in prestressing steel Single element tensile (thread bar) test	EAD 160004-00-0301	EAD 160004-00-0301	EAD 160004-00-0301	Once per 5 years
3	Thread bar in steel Mass per metre, Cross-sectional area Surface geometry Strength characteristics Elongation at maximum force Visual inspections	2.2.9 2.2.11.1 2.2.13 2.2.17 [5]	[2]	[4]	Each inspection

№	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
4	Thread bar in prestressing steel				Once per year
	Mass per metre, cross-sectional area	2.2.10	2)	8 6), 7)	
	Surface geometry	2.2.12	2)	8 6), 7)	
	Strength characteristics	2.2.14	2)	8 6), 7)	
	Elongation at maximum force	2.2.18	2)	8 6), 7)	
	Modulus of elasticity	2.2.16	2)	8 6), 7)	
	Constriction at break	2.2.19	2)	8 6), 7)	
	Visual inspection	5)	2)	8 6), 7)	
	Resistance to fatigue	2.2.2.3	2)	1 6)	
	Stress relaxation	2.2.20	2)	1 6)	
	Stress corrosion resistance	2.2.21	2)	1 series 8)	
5	Nuts, couplers, anchor pieces, and anchor plates				Each inspection
	Dimensions of anchor plate	2)	2)	3 9)	
	Dimensions of nut and coupler	2)	2)	3 9)	
	Material of anchor plate	2)	2)	3 9)	
	Material of nut and coupler	2)	2)	3 9)	
	Visual inspection of anchor plate	5)	2)	3 10)	
	Visual inspection of nut and coupler	5)	2)	3 10)	
6	Inner grout	EN 447	EN 447	EN 447	Once per year
7	Dimensions of heat shrinking sleeve	2)	2)	1 11)	per year
8	Thickness of heat shrinking sleeve after shrinking	2.2.6.3	2)	1 11)	per year
9	Mass per unit area of adhesive of heat shrinking sleeve	2.2.6.3	2)	1 11)	per year
10	Tensile strength of heat shrinking sleeve	2.2.6.3	2)	1 11)	per year
11	Elongation at break of heat shrinking sleeve	2.2.6.3	2)	1 11)	per year
12	Peel strength to steel surface of heat shrinking sleeve	2.2.6.3	2)	1 11)	per year
13	Bond to steel surface of heat shrinking sleeve	12)	2)	2 13)	per year
14	Chemical composition of adhesive of heat shrinking sleeve	14)	2)	1 11)	per year
15	Material of heat shrinking sleeve	15)	2)	1 11)	per year
16	Peel strength layer to layer of heat shrinking sleeve	2.2.6.3	2)	2 13)	Once every 5 years
17	Thermal aging resistance of heat shrinking sleeve	2.2.6.3	2)	2 13)	Once every 5 years

№	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
18	Indentation resistance of heat shrinking sleeve	2.2.6.3	2)	2 13)	Once every 5 years
19	Impact resistance of heat shrinking sleeve	2.2.6.3	2)	2 13)	Once every 5 years
20	Saponification value of heat shrinking sleeve	2.2.6.3	2)	2 15)	Once every 5 years
16	Corrugated plastic sheathing Material Dimensions	 2) 2)	 2) 2)	 1 16) 3 17)	Each inspection

1) Frequency of inspections by the notified body is once a year. Inspection of thread bar manufacturing is twice a year.
2) According to the control plan.
3) Each anchorage and coupling assembly with 1 reference thread bar diameter. All reference thread bar diameters shall be tested within 5 years.
4) According to EN 10080, clause 8.3.2.
5) Visual inspection means e.g., main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, corrosion according to the component's specification.
6) 1 reference thread bar diameter, all reference thread bar diameters shall be tested within 5 years.
7) After 5 years with positive test results, the number of samples may be reduced to 5.
8) Small reference thread bar diameter.
9) Per kind of component. One reference thread bar diameter shall be sampled. All thread bar reference diameters shall be sampled within 5 years.
10) Each kind of component for all reference thread bar diameters.
11) 1 size of heat shrinking sleeve, all sizes of heat shrinking sleeve shall be tested within 5 years. Sampling for peel strength is appropriate to the test procedure.
12) Visual inspection of applied heat shrinking sleeve regarding all-over adherence to steel surface, free of entrapped air and bond defects.
13) Samples from 2 sizes of heat shrinking sleeve.
14) Determination of infra-red spectrum according to Clause 3.4.1.
15) Test report type "2.2" according to EN 10204.
16) 1 nominal diameter of corrugated plastic sheathing. All nominal diameters of corrugated plastic sheathing shall be tested within 5 years.
17) All nominal diameters of corrugated plastic sheathing. Number per nominal diameter of corrugated plastic sheathing.

3.4 Special methods of control and testing used for the verification of constancy of performance

3.4.1 Infra-red spectrum

Chemical signature of the adhesive shall be determined by infra-red spectroscopy. Purpose is, to use the spectrum for qualitative comparisons only.

Equipment

– Spectrometer

  Infra-red spectrometer, operating with Fourier-transform infra-red spectroscopy, capable to measure an infra-red spectrum of a range between wave numbers 4 000 cm^{-1} and 600 cm^{-1}.

– Crystal

  Crystal, dedicated for infra-red spectroscopy, to apply attenuated total reflection technique.

Agents

– Reference material

  Polystyrene foil, dedicated as reference material for infra-red spectrometers.

Procedure

Following the instructions of the spectrometer manufacturer and record:

– The infra-red spectrum of the polystyrene foil in the range of 4 000 cm^{-1} to 600 cm^{-1}

– The infra-red spectrum of the adhesive in the range of 4 000 cm^{-1} to 600 cm^{-1} shall be determined in attenuated total reflection. According to the technique followed, the adhesive shall be placed on the crystal for attenuated total reflection.

Test report

The test report contains at least the following information:

– Name and address of the test laboratory

– Test report number

– Name and address of the client who has contracted the laboratory

– The complete identification of the Kit for rock and soil anchor carrying the adhesive

– The complete identification of the reference material, the polystyrene foil

– Description of detailed test procedure applied, with deviations if any, in particular the applied technique to determine the infra-red spectrum

– Infra-red spectra of adhesive and polystyrene foil

– Statement of any unexpected or unusual behaviour and respective observation during testing

– Date of the test.

4 REFERENCE DOCUMENTS

EAD 160004-00-0301:2016	Post-tensioning kits for prestressing of structures
EAD 160027-00-0301:2016	Special filling products for post-tensioning kits
EN 196-2:2013	Method of testing cement – Part 2: Chemical analysis of cement
EN 196-3:2016	Methods of testing cement – Part 3: Determination of setting times and soundness
EN 206:2013+A2:2021	Concrete – Specification, performance, production and conformity
EN 445:2007	Grout for prestressing tendons – Test methods
EN 446:2007	Grout for prestressing tendons – Grouting procedures
EN 447:2007	Grout for prestressing tendons – Basic requirements
EN 1238:2011	Adhesive – Determination of the softening point of thermoplastic adhesive (ring and ball)
EN 1537:2013	Execution of special geotechnical works – Ground anchors
EN 10080:2005	Steel for the reinforcement of concrete – Weldable reinforcing steel – General
EN 10204:2004	Metallic products – Types of inspection documents
EN 12068:1998	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
EN 12225:2020	Geotextiles and geotextile-related products – Method for determining the microbiological resistance by a soil burial test
EN 60811-501:2012 /A1:2018	Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds
EN ISO 62:2008	Plastic – Determination of water absorption
EN ISO 3126:2005	Plastic piping systems – Plastic components – Determination of dimensions
EN ISO 6892-1:2019	Metallic materials – Tensile testing – Part 1: Method of test at room temperature
EN ISO 9227:2022	Corrosion tests in artificial atmospheres – Salt spray tests
EN ISO 10304-1:2009 /AC:2012	Water quality – Determination of dissolved anions by liquid chromatography of ions – Part 1: Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate
EN ISO 10304-4:2022	Water quality – Determination of dissolved anions by liquid chromatography of ions – Part 4: Determination of chlorate, chloride and chlorite in water with low contamination
EN ISO 11357-6:2018	Plastics – Differential scanning calorimetry (DSC) – Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
EN ISO 15630-1:2019	Steel for the reinforcement and prestressing of concrete – Test methods – Part 1: Reinforcing bars, wire rod and wire
EN ISO 15630-3:2019	Steel for the reinforcement and prestressing of concrete – Test methods – Part 3: Prestressing steel
EN ISO/IEC 17025:2017	General requirements for the competence of testing and calibration laboratories

ANNEX A THREAD BAR IN STEEL – DETERMINATION OF REFERENCE VALUES

A.1 General

Reference values are determined only if information on nominal values is missing in the MPII.

A.2 Reference diameter

Actual mass per metre of the specimen shall be determined according to EN ISO 15630-1, clause 12. The actual mass per metre, m_{act}, shall be calculated as the quotient of the specimen mass in kg, divided by the specimen length in m. From actual mass per metre, the actual diameter shall be calculated with Equation A.2.1.

$$d_{act} = 2\,000 \cdot \sqrt{\frac{m_{act}}{\pi \cdot \rho}} \qquad \text{Equation A.2.1}$$

The actual diameters of all specimens shall be divided into groups of diameters. Grouping is according to the criteria below:

- The arithmetic mean of actual diameters of all specimens of the group shall be calculated.
- The arithmetic mean is rounded according to Equation A.2.2.

$$\begin{array}{l} \leq 30.0\text{ mm, rounded to the nearest } 0.1\text{ mm} \\ \left.\begin{array}{r} > 30.0\text{ mm} \\ \text{to} \\ 70.0\text{ mm} \end{array}\right\}\text{, rounded to the nearest } 0.2\text{ mm} \\ > 70.0\text{ mm, rounded to the nearest } 0.5\text{ mm} \end{array} \qquad \text{Equation A.2.2}$$

- The actual diameters of all specimens of the group do not deviate by more than ± 2.5 % of the rounded arithmetic mean.
- The rounded arithmetic mean of the group is the reference diameter, $\varnothing_{ref}$, of that group.
- The reference diameters of all groups establish a series of reference diameters.

Reference cross-sectional area of the group, $S_{s,\,ref}$, shall be calculated with the reference diameter, $\varnothing_{ref}$, by Equation 1.1.1.2.2.

Where

d_{act}.............. mm...................... Actual diameter of specimen

m_{act}.............kg/m..................... Actual mass per metre of specimen

ρ................kg/m³.................... Density, 7 850 kg/m³, for hot rolled thread bar

$\varnothing_{ref}$............. mm...................... Reference diameter of the group

$S_{s,\,ref}$...........mm²..................... Reference cross-sectional area of the group.

A.3 Reference yield strength and reference tensile strength

Yield strength and tensile strength shall be determined in tension, see also EN 10080, clause 7.2.3. Stress values shall be calculated based on the reference cross-sectional area, $S_{s,\,ref}$ according to Clause A.2. Tensile test on the specimen shall be carried out in accordance with EN ISO 15630-1, clause 5. The following parameters and procedures apply in relation to EN ISO 15630-1:

- Specimen shall be according to EN ISO 15630-1, clause 4, without artificial ageing and according to EN ISO 15630-1, clause 5.1.
- Test equipment shall be according to EN ISO 15630-1, clause 5.2.
- Tensile test shall be performed at room temperature.
- EN ISO 6892-1, clauses 10.1 and 10.2 apply.

- Force-extension diagram shall be recorded.
- Testing rate shall be according to EN ISO 6892-1, clauses 10.3.3.1, 10.3.3.2.1, 10.3.3.2.4, 10.3.3.2.5, and 10.3.3.3, whereby the crosshead separation rate applies.
- Determination of $R_{e, act}$ shall be according to EN ISO 6892-1, clauses 11 and 13, or EN ISO 15630-1, clause 5.3. These procedures are considered as equivalent. Reference procedure for proof strength is EN ISO 15630-1, clause 5.3, second method.
- Determination of $R_{m, act}$ shall be with the maximum force in tensile test, considering EN ISO 15630-1, clause 5.3.

The actual yield strengths, $R_{e, act}$, of the specimens shall be divided into groups of yield strength. Grouping is according to the criteria below:

- The arithmetic mean, $R_{e, mean}$, of actual yield strengths of all specimens of the group shall be calculated.
- The actual yield strengths of all specimens of the group do not deviate by more than $\pm$ 50 MPa of the arithmetic mean.

The reference yield strength of the group shall be calculated with Equation A.3.1.

$R_{e, ref} = 0.85 \cdot R_{e, mean}$, rounded to the nearest 10 MPa   Equation A.3.1

The arithmetic mean, $R_{m, mean}$, of actual tensile strengths of all specimens of the group shall be calculate and the reference tensile strength shall be calculated with Equation A.3.2.

$R_{m, ref} = 0.85 \cdot R_{m, mean}$, rounded to the nearest 10 MPa   Equation A.3.2

Where

$R_{e, act}$ .... MPa .... Actual yield strength of specimen

$R_{e, mean}$ .... MPa .... Arithmetic mean of actual yield strengths of all specimens of the group

$R_{e, ref}$ .... MPa .... Reference yield strength of the group

$R_{m, act}$ .... MPa .... Actual tensile strength of specimen

$R_{m, mean}$ .... MPa .... Arithmetic mean of actual tensile strengths of all specimens of the group

$R_{m, ref}$ .... MPa .... Reference tensile strength of the group

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of specimen, see Clause A.2.

ANNEX B THREAD BAR IN PRESTRESSING STEEL – DETERMINATION OF REFERENCE VALUES

B.1 General

Reference values are determined only if information on nominal values is missing in the MPII.

B.2 Reference diameter

Actual mass per metre of the specimen shall be determined according to EN ISO 15630-1, clause 12. The actual mass per metre, M_{act}, shall be calculated as the quotient of the specimen mass in kg, divided by the specimen length in m. From actual mass per metre, the actual diameter shall be calculated with Equation B.2.1.

$$d_{act} = 2\,000 \cdot \sqrt{\frac{M_{act}}{1.035 \cdot \pi \cdot \rho}}$$ Equation B.2.1

The actual diameters of all specimens shall be divided into groups of diameters. Grouping is according to the criteria below:

– The arithmetic mean, d_{mean}, of actual diameters of all specimens of the group shall be calculated.

– The actual diameters of all specimens of the group shall not deviate by more than ± 2.5 % of the arithmetic mean, d_{mean}.

– The arithmetic mean, d_{mean}, of the group shall be multiplied according to Equation B.2.2.

$$0.987\,2 \cdot d_{mean}$$ Equation B.2.2

– The reference diameter, $\varnothing_{ref}$, of the group is the arithmetic mean, d_{mean}, multiplied according to Equation B.2.2 and rounded according to Equation B.2.3.

≤ 30 mm, rounded to the nearest 0.1 mm
> 30 mm, rounded to the nearest 0.2 mm Equation B.2.3

– The reference diameters of all groups establish a series of reference diameters.

Reference cross-sectional area of the group, $S_{y,\,reff}$, shall be calculated with the reference diameter, $\varnothing_{ref}$, by Equation 1.1.1.4.2.

Where

d_{act} .... mm .... Actual diameter of specimen

d_{mean} .... mm .... Arithmetic mean diameter of all specimens of the group

M_{act} .... kg/m .... Actual mass per metre of specimen

ρ .... kg/m³ .... Density, 7 850 kg/m³, for hot rolled thread bar

$\varnothing_{ref}$ .... mm .... Reference diameter of the group

$S_{y,\,ref}$ .... mm² .... Reference cross-sectional area of the group.

B.3 Reference yield strength and reference tensile strength

Yield strength and tensile strength shall be determined in tension. Stress values shall be calculated based on the reference cross-sectional area, $S_{y,\,ref}$ according to Clause B.2. Tensile test on the specimen shall be carried out in accordance with EN ISO 15630-3, clause 5. The following parameters and procedures apply in relation to EN ISO 15630-3:

– Specimen shall be according to EN ISO 15630-3, clause 4 and clause 5.1.

– Test equipment shall be according to EN ISO 15630-3, clause 5.2.

– Tensile test shall be performed at room temperature.

- EN ISO 6892-1, clauses 10.1 and 10.2 apply.
- Force-extension diagram shall be recorded.
- Testing rate shall be according to EN ISO 6892-1, clauses 10.3.3.1, 10.3.3.2.4, 10.3.3.2.5, and 10.3.3.3, whereby the crosshead separation rate applies.
- Determination of $R_{p0.1,\ act}$ shall be according to EN ISO 6892-1, clause 13.
- Determination of $R_{m,\ act}$ shall be with the maximum force in tensile test, considering EN ISO 15630-3, clause 5.3.

The actual tensile strengths, $R_{m,\ act}$, of the specimens shall be divided into groups of tensile strength. Grouping is according to the criteria below:

- The arithmetic mean, $R_{m,\ mean}$, of actual tensile strengths of all specimens of the group shall be calculated.
- The actual tensile strengths of all specimens of the group do not deviate by more than ± 65 MPa of the arithmetic mean.
- The reference tensile strength of the group shall be calculated with Equation B.3.1.

$R_{m,\ ref} = 0.90 \cdot R_{m,\ mean}$, rounded to the nearest 10 MPa — Equation B.3.1

- The arithmetic mean, $R_{p0.1,\ mean}$, of actual yield strengths of all specimens of the group shall be calculate and the reference yield strength shall be calculated with Equation B.3.2.

$R_{p0.1,\ ref} = 0.90 \cdot R_{p0.1,\ mean}$, rounded to the nearest 10 MPa — Equation B.3.2

- Reference yield strengths and reference tensile strengths of all groups establish the reference strengths characteristics of the specimens.

With reference yield strength, $R_{p0.1,\ ref}$, and reference tensile strength, $R_{m,\ ref}$, reference 0.1 % proof force, $F_{p0.1,\ ref}$ and reference maximum force, $F_{m,\ ref}$, shall be calculated with Equation B.3.3 and Equation B.3.4.

$$F_{p0.1,\ ref} = \frac{R_{p0.1,\ ref} \cdot S_{y,\ ref}}{1\,000}$$, rounded to the nearest 1 kN — Equation B.3.3

$$F_{m,\ ref} = \frac{R_{m,\ ref} \cdot S_{y,\ ref}}{1\,000}$$, rounded to the nearest 1 kN — Equation B.3.4

Where

$R_{p0.1,\ act}$ .... MPa .... Actual yield strength of specimen
$R_{p0.1,\ mean}$ .... MPa .... Arithmetic mean of actual yield strengths of all specimens of the group
$R_{p0.1,\ ref}$ .... MPa .... Reference yield strength of the group
$F_{p0.1,\ ref}$ .... kN .... Reference 0.1 % proof force of the group
$R_{m,\ act}$ .... MPa .... Actual tensile strength of specimen
$R_{m,\ mean}$ .... MPa .... Arithmetic mean of actual tensile strengths of all specimens of the group
$R_{m,\ ref}$ .... MPa .... Reference tensile strength of the group
$F_{m,\ ref}$ .... kN .... Reference maximum force of the group
$S_{y,\ ref}$ .... mm^2 .... Reference cross-sectional area of specimen, see Clause B.2.

ANNEX C CALCULATION OF 5 % FRACTILE

Calculation of mean by Equation C.1.

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$$ Equation C.1

Calculation of standard deviation by Equation C.2.

$$s = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} (x_i - \bar{x})^2}$$ Equation C.2

Calculation of coefficient of variation by Equation C.3.

$$V = \frac{s}{\bar{x}}$$ Equation C.3

Calculation of 5 % fractile by Equation C.4.

$$x_{5\,\%} = \bar{x} \cdot (1 - k \cdot V)$$ Equation C.4

Table C.1 Factor for 5 % fractile

n	k	n	k	n	k
5	4.21	12	2.74	19	2.42
6	3.71	13	2.67	20	2.40
7	3.40	14	2.61	30	2.22
8	3.19	15	2.57	40	2.13
9	3.03	16	2.52	50	2.07
10	2.91	17	2.49		
11	2.82	18	2.45		

Where

i .... i^{th} observation, i = 1, 2, ..., n
n .... Number of all observations to be evaluated
x_i .... i^{th} observed value
$\bar{x}$ .... Arithmetic mean of all observations
s .... Standard deviation of all observations
V .... Coefficient of variation
k .... Factor in dependence of n, see Table C.1
$x_{5\,\%}$ .... 5 % fractile.

ANNEX D STATIC LOAD TEST

D.1 Specimen

Anchorage and coupling assembly shall be assembled according to the MPII, using all components necessary for anchoring and jointing the thread bar, see Figure D.2.1.

The free length of the thread bars in the specimen for static load test shall be not less than a minimum length of 1.0 m for thread bars.

The following data of the thread bar in steel shall be determined:

- 3 tensile tests on thread bars according to EN ISO 15630-1 shall be performed. The thread bars for tensile tests and the thread bar for static load test shall be taken from the same batch.
- Calculated actual tensile strength, $R_{m, act}$, as arithmetic mean out of tensile strength of 3 tensile tests.
- Stress shall be calculated with the reference cross-sectional area of thread bar, $S_{s, ref}$.

The following data of the thread bar in prestressing steel shall be determined:

- 3 tensile tests on thread bars according to EN ISO 15630-3 shall be performed. The thread bars for tensile tests and the thread bar for static load test shall be taken from the same batch.
- Calculated actual maximum force, $F_{m, act}$, as arithmetic mean out of maximum force of 3 tensile tests.

Where

$R_{m, act}$ .... MPa .... Actual tensile strength of thread bar in steel

$S_{s, ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$F_{m, act}$ .... kN .... Actual maximum force of thread bar in prestressing steel.

D.2 Test procedure

The specimen shall be mounted in the test rig or testing machine, see Figure D.2.1.

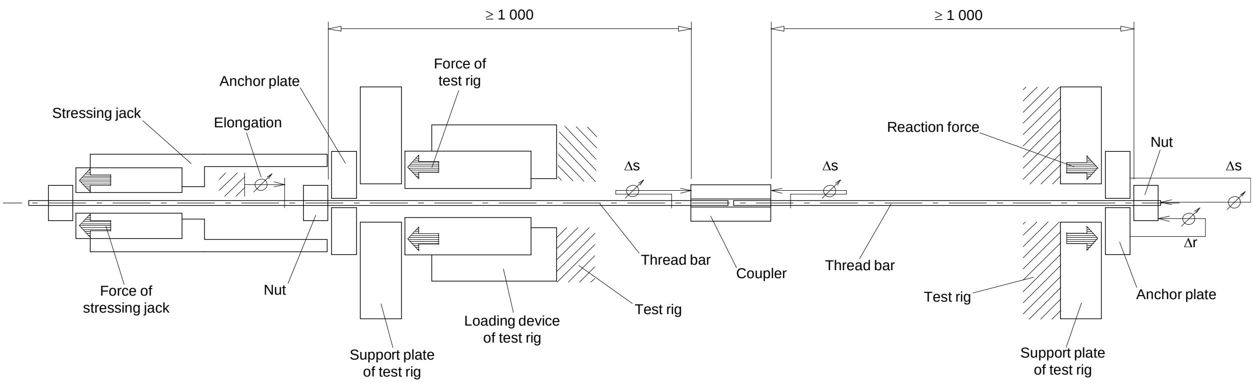
The specimen shall be stressed at one end with a stressing jack in steps corresponding to:

- 20 %, 40 %, 60 %, and 80 % of the reference tensile strength of the thread bars in steel. Stresses shall be calculated with the reference cross-sectional area of the thread bar in steel, $S_{s, ref}$.
- 20 %, 40 %, 60 %, and 80 % of the reference maximum force of the thread bars in prestressing steel.

The load shall be increased at a constant rate corresponding to about 100 MPa per minute. At 80 % level, the load shall be transferred from the stressing jack to the anchorage and test rig. It shall then be held constant at 80 % level by the test rig for at least two hours. The load shall then be reduced by the test rig to 20 % level. Subsequently, the load shall be gradually increased with the test rig to failure at a maximum strain rate of 0.002 per minute.

The displacements are measured at the load steps and during holding time.

The uncertainty of values measured with the measuring equipment shall be within ± 1 %. Loads shall be maintained with a maximum tolerance of ± 2 %. The load measured in the stressing jack shall be adjusted for estimated friction losses in the anchorages to assure that the specified load has been applied to the anchorage used for measurement.



Dimensions in mm

Figure D.2.1 Static load test – Schematic

Where

$S_{s, ref}$ .... mm² .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

Δr .... mm..................... Displacement between anchorage components, see Figure D.4.1

Δs.............. mm..................... Displacement between thread bar and coupler or anchorage, see Figure D.4.1.

D.3 Stabilisation criteria

The following stabilisation criteria[5] apply:

- For thread bar in steel, with the load held at 80 % of reference tensile strength, $R_{m, ref} \cdot S_{s, ref}$, the displacements shall stabilise within the first 30 minutes.
- For thread bar in prestressing steel, with the load held at 80 % of the thread bar reference maximum force, $F_{m, ref}$, the displacements shall stabilise within the first 30 minutes.
- Total elongation, ε_{Tu}, of thread bar on the free length at measured maximum load shall be at least 2 %.
- Failure shall be by fracture of the thread bar. Failure of the specimen shall not be induced by failure of anchorage components or coupler.
- Residual deformations of anchorage components and coupler after testing shall confirm reliability of anchorage and coupler.

Where

$R_{m, ref}$ .... MPa .... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2

$S_{s, ref}$ .... mm² .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$F_{m, ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel, see Clause 1.1.1.4

ε_{Tu} .... % .... Elongation of thread bar at maximum load in static load test.

D.4 Measurements and observations

The following measurements and observations shall be made and recorded:

- Determination of actual material characteristics of tested components.
- Checking of the components for materials, machining, geometry, hardness, et cetera.
- Load – and time – dependent displacement Δs of the thread bars with respect to the anchorage or coupler, see Figure D.4.1.
- Load – and time – dependent displacement Δr between the individual components of the anchorage, see Figure D.4.1.

[5] The stabilisation criteria originate from EAD 160004-00-0301.

- Complete load-elongation diagram, continuously recorded during the test.
- Elongation of the thread bars, ε_{Tu}, on free length at measured maximum force F_{Tu}.
- Measured maximum force F_{Tu}.
- Location and mode of failure.
- Examination of components after dismantling, photographic documentation, comments. Any unusual deformations of anchorage components after the end of the test should be recorded. If measurements of deformations are made, they shall have resolution lower or equal than 0.01 mm.

Where

Δr .... mm...................... Displacement between anchorage components, see Figure D.4.1

Δs............... mm...................... Displacement between thread bar and coupler or anchorage, see Figure D.4.1

F_{Tu}............... kN .... Maximum force in static load test

ε_{Tu} ....%....................... Elongation of thread bar at maximum load in static load test.

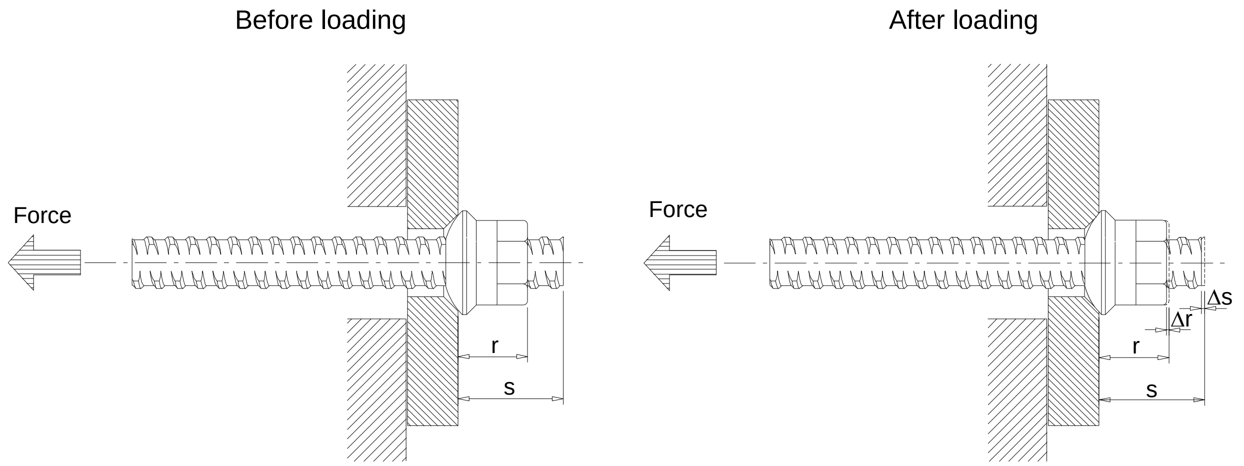


Figure D.4.1 Displacements during testing – Schematic example

ANNEX E FATIGUE TEST

E.1 Specimen

The specimen corresponds to Clause D.1 without stressing jack. At least at one end of the specimen anchorage assembly shall be assembled according to the MPII, using all components necessary for anchoring the thread bar. If both ends of the specimen have such anchorage details as specified above, the specimen may count as two tests, see Figure E.2.1. For the coupling assembly this applies analogously, see Figure E.2.1.

E.2 Test procedure

The specimen shall be mounted in the test rig or testing machine, see Figure E.2.1.

The test shall be performed at a constant load frequency of not more than 30 Hz, generated by the test rig and with a constant upper force, F_{max}, of:

– 65 % of the reference tensile strength of the thread bar in steel, see Equation E.2.1.

– 65 % of the reference maximum force of the thread bar in prestressing steel, see Equation E.2.2.

$$F_{max} = 0.65 \cdot \frac{R_{m,\,ref} \cdot S_{s,\,ref}}{1\,000}$$ Equation E.2.1

$$F_{max} = 0.65 \cdot F_{m,\,ref}$$ Equation E.2.2

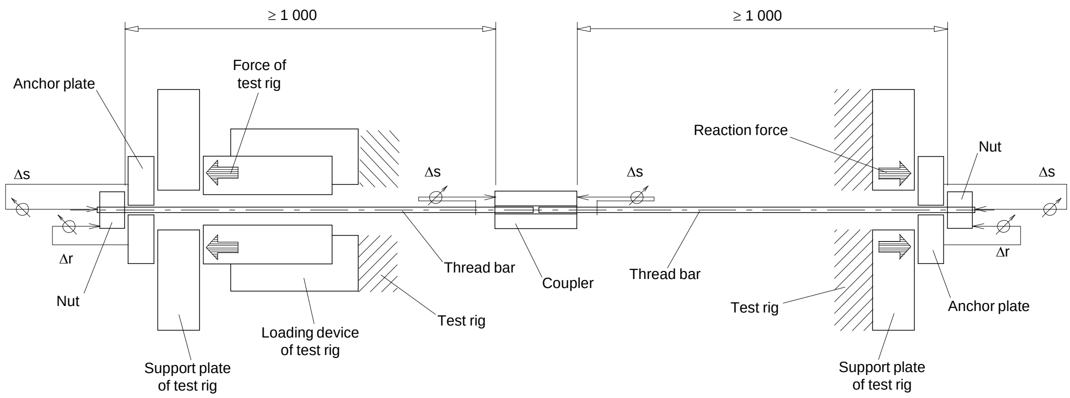
Stress range, $2 \cdot \sigma_a$, shall be maintained constant throughout the test for 2 million cycles. See Figure E.2.2 for force in fatigue test. On its free length, the specimen shall be without duct and filling material.

NOTE The test may be performed with higher upper force, reference is the upper force in the paragraph above.

The displacements are measured during fatigue loading.

The specimen shall be tested in such a way that secondary oscillations are precluded.

Stress shall be calculated with the reference cross-sectional area of thread bar, $S_{s,\,ref}$ or $S_{y,\,ref}$.



Dimensions in mm

Figure E.2.1 Fatigue test – Schematic example with two anchorages and one coupling assembly

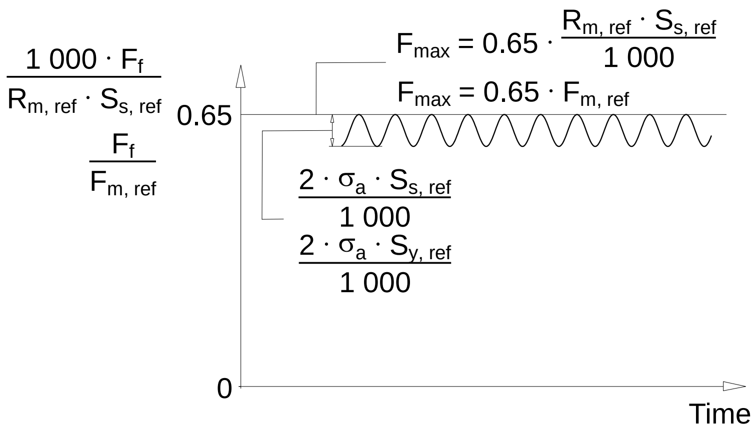


Figure E.2.2 Force in fatigue test – Schematic

Where

Δr .... mm...................... Displacement between anchorage components, see Figure D.4.1

Δs............... mm...................... Displacement between thread bar and coupler or anchorage, see Figure D.4.1

$R_{m,\,ref}$ ....MPa..................... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2

$S_{s,\,ref}$ ....mm^2..................... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

F_f................. kN .... Force in fatigue test

F_{max} .... kN .... Upper force in fatigue test

$S_{y,\,ref}$ ....mm^2..................... Reference cross-sectional area of thread bar in prestressing steel, see Clause 1.1.1.4

$F_{m,\,ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel, see Clause 1.1.1.4

$2 \cdot \sigma_a$ ....MPa..................... Stress range in fatigue test, i.e., two times the stress amplitude.

E.3 Stabilisation criteria

The following stabilisation criteria[6] apply:

- The displacements between anchorage components, between thread bar and coupler, and between thread bar and anchorage components shall stabilise during the test.
- No fatigue failure in anchorage components and coupler shall occur.
- The specimen shall sustain a fatigue loading of 2 million ($2 \cdot 10^6$) load cycles at the stress range of $2 \cdot \sigma_a$.

Stress shall be calculated with the reference cross-sectional area of thread bar, $S_{s,\,ref}$ or $S_{y,\,ref}$.

Where

$S_{s,\,ref}$ ....mm^2..................... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$S_{y,\,ref}$ ....mm^2..................... Reference cross-sectional area of thread bar in prestressing steel, see Clause 1.1.1.4

$2 \cdot \sigma_a$..........MPa..................... Stress range in fatigue test, i.e., two times the stress amplitude.

E.4 Measurements and observations

The following measurements and observations shall be made and recorded:

6 Stabilisation criteria in fatigue test originate from EAD 160004-00-0301.

- Determination of actual material characteristics of tested components.
- Checking of the components for materials, machining, geometry, hardness, et cetera.
- Displacement between thread bar and individual anchorage and coupler components as well as between the anchorage components, dependent on load and on number of load cycles, see Δr and Δs in Figure D.4.1.
- Examination of anchorage and coupler components and thread bar after test with respect to fatigue damage and deformation.
- Number of load cycles attained.
- Fracture location of thread bar or component that has failed by fatigue, as a function of the number of load cycles.
- Examination of components after dismantling, photographic documentation, comments.

Where

Δr .... mm...................... Displacement between anchorage components, see Figure D.4.1

Δs............... mm...................... Displacement between thread bar and coupler or anchorage, see Figure D.4.1.

ANNEX F LOAD TRANSFER TEST

F.1 Specimen

The specimen is schematically shown in Figure F.4.1.

Table F.1.1 Parameter of specimens for load transfer test

Parameter	Parameter specified in MPII	Parameter not specified in the MPII
Anchorage components	The components of the Kit for rock and soil anchor shall be used, see Clause 1.1.	
Void	Shape and dimensions as specified in the MPII.	Shape and dimensions shall be according to the steel tube, see Clause 1.1.2.
Bursting reinforcement	The component of the Kit for rock and soil anchor shall be used, see Clause 1.1.2.	The Kit for rock and soil anchor is without bursting reinforcement, see Clause 1.1.2.
Auxiliary reinforcement	As specified in Clause F.1.	
Combined bursting and auxiliary reinforcement	As specified in the MPII.	The Kit for rock and soil anchor is without bursting reinforcement, see Clause 1.1.2.
Reference concrete compressive strength, $f_{cm,0}$	$f_{cm,0}$ according to the MPII.	Concrete compressive strength C20/25 shall be applied.
Centre distances in x- and y-direction	Dimensions a and b shall be according to the MPII.	A square specimen with a = b shall be used. Pre-tests shall be carried out in accordance with Annex F. Once maximum force F_u given by Equation F.2.1, Equation F.2.2, Equation F.2.3, or Equation F.2.4 and stabilisation criteria given by clause F.3 are met, the side length of the tested specimen shall be taken as dimension a.

The test specimens shall be a concrete prism. Their concrete cross section, $A_c = a \cdot b$, corresponding to the minimum centre distances, their shape and dimensions of the void, and their reference concrete strength shall be taken from Table F.1.1. The specimens shall contain those anchorage components and bursting reinforcement that will be embedded in the structural concrete. Components and reinforcement shall be arranged as given in Table F.1.1.

The height h of specimens shall be:

– At least twice the longer of the two side lengths a or b. See Figure F.4.2, showing a specimen of that proportions.

  And

– The height of the lower part of the specimen, i.e., part with auxiliary reinforcement reinforced shall be at least $0.5 \cdot h$. See Figure F.4.1, showing a specimen with bursting reinforcement and auxiliary reinforcement.

Reinforcement shall be placed as bursting reinforcement and auxiliary reinforcement:

– For Kit for rock and soil anchor with bursting reinforcement, amount and configuration of the bursting reinforcement shall be as given in Table F.1.1. The part of the specimens with the anchorage components shall contain the bursting reinforcement.

– Auxiliary reinforcement comprises longitudinal reinforcement and transverse stirrups reinforcement:

   - Longitudinal reinforcement shall be bars with a total cross-sectional area of ≤ 0.003 · A_c.
   - Transverse reinforcement shall be stirrups, uniformly distributed along the height of specimens, with ≤ 50 kg steel/(m^3 concrete).
   - The 50 kg/m^3 stirrups, uniformly distributed along the height of specimens, shall be placed over the entire height of the specimen.
   - If specified according to Table F.1.1, auxiliary reinforcement shall be combined with bursting reinforcement. For combined reinforcement, only the reinforcement beyond 50 kg/m^3 shall be considered as bursting reinforcement. If not specified as combined reinforcement, bursting reinforcement and auxiliary reinforcement shall be placed as two independent reinforcements.
- For Kit for rock and soil anchor without bursting reinforcement, only the auxiliary reinforcement shall be placed in the specimen.

The concrete cover to the reinforcement shall be 10 mm, see Figure F.4.1.

The concrete of the test specimens shall be according to Table F.1.1. The composition of the concrete used for the load transfer test specimens shall be given in the test report. The test specimens should be concreted normally in a horizontal position. After casting the specimens shall be de-moulded after one day and then moist-cured by covering until testing. The test cylinders or cubes cast for determination of compressive strength of concrete shall be cured the same way.

For extended applications, minimum centre spacing of anchorage in x- and y-directions, x and y, and minimum edge spacing can be derived from the tested dimensions a and b. Without specific testing Equation F.1.1, Equation F.1.2, Equation F.1.3, Equation F.1.4, and Equation F.1.5 shall be applied.

Derived centre spacings shall conform to Equation F.1.1 and Equation F.1.2.

$$x \geq 0.85 \cdot a$$ Equation F.1.1

$$y \geq 0.85 \cdot b$$ Equation F.1.2

With derived centre spacings Equation F.1.3 shall be met. I.e., reduction of centre distance in one direction requires to increase centre distance in the other direction.

$$A_c = x \cdot y \geq a \cdot b$$ Equation F.1.3

Edge distances shall be calculated with centre spacings in x- and y-direction by Equation F.1.4 and Equation F.1.5.

$$e_x = \frac{x}{2} - 10\text{ mm} + c$$ Equation F.1.4

$$e_y = \frac{y}{2} - 10\text{ mm} + c$$ Equation F.1.5

Where

a, b .... mm...................... Side lengths of test specimen

x, y .... mm...................... Minimum specified centre spacing in x- and y-direction

A_c ....mm^2..................... Gross cross-sectional concrete area of specimen

e_x, e_y .... mm...................... Edge distance in x- and y-direction respectively

c................. mm...................... Concrete cover of reinforcement

$f_{cm,0}$ ....MPa..................... Reference concrete compressive strength for load transfer test, see Table F.1.1

h................. mm...................... Height of specimen.

F.2 Test procedure

The specimen shall be mounted in a calibrated test rig or testing machine. The load shall be applied to the specimen using the anchorage components.

– Loading for thread bar in steel

  The load shall be increased in steps, see Figure F.2.1, $0.12 \cdot R_{m, ref} \cdot S_{s, ref}$, $0.2 \cdot R_{m, ref} \cdot S_{s, ref}$, $0.4 \cdot R_{m, ref} \cdot S_{s, ref}$, $0.6 \cdot R_{m, ref} \cdot S_{s, ref}$, and $0.8 \cdot R_{m, ref} \cdot S_{s, ref}$. After attaining the load $0.8 \cdot R_{m, ref} \cdot S_{s, ref}$, at least ten, i.e., $m \geq 10$, load cycles shall be performed with a force range of $0.8 \cdot R_{m, ref} \cdot S_{s, ref}$ and $0.12 \cdot R_{m, ref} \cdot S_{s, ref}$ being the upper and the lower load respectively.

– Loading for thread bar in prestressing steel

  The load shall be increased in steps, see Figure F.2.1, $0.12 \cdot F_{m, ref}$, $0.2 \cdot F_{m, ref}$, $0.4 \cdot F_{m, ref}$, $0.6 \cdot F_{m, ref}$, and $0.8 \cdot F_{m, ref}$. After attaining the load $0.8 \cdot F_{m, ref}$, at least ten, i.e., $m \geq 10$, load cycles shall be performed with a force range of $0.8 \cdot F_{m, ref}$ and $0.12 \cdot F_{m, ref}$ being the upper and the lower load respectively.

The load cycle shall be performed force controlled and comprises:

– Steadily increase force from lower load to upper load. Time to increase force from lower load to upper load shall be at least 1 minute.
– Holding upper load constant as long as required to inspect the specimen and perform measurements.
– Steadily decrease force from upper load to lower load. Time to decrease force from upper load shall be at least 1 minute.
– Holding lower load constant as long as required to inspect the specimen and perform measurements.

The necessary number of load cycles depends upon stabilisation of strain readings and crack widths. See Clause F.3 for stabilisation criteria. Following cyclic loading, the specimen shall be loaded continuously to failure. The test may be terminated without failure at a force exceeding:

– For specimen with bursting reinforcement as by Equation F.2.1 – Thread bar in steel.

$$F_{u, br, s} \geq 1.1 \cdot \frac{R_{m, ref} \cdot S_{s, ref}}{1\,000} \cdot \frac{f_{cm, e}}{f_{cm, 0}} \qquad \text{Equation F.2.1}$$

– For specimen without bursting reinforcement as by Equation F.2.2 – Thread bar in steel.

$$F_{u, 0, s} \geq 1.3 \cdot \frac{R_{m, ref} \cdot S_{s, ref}}{1\,000} \cdot \frac{f_{cm, e}}{f_{cm, 0}} \qquad \text{Equation F.2.2}$$

– For specimen with bursting reinforcement as by Equation F.2.3 – Thread bar in prestressing steel.

$$F_{u, br, y} \geq 1.1 \cdot F_{m, ref} \cdot \frac{f_{cm, e}}{f_{cm, 0}} \qquad \text{Equation F.2.3}$$

– For specimen without bursting reinforcement as by Equation F.2.4 – Thread bar in prestressing steel.

$$F_{u, 0, y} \geq 1.3 \cdot F_{m, ref} \cdot \frac{f_{cm, e}}{f_{cm, 0}} \qquad \text{Equation F.2.4}$$

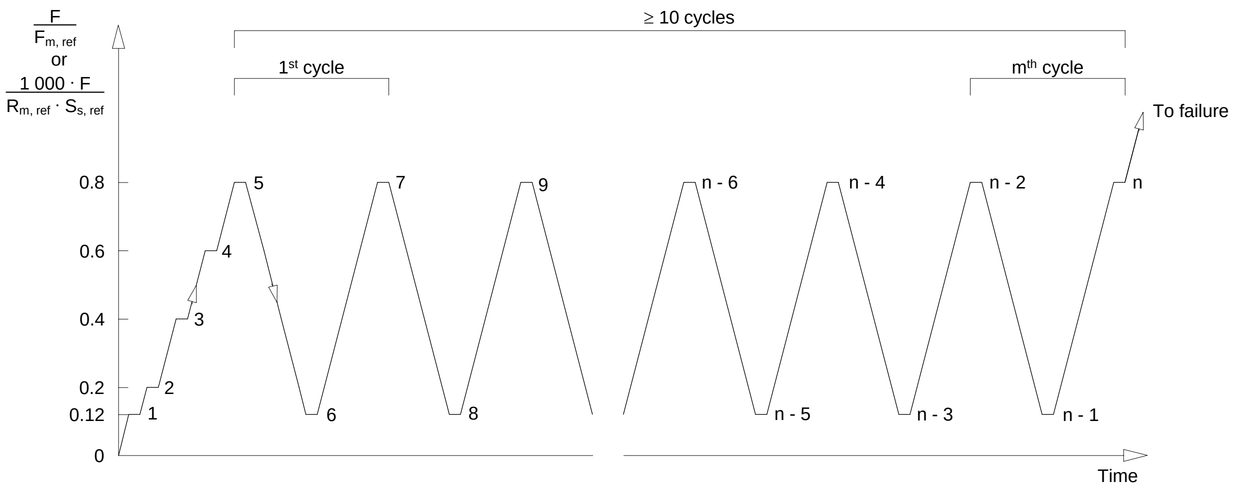


Figure F.2.1 Loading sequence in load transfer test

During cyclic loading, measurement shall be taken as numbered in Figure F.2.1, i.e., 1, 2, … to n. At the upper and the lower loads of several cycles, the measurements shall permit to decide whether stabilisation of strains and crack widths is being attained, see Clause F.3.

Equivalent to Figure F.2.1, the measurement at 1 to 4 may be taken at different load levels than indicated in Figure F.2.1. Measurement shall be performed at least at 3 load levels.

At the final test to failure, the mean compressive strength of concrete[7] of specimen shall be as by Equation F.2.5.

$$f_{cm,\,e} \leq f_{cm,\,0} + 3\ \text{MPa} \qquad \text{Equation F.2.5}$$

Where

F .... kN .... Force in load transfer test

$F_{u,\,br,\,s}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in steel

$F_{u,\,0,\,s}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in steel

$F_{u,\,br,\,y}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in prestressing steel

$F_{u,\,0,\,y}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in prestressing steel

$R_{m,\,ref}$ .... MPa .... Reference tensile strength of thread bar in steel, see Clause 1.1.1.2

$S_{s,\,ref}$ .... mm^2 .... Reference cross-sectional area of thread bar in steel, see Clause 1.1.1.2

$F_{m,\,ref}$ .... kN .... Reference maximum force of thread bar in prestressing steel, see Clause 1.1.1.4

$f_{cm,\,e}$ .... MPa .... Concrete compressive strength at time of end of load transfer test

$f_{cm,\,0}$ .... MPa .... Reference concrete compressive strength for load transfer test, see Table F.1.1

m................. — .... Number of load cycles

n.................. — .... Number of readings for measurements.

[7] The criterion regarding compressive strength of concrete originates from EAD 160004-00-0301.

F.3 Stabilisation criteria

Crack widths[8] w shall be:

- Upon first attainment of upper load, $w_{max} \leq 0.15$ mm
- Upon last attainment of lower load, $w_{max} \leq 0.15$ mm
- Upon last attainment of upper load, $w_{max} \leq 0.25$ mm.

Crack widths shall be considered to have stabilised, either if their width under upper load conforms to Equation F.3.1 or crack width does not exceed 0.10 mm throughout the test.

$$w_n - w_{n-8} \leq \frac{1}{3} \cdot (w_{n-8} - w_5),\ m \geq 10 \qquad \text{Equation F.3.1}$$

Longitudinal and transverse strains[8] can be considered to have stabilised if the increase of strain under the upper load conforms to Equation F.3.2.

$$\varepsilon_n - \varepsilon_{n-8} \leq \frac{1}{3} \cdot (\varepsilon_{n-8} - \varepsilon_5),\ m \geq 10 \qquad \text{Equation F.3.2}$$

See Figure F.4.3 and Figure F.4.4 for details on how to assess stabilisation criteria.

Stabilisation criteria shall be assessed for all cracks and for all strain measurement gauges placed on the specimen.

Where

w .... mm...................... Crack width

w_{max}............ mm...................... Maximum crack width

w_5, w_{n-8}, w_n .... mm...................... Crack width, measured at specific load cycles.

ε_5, ε_{n-8}, ε_n .... mm/m.................... Strain, measured at specific load cycles.

m.................—....................... Number of load cycles

n..................—....................... Number of readings for measurements.

F.4 Measurements and observations

The following measurements and observations shall be made and recorded:

- Determination of actual material characteristics of tested components.
- Checking of the components for materials, machining, geometry, hardness, et cetera.
- Longitudinal and transverse concrete strains on at least two side faces of the specimen in the region of maximum bursting effect under the upper and lower load, dependent on number of load cycles. Longitudinal and transverse concrete strains and crack width and propagation shall also be recorded at readings 1, 2, and 3 indicated in Figure F.2.1.
- Formation, width, and propagation of cracks on the side faces of the specimen, as mentioned above.
- Visual inspection and/or measurement of deformation of anchorage components in contact with concrete. Any unusual or excessive deformation, such as large permanent deformations, shall be reported in the test report, and such actual deformation may be measured.
- Location and mode of failure.
- Measured maximum force $F_{u, br, s}$, $F_{u, 0, s}$, $F_{u, br, y}$, or $F_{u, 0, y}$
- Concrete compressive strength at time of end of load transfer test, $f_{cm, e}$.

[8] The criteria regarding crack width and stabilisation of crack width and strain originate from EAD 160004-00-0301.

– Examination of components and specimen after testing, photographic documentation, comments.

Where

$F_{u,\,br,\,s}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in steel

$F_{u,\,0,\,s}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in steel

$F_{u,\,br,\,y}$ .... kN .... Maximum force in load transfer test for specimen with bursting reinforcement for thread bar in prestressing steel

$F_{u,\,0,\,y}$ .... kN .... Maximum force in load transfer test for specimen without bursting reinforcement for thread bar in prestressing steel.

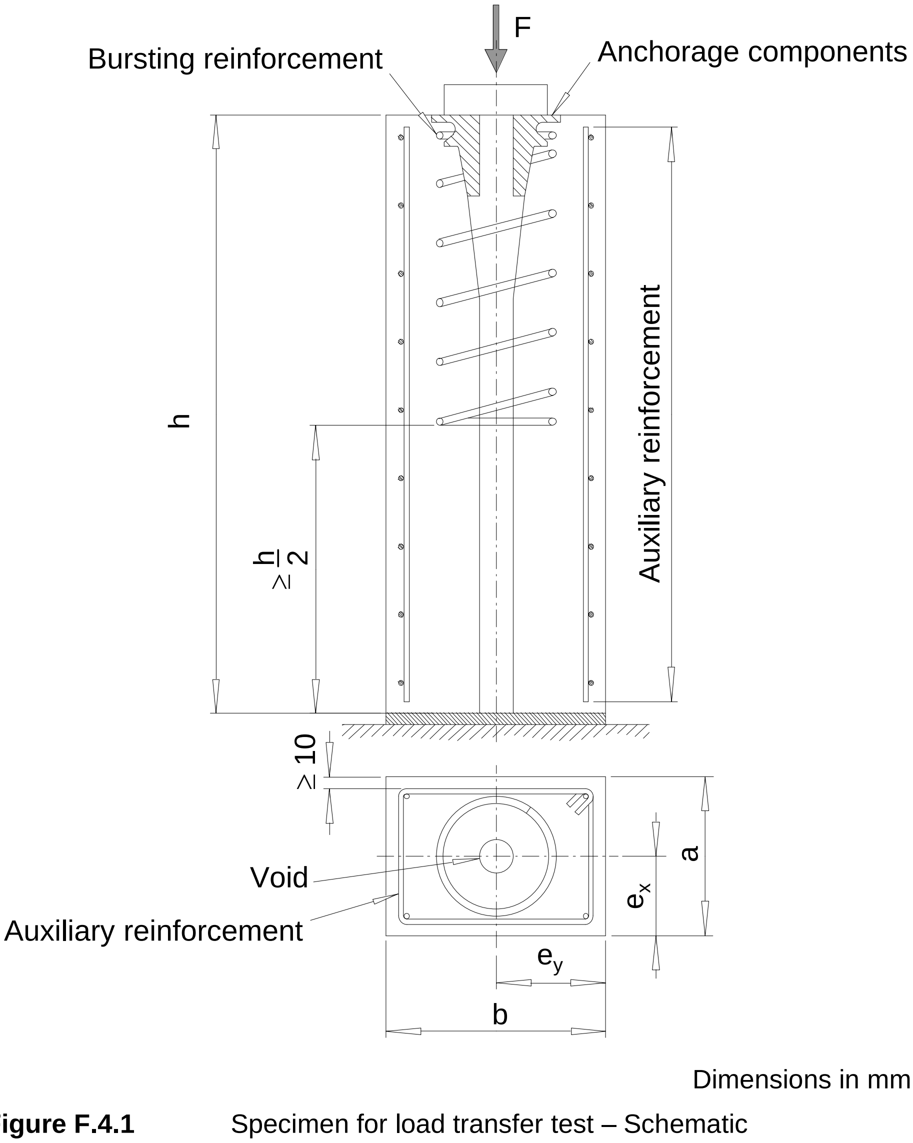
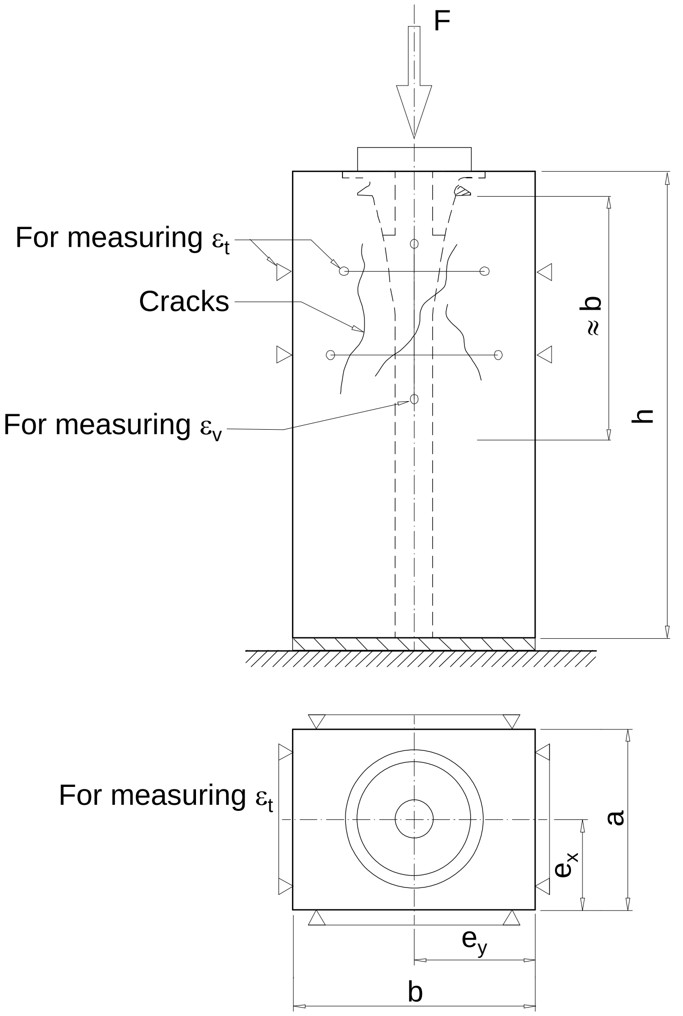


Figure F.4.1 Specimen for load transfer test – Schematic



For b ≥ a

Gauges for strain measurements shall be placed in the middle of the section, indicated as ≈ b.

Gauge length for strain measurement ≈ 0.6 up to 0.8 · b

Figure F.4.2 Load transfer test – Measurements on at least 2 side faces – Schematic

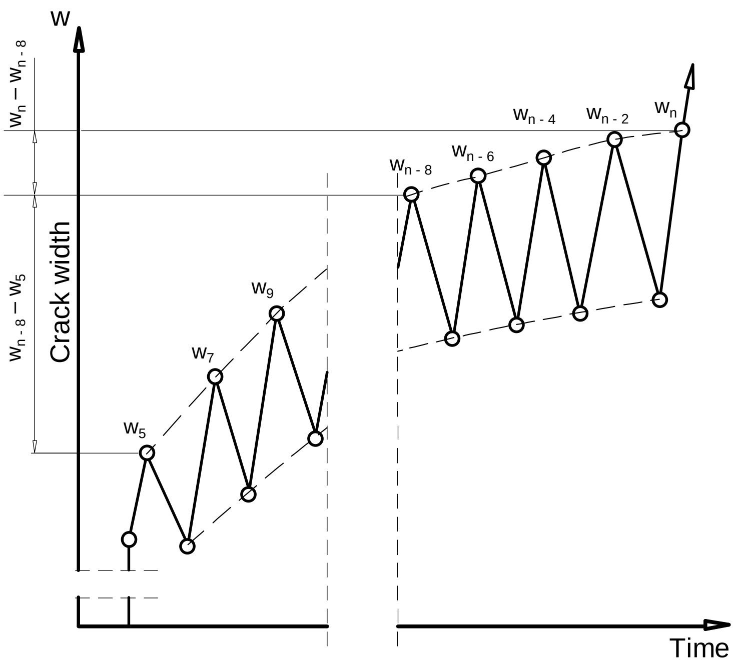


Figure F.4.3 Assessment of crack width stabilisation

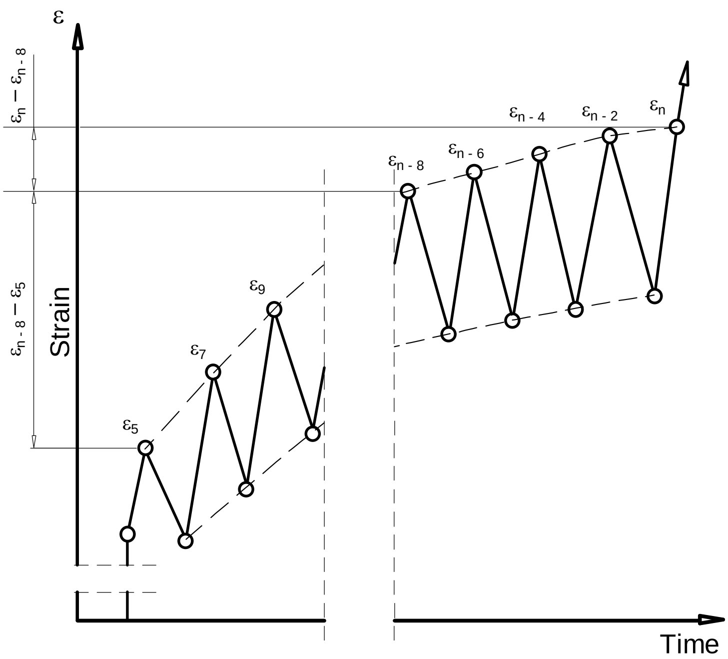


Figure F.4.4 Assessment of strain stabilisation

Where

ε_5, ε_7, ε_9, ε_{n-8}, ε_{n-6}, ε_{n-4}, ε_{n-2}, ε_n .... mm/m.................... Strain, measured at specific readings, see Clause F.3.

w_5, w_7, w_9, w_{n-8}, w_{n-6}, w_{n-4}, w_{n-2}, w_n .... mm...................... Crack width, measured at specific readings.

a, b .... mm...................... Side lengths of test specimen

ε .... mm/m.................... Strain

ε_t .... mm/m.................... Strain, measured perpendicular to loading direction – transversal strain

ε_v .... mm/m.................... Strain, measured parallel to loading direction – longitudinal strain

c .... mm...................... Concrete cover of reinforcement

e_x, e_y .... mm...................... Edge distance in x- and y-direction respectively

F .... kN .... Force in load transfer test

$f_{cm, e}$ ....MPa..................... Concrete compressive strength at time of end of load transfer test

h................. mm...................... Height of specimen

m.................—....................... Number of load cycles

n..................—....................... Number of readings for measurements

w .... mm...................... Crack width.

ANNEX G EXTRACTION

G.1 Equipment

The following equipment is used for the extraction:

- Glass extraction apparatus comprising a 500 ml boiling flask, reflux condenser with aspirator, thistle tube, and heating tube, see Figure G.1.1. The boiling energy is supplied along the heating tube.
- Beakers
- Filter with filter paper
- Laboratory equipment for stirring and pre-heating
- Fume cupboard.

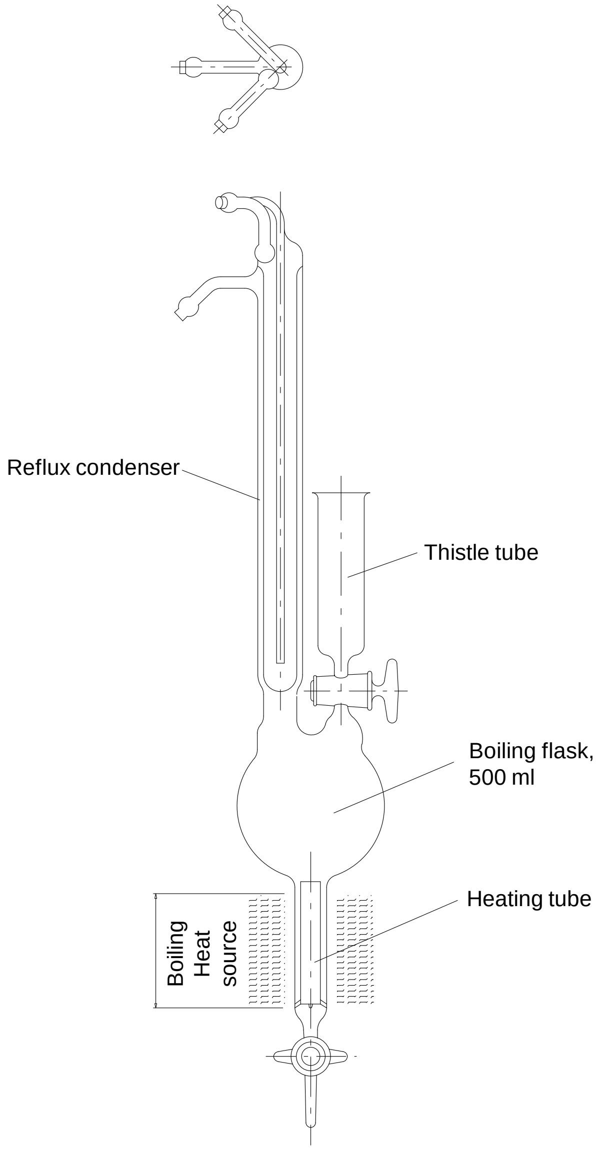


Figure G.1.1 Glass extraction apparatus

G.2 Agents

The following agents shall be used for the extraction:

- Toluene

- Anhydrous ethyl alcohol or anhydrous ethyl alcohol denatured by addition of not more than 5 % methyl alcohol
- Acetone
- Distilled water.

G.3 Extraction procedure

Perform the extraction under a fume cupboard.

Weigh 40 g of test material to the nearest 0.1 g into a 250 ml beaker and heat to (60 ± 5) °C. Heat 80 ml of toluene to the same temperature and add it slowly to the test sample, stir continuously until completely dissolved. Transfer the solution to the extraction apparatus and rinse the beaker twice with 15 ml of toluene, brought to approximately 60 °C. Without allowing the mixture to cool in the extractor, add 25 ml of alcohol and 15 ml of acetone, pre-heated to about 40 °C.

NOTE 1 Perform two successive one-hour extractions for products with a kinematic viscosity greater than 110 mm^2/s at 50 °C.

Boil the mixture vigorously for two minutes. Turn off the heat source. Once the boiling has stopped, add 125 ml of distilled water. Boil again for one hour.

Allow to cool and rest to obtain the separation of two phases. Remove the lower layer and filter, if necessary, on filter paper to obtain the aqueous extract.

NOTE 2 A certain amount of alcohol and acetone remains dissolved in the hydrocarbon phase.

The volume of the aqueous extract obtained is counted as 160 ml.

ANNEX H NUMBER OF TESTS

Table H.1, Table H.2, Table H.3, and Table H.4 rely on the concept of series. This concept presumes a series of sizes of thread bars and other components, where within each series there are similarities among others in terms of:

- Material
- Grade of material, strength of concrete
- Geometry
- The same method of anchoring the thread bar.

Untested sizes shall be assessed based on affinity of the components. Criteria among others for affinity are:

- Dimensions follow sizes in a steady progression.
- Properties of lager sizes are also applicable to smaller sizes.
- Properties are interpolated between sizes.

Table H.1 Number of tests for resistance to static load, resistance to fatigue, and load transfer to the structure

Test method	Number of tests		
	Reference diameter		
	Small	Medium	Largest
Resistance to static load, anchorage and coupling assembly, including measurement of displacements	2	1	2
Resistance to fatigue, anchorage and coupling assembly	1	1	2
Load transfer to the structure, anchorage, for concrete grade C20/25	1 [1)]	1 [1)]	2 [1)]
Load transfer to the structure, anchorage, for one concrete grade according to the MPII	1	1	2
Coupler dimensions	3	3	3

1) These tests shall be omitted if the MPII explicitly excludes concrete grades other than those specified in the MPII.

Table H.2 Number of tests for the thread bar in steel

Characteristics	Number of tests			
	Reference diameter			
	Smallest	Small	Medium	Largest
Mass per metre, cross-sectional area, surface geometry 3 heats [1)] per reference diameter, 3 tests each	9	9	9	9
Strength properties 3 heats [1)] per reference diameter, 10 tests each	30	30	30	30
Modulus of elasticity 3 heats [1)] per reference diameter, 1 test each	3	3	3	3
Resistance to fatigue [2)]	5	5	5	5
Bond characteristics in pull-out test	5	5	5	5

1) Heat of steel is metal produced by a single cycle of a melting process.
2) Number of tests for static and quasi static actions. For actions with fatigue loading two further heats with 5 tests each shall be tested. These tests may be spread across the finite and high cycle fatigue range.

Sizes out of a series of sizes of one kit are interpreted as follows:

- "Smallest" The smallest size in one series
- "Small" The largest in the lower third of sizes in one series
- "Medium" In middle third of sizes in one series
- "Largest" The largest size in one series.

Table H.3 Number of tests for the thread bar in prestressing steel

Characteristics	Number of tests		
	Reference diameter		
	Small [1)]	Medium [1)]	Largest [1)]
Number of tests is 2 heats [2)], split in 4 units of products, and 2 specimens are taken from each unit of product. Mass per metre, Cross-sectional area, Surface geometry, Core diameter [3)]	16	16	16
Strength characteristics, Elongation at maximum force, Constriction at break [4)]	16	16	16
Modulus of elasticity [4)] – 2 heats [2)] – 2 specimens taken from each heat	4	4	4
Resistance to fatigue [5)] – 2 heats [2)] – 2 specimens taken from each heat	4	4	4
Stress relaxation – 2 heats [2)] – 1 specimen taken from each heat	2	2	2
Stress corrosion resistance – 2 heats [2)] – 1 test series, i.e., 6 specimens, taken from each heat	12	—	—

1) From the given reference diameters, see e.g., Table 1.1.1.3.1, the extreme sizes shall be subjected to testing, e.g., 17.5 mm and 47 mm. If the span of reference diameters exceeds 15 mm, the reference diameters selected for testing are e.g., 17.5 mm, 32 mm, and 47 mm.

2) Heat of steel is metal produced by a single cycle of a melting process.

3) Mass per metre, Cross-sectional area, Surface geometry, and Core diameter can be tested with one specimen.

4) Strength characteristics, Elongation at maximum force, Constriction at break, and Modulus of elasticity can be tested in one combined test.

5) Number of tests for static and quasi static actions. For actions with fatigue loading three further specimens per heat shall be tested. These tests may be spread across the finite and high cycle fatigue range.

Table H.4 Number of tests for the heat shrinking sleeve

Characteristics	Number of tests	
	Size of heat shrinking sleeve	
	Smallest	Largest
Thickness after shrinking	1 each size [1)]	
Mass per unit area of adhesive	2 each size [1)]	
Tensile strength	5	5
Elongation at break	5	5
Peel strength layer to layer	3 – ambient 3 – T_{max} Small [2)] size instead of smallest	3 – ambient 3 – T_{max} Large [2)] size instead of largest
Peel strength to steel surface	3 – ambient 3 – T_{max} Small [2)] size instead of smallest	3 – ambient 3 – T_{max} Large [2)] size instead of largest
Thermal ageing resistance		
Tensile strength, Elongation at break	5 – initial 5 – 70 days 5 – 100 days	5 – initial 5 – 70 days 5 – 100 days
Peel strength layer to layer	3 – initial 3 – 720 days 3 – 100 days Small [2)] size instead of smallest	3 – initial 3 – 70 days 3 – 100 days Large [2)] size instead of largest
Peel strength to steel surface	3 – initial 3 – 70 days 3 – 100 days Small [2)] size instead of smallest	3 – initial 3 – 70 days 3 – 100 days Large [2)] size instead of largest
Indentation resistance	3 – ambient or 3 – T_{max} Small [2)] size instead of smallest	3– ambient or 3 – T_{max} Large [2)] size instead of largest
Impact resistance	1 Small [2)] size instead of smallest	1 Large [2)] size instead of largest
Saponification value	4	
Microbiological resistance		
Tensile strength, Elongation at break	5 – initial 5 – 6 months	5 – initial 5 – 6 months
Peel strength to steel surface	3 – initial 3 – 6 months Small [2)] size instead of smallest	3 – initial 3 – 6 months Large [2)] size instead of largest
Water absorption	2	2

Characteristics	Number of tests	
	Size of heat shrinking sleeve	
	Smallest	Largest
Softening point of adhesive	2	
Oxygen stability of adhesive	1	
Resistance to salt spray of adhesive	2	
Content of aggressive components of adhesive	1	

1) Number of sizes of heat shrinking sleeve.
2) Small and large refer to smallest and largest sizes suitable for a tube with external diameter of 100 mm.

ANNEX I ESSENTIAL CHARACTERISTICS FOR THE INTENDED USES

I.1 Thread bar in steel

The essential characteristics relevant for the categories of intended use are listed in Table I.1.1. Categories of intended use are according to Table 1.2.1.1:

- Column 1 in Table I.1.1 Rock and soil anchor for temporary use
- Column 2 in Table I.1.1 Rock and soil anchor for temporary use with extended working life
- Column 3 in Table I.1.1 Rock and soil anchor for permanent use.

Table I.1.1 Essential characteristics for the categories of intended use – Thread bar in steel

№ 1)	Essential characteristic 1)	Product and category of intended use		
		1	2	3
Basic requirement for construction works 1: Mechanical resistance and stability				
1	Resistance to static load	+	+	+
2	Resistance to fatigue	+	+	+
3	Load transfer to the structure	+	+	+
4	Corrosion protection of temporary rock and soil anchor	+	—	—
5	Corrosion protection of temporary rock and soil anchor with extended working life	—	+	—
6	Corrosion protection of permanent rock and soil anchor	—	—	+
7	Transition anchorage to free length – Tightness	—	—	+
8	Crack width in inner grout	—	—	+
9	Mass per metre – Thread bar in steel	+	+	+
10	Mass per metre – Thread bar in prestressing steel	—	—	—
11	Bond strength – Thread bar in steel	+	+	+
12	Surface geometry – Thread bar in prestressing steel	—	—	—
13	Strength characteristics – Thread bar in steel	+	+	+
14	Strength characteristics – Thread bar in prestressing steel	—	—	—
15	Modulus of elasticity – Thread bar in steel	+	+	+
16	Modulus of elasticity – Thread bar in prestressing steel	—	—	—
17	Elongation at maximum force – Thread bar in steel	+	+	+

№ 1)	Essential characteristic 1)	Product and category of intended use		
		1	2	3
18	Elongation at maximum force – Thread bar in prestressing steel	—	—	—
19	Constriction at break – Thread bar in prestressing steel	—	—	—
20	Stress relaxation – Thread bar in prestressing steel	—	—	—
21	Stress corrosion resistance – Thread bar in prestressing steel	—	—	—

Key

+ ....Essential characteristic relevant for the intended use
—.........Essential characteristic not relevant for the intended use
1) ....Line numbers and essential characteristics correspond to Table 2.1.1.

I.2 Thread bar in prestressing steel

The essential characteristics relevant for the categories of intended use are listed in Table I.2.1. Categories of intended use are according to Table 1.2.1.1:

- Column 1 in Table I.2.1 Rock and soil anchor for temporary use
- Column 2 in Table I.2.1 Rock and soil anchor for temporary use with extended working life
- Column 3 in Table I.2.1 Rock and soil anchor for permanent use.

Table I.2.1 Essential characteristics for the categories of intended use – Thread bar in prestressing steel

№ 1)	Essential characteristic 1)	Product and category of intended use		
		1	2	3
Basic requirement for construction works 1: Mechanical resistance and stability				
1	Resistance to static load	+	+	+
2	Resistance to fatigue	+	+	+
3	Load transfer to the structure	+	+	+
4	Corrosion protection of temporary rock and soil anchor	+	—	—
5	Corrosion protection of temporary rock and soil anchor with extended working life	—	+	—
6	Corrosion protection of permanent rock and soil anchor	—	—	+
7	Transition anchorage to free length – Tightness	—	—	+
8	Crack width in inner grout	—	—	+

№ [1)]	Essential characteristic [1)]	Product and category of intended use		
		1	2	3
9	Mass per metre – Thread bar in steel	—	—	—
10	Mass per metre – Thread bar in prestressing steel	+	+	+
11	Bond strength – Thread bar in steel	—	—	—
12	Surface geometry – Thread bar in prestressing steel	+	+	+
13	Strength characteristics – Thread bar in steel	—	—	—
14	Strength characteristics – Thread bar in prestressing steel	+	+	+
15	Modulus of elasticity – Thread bar in steel	—	—	—
16	Modulus of elasticity – Thread bar in prestressing steel	+	+	+
17	Elongation at maximum force – Thread bar in steel	—	—	—
18	Elongation at maximum force – Thread bar in prestressing steel	+	+	+
19	Constriction at break – Thread bar in prestressing steel	+	+	+
20	Stress relaxation – Thread bar in prestressing steel	+	+	+
21	Stress corrosion resistance – Thread bar in prestressing steel	+	+	+

Key

+ ....Essential characteristic relevant for the intended use
—.........Essential characteristic not relevant for the intended use
1) ....Line numbers and essential characteristics correspond to Table 2.1.1.

ANNEX J CONTENTS OF TEST REPORT

Testing of the Kit for rock and soil anchor shall be documented with test reports that should be prepared in accordance with the general principles of EN ISO/IEC 17025 and include at least the following specific information:

- Detailed description of all components of the Kit for rock and soil anchor.
- Certificates of all relevant materials to confirm conformity with respective specifications. Actual characteristics of components (mechanical, chemical, metallurgical, geometrical, etc. as relevant) at time of testing and source of manufacture. These include in particular thread bar, anchorage and coupler components, and corrosion protection components (internal grout, cement grout, corrugated plastic sheathing, etc.) and ancillary components used in testing.
- Certificates of equipment and test machine calibration.
- Description and drawing of test specimen with actual dimensions.
- Description and drawing of test set-up and measuring equipment including calibration certificate.
- Reference to relevant clause of the EAD.
- Actual ambient temperature, where relevant.
- Record of all measurements and observations.
- Photographs of test specimen prior, during, and after testing.
- Any other information specified in the test procedures.
- Statement of any unexpected or unusual behaviour / observation of components during testing.