AFRY

New Eurocodes in rock engineering

7.10.2025 KMP - Guido Nuijten

New Eurocodes in rock engineering
Current status: online.sfs.fi

Voimassa olevat (kansallisliitteineen)

- SFS-EN 1990 + A1 + AC
  - Eurokoodi. Rakenteiden suunnitteluperusteet
  - Vahvistettu 26.06.2006, kieli: suomi/englanti
- SFS-EN 1992-1-1 + A1 + AC
  - Eurokoodi 2: Betonirakenteiden suunnittelu. Osa 1-1: Yleiset säännöt ja rakennuksia koskevat säännöt
  - Vahvistettu 19.01.2015, kieli: suomi
- SFS-EN 1993-1-1
  - Eurokoodi 3: Teräsrakenteiden suunnittelu. Osa 1-1: Yleiset säännöt ja rakennuksia koskevat säännöt
  - Vahvistettu 15.08.2005, kieli: suomi

Uudet versiot (vahvistettu, mutta ilman kansallisliitteitä)

- SFS-EN 1990:2023:en
  - Eurocode. Basis of structural and geotechnical design
  - Vahvistettu 31.03.2023, kieli: englanti
- SFS-EN 1992-1-1:2023:en
  - Eurocode 2. Design of concrete structures. Part 1-1: General rules and rules for buildings, bridges and civil engineering structures
  - Vahvistettu 01.12.2023, kieli: englanti
- SFS-EN 1993-1-1:2022:en
  - Eurocode 3. Design of steel structures. Part 1-1: General rules and rules for buildings
  - Vahvistettu 18.11.2022, kieli: englanti

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Voimassa olevat (kansallisliitteineen)

- SFS-EN 1997-1 + A1 + AC
  - Eurokoodi 7: Geotekninen suunnittelu. Osa 1: Yleiset säännöt
  - Vahvistettu 27.01.2014, kieli:
- SFS-EN 1997-2 + AC
  - Eurokoodi 7. Geotekninen suunnittelu. Osa 2: Pohjatutkimus ja koestus
  - Vahvistettu 16.04.2007, kieli: suomi

Uudet versiot (vahvistettu, mutta ilman kansallisliitteitä)

- SFS-EN 1997-1:2024:en
  - Eurocode 7. Geotechnical design. Part 1: General rules
  - Vahvistettu 04.10.2024, kieli: englanti
- SFS-EN 1997-2:2024:en
  - Eurocode 7. Geotechnical design. Part 2: Ground properties
  - Vahvistettu 04.10.2024, kieli: englanti
- SFS-EN 1997-3:2025:en
  - Eurocode 7. Geotechnical design. Part 3: Geotechnical structures
  - Vahvistettu 28.03.2025, kieli: englanti

New Eurocodes in rock engineering Preparation and commissioning

- 2025
  - ✓ Kansallisliitteiden laadinta
  - ✓ Kommentointi
  - Laadinnan viimeistelyt
- 2026
  - Päämääräysten jalkauttaminen asetuksiin (ympäristöministeriö): asetusluonnosten tekniset asiasisällöt
  - Eurokoodien ja kansallisliitteiden kääntäminen Suomeksi
- 2027
  - Asetukset valmiit (30.9.2027 mennessä)
  - Toimialojen valmistautuminen
- 2028
  - 2. sukupolven eurokoodien käyttö alkaa 1.1.2028
  - 1. sukupolven eurokoodien käyttö päättyy 30.3.2028

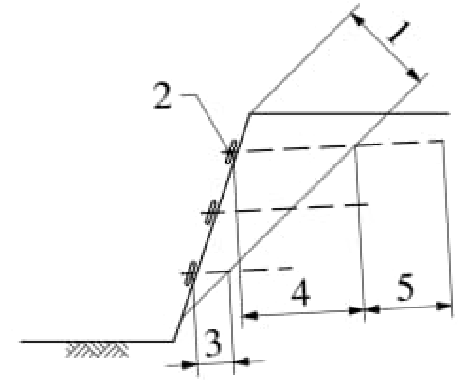
New Eurocodes in rock engineering
Use in Rock Engineering

- Kallion avoleikkaukset ja rintamat
  - Suunnittelu ja tutkimukset:
    - SFS-EN 1990, 1997-1, 1997-2
  - Mitoitus:
    - SFS-EN 1997-3 kpl 4: ”Slopes, Cuttings & Embankments” → Kallioleikkaukset
    - Lujituksille edelleen sopii mitoittaa suunnittelusäännöillä, esim. :
    - 2018 Bar & Barton - Rock Slope Design using Q-slope and Geophysical Survey Data
- Kallion perustukset
  - Suunnittelu ja tutkimukset:
    - SFS-EN 1990, 1997-1, 1997-2 (ulkopuolisille kuormituksille SFS-EN 1991)
  - Mitoitus:
    - SFS-EN 1997-3 kpl 5: ”Spread Foundations”
    - SFS-EN 1997-3 kpl 11: ”Rock Bolts” (mikäli perustukseen tai sen alle tulee asentaa kalliopultteja)
    - SFS-EN 1992-1-1: Kalliopultin juotoslaastille
    - SFS-EN 1993-1-1: Kalliopultin teräkselle

New Eurocodes in rock engineering
Use in Rock Engineering

- Kalliotunnelit ja muut maanalaiset tilat
  - Suunnittelu ja tutkimukset:
    - SFS-EN 1990, 1997-1, 1997-2
  - Mitoitus:
    - Tunneleille ei ole vielä omaa mitoituskappaletta laadittu, ehkä 3. sukupolvelle v. 2035 (?)
    - Nykykäytännön mukaan.
    - Ei ole kielletty käyttää eurokoodien mitoitussääntöjä (soveltaen), eikä ole opastettukaan.
- Muut kohdekohtaiset kallion lujitukset
  - Suunnittelu ja tutkimukset:
    - SFS-EN 1990, 1997-1, 1997-2 (ulkopuolisille kuormituksille SFS-EN 1991)
  - Mitoitus:
    - SFS-EN 1997-3 kpl 8: ”Anchors”
    - SFS-EN 1997-3 kpl 11: ”Rock Bolts”
    - SFS-EN 1992-1-1: Kalliopultin juotoslaastille
    - SFS-EN 1993-1-1: Kalliopultin teräkselle
    - .

New Eurocodes in rock engineering
Ankkurit ↓ ja pultit →



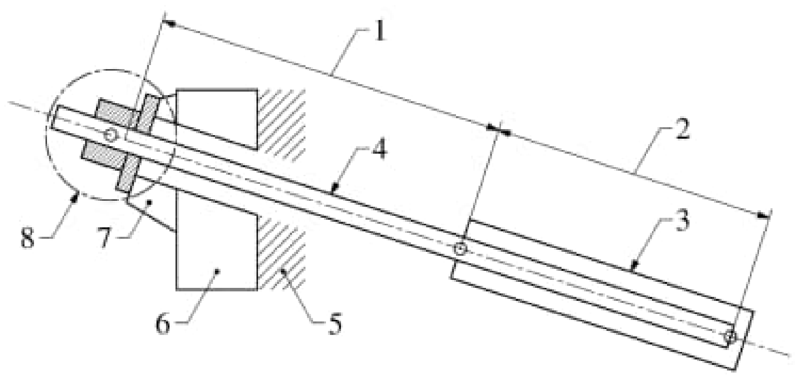
8 Anchors

8.1 Scope and field of application

(1) This clause shall apply to temporary and permanent anchors that transmit a tensile force from the anchor head through a free anchor length over a resisting element to a load resisting ground formation.

NOTE 1 This includes anchors within the scope of EN 1537 and mechanical anchors with a free anchor length (such as screw, harpoon, and expander anchors).

NOTE 2 Figure 8.1 shows an example of an anchor within the scope of this clause.



Key

1	free anchor length	5	ground
2	fixed anchor length	6	anchored structure
3	resisting element	7	load transfer block
4	tendon	8	anchor head

Figure 8.1 — Example of an anchor within the scope of Clause 8

Määrittelyssä suurin ero:

free anchor length

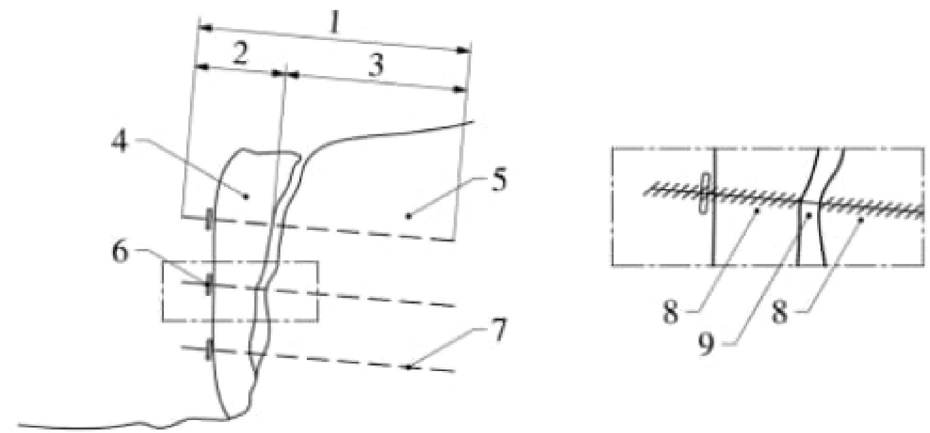
Kallioankkurit ovat siis eurokoodeittain edelleen pultteja.

Key

1	supported rock mass	4	pick up length
2	head plate	5	anchoring length
3	short pick-up length strengthened with a head plate		

NOTE The direction of the bolt depends on the geometrical properties of the rock mass. The direction of the bolts shown in the figure is therefore indicative.

Figure 11.1 — Example of support of a rock slope with rock bolts working mainly in tension



Key

1	total length of the bolt	6	head plate
2	pick-up length	7	rock bolt
3	anchoring length	8	pick-up length (short pick-up length strengthened with head plate)
4	rock column	9	tendon subject to tension and shear stress
5	supporting rock mass		

Figure 11.2 — Example of a rock column supported by rock bolts working mainly in shear (dowel effect)

New Eurocodes in rock engineering
Rock bolt ultimate limit state (ULS)

- Ennen (yksinkertaistetusti)
  - Kokonaispituus: suunnittelusääntöjen pohjalta, useimmiten 3 tai 4 m.
  - Ankkurointipituus: kokemusperäisesti / kirjallisuutta, eli n. 0,5 m, eikä juurikaan erikseen speksata.
  - Pultin halkaisija: suunnittelusääntöjen pohjalta / kokemusperäisesti, useimmiten 20 tai 25 mm (joskus 32 mm).
  - Reiän halkaisija: vakiintuneen käytännön mukaan, eli 1,5 * pultin halkaisija.
  - Teräsmateriaali: A500HW (aiemmin), nyt B500B mahdollisesti sinkitty tai pinnoitettu (harvoin muu materiaali)
  - Juotoslaasti: useimmiten toteutusluokan 1 mukaan lujuusluokka C30/37 (vaikka usein kestääkin enemmin)

- Toisen sukupolven eurokoodien mukaan
  - Mitoitettava pultin pituus ja osoitettava ankkuripituutta riittäväksi: SFS-EN 1997-3, kpl 11 + kansallisliite
  - Mitoitettava pultin kestävyys (teräksen veto- ja/tai leikkauslujuus): SFS-EN 1993-1-1
  - Mitoitettava pultin ja juotoslaasti rajapinta: SFS-EN 1992-1-1 + 1997-3, kpl 11 + kansallisliite
  - Mitoitettava juotoslaastin ja reiän kalliopinnan rajapinta: SFS-EN 1992-1-1 + 1997-3, kpl 11 + kansallisliite
  - Osoitettava kestävyys: kaikki Eurokoodit

New Eurocodes in rock engine
Materials

- Luku 11.3 tulee soveltaa seuraavin tarkennuksin.
  - Pohjaveden rasitusluokat määritetään SFS-EN 206:2021 ja SFS 7022:2024 mukaan.
  - Kalliopultin pulttitangolle noudatetaan SFS-EN 10080 ja SFS 1268:2010.
  - Kalliopultin juotoslaastille noudatetaan SFS-EN 197-1:2012 ja 197-2:2020.
  - Kalliopultin sinkitykselle noudatetaan SFS-EN ISO 1461.
  - Ruiskubetonille noudatetaan SFS-EN 13670:2010 ja SFS-EN 14487-1:2022.
  - Ruiskubetonin kuiduille noudatetaan SFS-EN 14489:2006, kaikki osat (1 ja 2).
  - Lujitusverkolle noudatetaan SFS-EN 10223-3:2014 ja soveltuen muut osat (1, 2, 4 ja 5).

(4) Bimetallic corrosion of different connecting elements shall be prevented.

(5) For connecting elements, the corrosion protection shall be at least equivalent to that of the other steel elements.

(6) Continuity of corrosion protection at connecting elements shall be provided.

(7) Where the corrosion protection is provided by a sacrificial thickness allowance, loss of steel thickness specific to the ground shall be considered.

(8) The corrosion protection of steel rock bolts with yield strength $f_y > f_{y,bolt}$ shall comply with EN 1537.

NOTE The value of $f_{y,bolt}$ is 600 MPa, unless the National Annex gives a different value.

11.3.4 Sprayed concrete

(1) Sprayed concrete used for rock surface support shall comply with EN 1997-1:2024, 5.5.

11.3 Materials

11.3.1 Ground

(1) EN 1997-2:2024, Clauses 7 to 12 shall apply to rock bolts and rock surface support.

11.3.2 Grout

(1) EN 1997-1:2024, 5.4 shall apply to grout in rock bolts.

11.3.3 Steel

11.3.3.1 General

(1) EN 1997-1:2024, 5.6 shall apply to steel rock bolts and rock surface support.

(2) Steel grades produced according to the following standards may be used for steel rock bolts:

— EN 10025 (all parts);

— EN 10080;

— prEN 10138 (all parts);

— EN 10210 (all parts); and

— EN 10219 (all parts).

(3) The provisions on ductility of EN 1993-1-1:2022, 5.2.2 shall apply to rock bolts and rock surface support.

NOTE Class B reinforcing steel (as defined in EN 1992-1-1:2023, Table 5.5) meets this requirement.

(4) For tension elements used in prestressed applications, the ductility requirements of prEN 10138 (all parts) should apply.

(5) Steel used in grouted rock bolts shall conform to EN 1992-1-1:2023, 5.2.

11.3.3.2 Durability

(1) EN 1997-1:2024, 4.1.6 shall apply to rock bolts and rock surface support.

(2) prEN 1993-5:2023, 6.1 and 6.3 shall apply to steel rock bolts, except as specified in this sub-clause.

(3) The design service life for rock bolts made of steel shall be achieved by one or more of the following corrosion protection measures:

— surface coating;

— cover of appropriate grout, mortar, concrete or resin;

— sacrificial thickness allowance;

— corrugated duct with grout;

— the use of low corrosion steel grades.

New Eurocodes in rock engineering Rock bolt tension (ULS)

8.2.3 Tension

(1) The design value of the tensile axial force N_{Ed} at each cross-section shall satisfy the criterion in Formula (8.13):

$$\frac{N_{Ed}}{N_{t,Rd}} \leq 1{,}0 \tag{8.13}$$

where

$N_{t,Rd}$ is the design tension resistance., it is given by:

(2) The design tension resistance of the gross cross-section $N_{t,Rd}$ should be taken as:

$$N_{t,Rd} = N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} \tag{8.14}$$

(3) For cross-sections with holes, the design tension resistance $N_{t,Rd}$ should be taken as the smaller of:

a) the design plastic resistance, $N_{pl,Rd}$, of the gross cross-section according to Formula (8.14);

b) the design ultimate resistance of the net cross-section considering holes:

$$N_{u,Rd} = \frac{k A_{net} f_u}{\gamma_{M2}} \tag{8.15}$$

SFS-EN 1993-1-1,
kpl 8.2.3

New Eurocodes in rock engineering
Rock bolt shear (ULS)

8.2.6 Shear

(1) The design value of the shear force V_{Ed} at each cross-section shall satisfy the criterion in Formula (8.22):

$$\frac{V_{Ed}}{V_{c,Rd}} \leq 1{,}0 \tag{8.22}$$

where

$V_{c,Rd}$ is the design shear resistance. For plastic design $V_{c,Rd}$ is the design plastic shear resistance $V_{pl,Rd}$.

For elastic design, verification of the cross-section should be made using the yield criterion in (4) and (5).

(2) In the absence of torsion the design plastic shear resistance $V_{pl,Rd}$ should be calculated from Formula (8.23):

$$V_{pl,Rd} = \frac{A_v \left(f_y / \sqrt{3}\right)}{\gamma_{M0}} \tag{8.23}$$

where

A_v is the shear area.

SFS-EN 1993-1-1, kpl 8.2.3

Huom. √3. Se ei ole osavarmuuskerroin!

New Eurocodes in rock engineering Rock bolt and grout interface (ULS)

- Lujituspulteille ankkurointipituudella L tarkoitetaan kuormaa kantavassa kalliossa oleva osuus juotettuna.
- Harjateräspultin ja juotoslaastin ankkurointipituuden rajapintakestävyys voidaan määrittää SFS-EN 1992-1-1:2023, 11.4 taulukon 11.1 ja kaavan 11.3 soveltaen seuraavasti:

Table 11.1 (NDP) — Anchorage length of straight bars divided by diameter l_{bd}/ϕ

ϕ [mm]	Anchorage length l_{bd}/ϕ							
	f_{ck}							
	20	25	30	35	40	45	50	60
≤ 12	47	42	38	36	33	31	30	27
14	50	44	41	38	35	33	31	29
16	52	46	42	39	37	35	33	30
20	56	50	46	42	40	37	35	32
25	60	54	49	46	43	40	38	35
28	63	56	51	47	44	42	40	36
32	65	58	53	49	46	44	41	38

SFS-EN 1992-1-1,
kpl 11.4 Anchorage
of reinforcing steel …

- l_{bd} = max[10 ; $(\sigma_{sd}/435)^{n\sigma}$ * taulukon 11.1-arvo]* ϕ.

missä:

- l_{bd} = ankkurointipituuden mitoitusarvo
- σ_{sd} = teräspultin vetojännityksen mitoitusarvo [MPa]
- ϕ = pultin halkaisija
- n_σ = eksponentti, jolla otetaan huomioon teräksen jännityksen vaikutus ankkurin pituuteen → 3/2

HUOM. Ainoastaan leikkausvoimin kuormittuvalle pultille σ_{sd} = teräspultin vetojännitys = 0 ja täten l_{bd} = 10 * f.

New Eurocodes in rock engineering Rock bolt grout and rock interface (ULS)

- Juotoslaastin ja pulttireiän kalliopinnan rajapintakestävyys voidaan määrittää SFS-EN 1992-1-1:2023, 8.26 kaavan 8.76 soveltaen seuraavasti:

– τ_{Rdi} = $min[c_{v1} * (\sqrt{f_{ck}})/\gamma_c + m_v * \sigma_n ; c_{v1} * (\sqrt{s_{rm}})/(\gamma_{Rr} * \gamma_{Rd,bolt}) ; 0,30 f_{ck}/\gamma_c]$

missä:

– τ_{Rdi} = *juotoslaastin ja pulttireiän kalliopinnan rajapintakestävyyden mitoitusarvo [MPa]*
- c_{v1} = *juotoslaastin ja pulttireiän kalliopinnan leikkausvastuskerroin*
- f_{ck} = *juotoslaastin puristuslujuus [MPa]*
- s_{rm} = *kalliomassan lujuuden ominaisarvo [MPa]*
- m_v = *juotoslaastin ja pulttireiän kalliopinnan kitkavastuskerroin*
– σ_n = *normaalijännitys juotoslaastin ja pulttireiän kalliopinnan rajapinnassa [MPa]*

Table 8.2 — Coefficients depending on the roughness of the surface

	Formula (8.76)	Formula (8.76) and (8.77)	Formula (8.77)		
Surface roughness	c_{v1}	μ_v	c_{v2}	k_v	k_{dowel}
very smooth	0,01[a]	0,5	0	0	1,5
smooth	0,08[a]	0,6	0	0,5	1,1
rough	0,15[a]	0,7	0,08[a]	0,5	0,9
very rough	0,19[a]	0,9	0,15[a]	0,5	0,9
keyed[b]	0,37	0,9	—	—	—

[a] When the interface is subjected to tensile stresses caused by external axial force in perpendicular direction: $c_{v1} = 0$ and $c_{v2} = 0$.
[b] The factors for keyed interfaces shall be applied for the area of each key considering its concrete strength.

SFS-EN 1992-1-1, kpl 8.26 Shear at interfaces

- Harjateräspultille leikkaus- ja kitkavastuskertoimille (c_{v1} ja m_v) voidaan soveltaa SFS-EN 1992-1-1:2023, 8.26 taulukon 8.2 luokitus ”hyvin karkea” (very rough), mikäli oletetaan σ_n = 0.

07.10.2025 KALLIOMEKANIIKAN PÄIVÄ 2025
LISA HAGMAN -SALI, TIETEIDEN TALO, KIRKKOKATU 6, HELSINKI

New Eurocodes in rock engineering

A highlight of steps to undertake design verification by using the partial factoring method for slopes and rock bolts.

New Eurocodes in rock engineering
Slope resistance (ULS) step 1: EN 1997-3

4.6.2 Supporting elements

(1) In cases where a combined failure of supporting elements and the ground could occur, ground-structure interaction shall be considered allowing for the difference in strength and stiffness of the ground and that of the supporting element.

NOTE Supporting elements include but are not limited to walls, piles, anchors, props, discrete ground improvement, soil nails and rock bolts.

(2) If supporting elements are used to increase overall stability, their structural resistance shall be verified for the combined effects of actions from the ground and the structure for all relevant design situations.

(3) Supporting elements used to improve overall or local stability, bearing resistance, or settlement performance shall be verified in accordance with Clauses 6 to 12.

NOTE Actions in the supporting elements can include axial forces, shear forces or bending moments depending on the types of interaction between the ground and the supporting elements.

(4) It shall be verified that the supporting element can resist the design value of the effect of actions E_d from the structure given by either Formula (4.1) for Verification Cases 1 and 3 or Formula (4.2) for Verification Case 4:

$$E_d = \max\{F_{d,ULS};\ \gamma_F F_{rep,SLS}\} \quad (4.1)$$

$$E_d = \max\{\gamma_E F_{rep,ULS};\ \gamma_E F_{rep,SLS}\} \quad (4.2)$$

where

$F_{d,ULS}$ is the design value of the action that the supporting element shall provide to prevent an ultimate limit state of the supported structure;

4.6.3 Partial factors

(1) Partial factors for the verification of slopes, cuttings, and embankments at the ultimate limit state shall be determined according to EN 1997-1:2024, 4.4.1 using the Material Factor Approach.

NOTE Values of the partial factors are given in Table 4.2 (NDP) for persistent and transient design situations unless the National Annex gives different values.

Table 4.2 (NDP) — Partial factors for the verification of ground resistance of slopes, cuttings, and embankments for fundamental (persistent and transient) design situations

Verification of	Partial factor on	Symbol	Material Factor Approach
Overall stability	Actions	γ_F	VC3[a]
	Ground properties[c]	γ_M	M2[b]
Bearing resistance	see Clause 5		

[a] Values of the partial factors for Verification Case 3 (VC3) are given in EN 1990:2023, Annex A.
[b] Values of the partial factors for Set M2 are given in EN 1997-1:2024, 4.4.1.3.
[c] Also includes ground properties of Class AI ground improvement (see Clause 12).

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New Eurocodes in rock engineering
Rock bolt resistance (ULS) step 1: EN 1997-3

Luku 11.6 tulee soveltaa seuraavin tarkennuksin.

- B400 … B700 kalliopultin vetolujuus määritetään SFS-EN 1992-1-1:2023 luvun 5.2 mukaan.
- Muun materiaalin kalliopultin vetolujuus määritetään SFS-EN 1993-1-1:2022 luvun 8.2.3 mukaan.
- Kalliopultin leikkauslujuus määritetään SFS-EN 1993-1-1:2022 luvun 8.2.6 mukaan.
- Kalliopultin yhdistetty taivutusmomentti-, veto- ja leikkauslujuus määritetään SFS-EN 1993-1-1:2022 lukujen 8.2.3 … 8.2.10 mukaan.
- Ruostumattomille teräksille sovelletaan SFS-EN 1993-1-4:2006 mukaiset lisäsäännöt.

11.6.4 Interface resistance of rock bolts (by prescriptive rules)

(1) When designing using prescriptive rules, EN 1997-1:2024, 4.5 shall apply to rock bolts.

(2) Prescriptive rules shall only be used if the rock bolts comply with the control tests specified in 11.9.

(3) When prescriptive rules are used, the Inspection Plan shall include measures to ensure that the installed elements fulfil the requirements of the prescriptive rules.

11.6.5 Partial factors

(1) Partial factors for the verification of rock bolts at the ultimate limit state shall be determined according to EN 1997-1:2024, 4.4.1, using the Resistance Factor Approach.

Table 5.4 — Strength classes of reinforcing steel

Properties for stress-strain-diagram (Fig. 5.2)	Reinforcing steel strength class					
	B400	B450	B500	B550	B600	B700
Characteristic value f_{yk} [MPa]	400	450	500	550	600	700

NOTE All strength classes apply unless the National Annex excludes specific classes. Intermediate strength classes can be used, if included in the National Annex.

Table 5.5 — Ductility classes of reinforcing steel

Properties for stress-strain-diagram (Fig. 5.2)	Reinforcing steel ductility class		
	A	B	C
Characteristic value of $k = (f_t/f_y)_k$	1,05	1,08	1,15 to 1,35
Characteristic strain at maximum force ε_{uk}	2,5 %	5,0 %	7,5 %

Verification of	Partial factor on	Symbol	RFA = Resistance Factor Approach
$R_{ri,d}$: Structural resistance, mobilised at the interface between rock bolt / grout	interface resistance	$\gamma_S + \gamma_C$	See EN 1992-1-1, 4.3.3
$R_{ro,d}$: Structural resistance, mobilised at the interface between grout / rock	interface resistance	γ_C	See EN 1992-1-1, 4.3.3
$R_{ro,d}$: Geotechnical resistance, mobilised at the interface between grout / rock	interface resistance	γ_{Rr}	1,25
$R_{el,d}$: Structural tensile resistance of steel bar (class B400 … B700)	tensile resistance of cross-sections	γ_S	See EN 1992-1-1, 4.3.3
$R_{el,d}$: Structural resistance of steel bar / stainless steel bar	resistance of cross-sections (whatever the class is)	γ_{M0}	See EN 1993-1-1, 8.1 / See EN 1993-1-4, 5.1
$R_{el,d}$: Structural resistance of steel bar / stainless steel bar	resistance of cross-sections in tension to fracture	γ_{M2}	See EN 1993-1-1, 8.1 / See EN 1993-1-4, 5.1

New Eurocodes in rock engineering
Rock bolt resistance (ULS) step 2: EN-1997-1

4.4 Verification by the partial factor method

4.4.1 Verification of ultimate limit states

4.4.1.1 General

(1) In addition to EN 1990:2023, 8.3, ultimate limit states that involve the ground should be verified using either:

— the material factor approach (MFA); or

— the resistance factor approach (RFA).

NOTE EN 1997-3 specifies which approach or approaches can be used for specific geotechnical structures.

(2) When using MFA, partial factors γ_M should be applied to ground properties, using Formula (8).19) of EN 1990:2023.

NOTE This document gives values of γ_M for geotechnical structures.

(3) When using RFA, partial factors γ_R should be applied to ground resistance, using Formula (8).20) of EN 1990:2023.

NOTE EN 1997-3 gives values of γ_R for geotechnical structures.

(4) Partial factors should be applied to actions or their effects using either:

— Formula (8).4) of EN 1990:2023, when applying γ_F to actions, or

— Formula (8).5) of EN 1990:2023, when applying γ_E to effects of actions.

NOTE 1 Values of the partial factor γ_F for ultimate limit states are given in EN 1990.

NOTE 2 Values of the partial factor γ_E for ultimate limit states are given in EN 1990.

(5) The consequence of failure should be taken into account by use of a consequence factor, k_F, k_M or k_R.

(6) Only one of the consequence factors k_F, k_M and k_R shall be applied in a single verification.

NOTE 1 Values of k_F are given in EN 1990.

NOTE 2 Values of k_M and k_R for different consequence classes are given in 4.4.1.3 and 4.4.1.5.

(7) In addition to EN 1990:2023, 5.5(3), the geotechnical structure shall be verified for all critical load cases in each relevant design situation.

(8) In addition to EN 1990:2023, 5.1(2), the ultimate limit state may be verified implicitly without computing specific values of E_d and R_d.

4.4.1.3 Design values of ground properties

(1) In addition to EN 1990:2023, 8.3.5, when design values of geotechnical resistance are calculated using Formula (8).19) of EN 1990:2023 (material factor approach), partial factors γ_M should be applied to ground properties.

NOTE 1 Values of the partial factor γ_M for persistent and transient design situations are given in Table 4.8 (NDP) unless the National Annex gives different values.

NOTE 2 Values of the partial factors for resistance are given in EN 1997-3.

NOTE 3 The value of γ_M for an accidental design situation is equal to the square root of the value of γ_M for the corresponding persistent design situation unless the National Annex gives a different value.

NOTE 4 Values of k_M for different consequence classes are given in Table 4.9 (NDP) unless the National Annex gives different values.

(2) The design value of a ground property may be determined directly, in accordance with EN 1990:2023, 8.3.6(2).

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4.4.1.1(6) Seuraamuskertoimien käyttö

NCCI: Ohje seuraamuskertoimen k_F, k_M ja k_R käytölle geoteknisissä rakenteissa

- *Kerrointa k_F käytetään todentamistapauksissa VC1, VC2 ja VC4/M1 SFS-EN 1990-1:2023 Liite A mukaisesti.*
  - *Todentamistapauksissa VC1 ja VC2 kerroin kohdistetaan kuormiin, todentamistapauksessa VC4 kerroin kohdistetaan kuormien vaikutuksiin.*
- *Kerrointa k_M käytetään todentamistauksessa VC3/M2 (katso SFS-EN 1990-1:2023 Liite A ja SFS-EN 1997-1:2023 Taulukko 4.8).*
- *Kerrointa k_R käytetään todentamistauksessa VC4/RFA geoteknisen kestävyyden mitoittamiseen.*

Seuraamusluokka (CC)	Kuvaus seuraamuksista	Seuraamuskerroin k_R
CC3	suuri	1,1
CC2	normaali	1,0
CC1	pieni	1,0

4.4.1.3(1)

Maan tai kallion ominaisuuksien mitoitusarvot, taulukko 4.8

Taulukko 4.8 Maan tai kallion ominaisuuksien osavarmuusluvut normaalisti vallitseville ja lyhytaikaisille mitoitustilanteille

Maan tai kallion ominaisuus	Merkintä	M1[a]	M2[a]
Kalliomateriaali ja kalliomassa [f]			
Leikkauslujuus (τ_r)	$\gamma_{\tau r}$	1,0	1,25 k_M
Yksiaksiaalinen puristuslujuus [c] (q_u)	γ_{qu}	1,0	1,4 k_M
Kallion epäjatkuvuudet			
Leikkauslujuus (τ_{dis})	$\gamma_{\tau dis}$	1,0	1,25 k_M
Jäännöskitkan kerroin (tan φ'_{dis}) [e]	$\gamma_{\tan\phi dis,r}$	1,0	1,1 k_M
Rajapinta			
Maan tai kallion ja rakenteen rajapinnan kitkakerroin (tan δ)	$\gamma_{\tan\delta}$	1,0	1,25 k_M

a M1 ja M2 ovat materiaalikertoimien vaihtoehtoisia sarjoja. Standardi SFS-EN 1997-3:2025 määrää, mitä sarjaa on käytettävä nimenomaisissa geoteknisissä rakenteissa. Sulkeissa esitettyjä arvoja käytetään kohdan 9.1(4) mukaisessa käyttörajatilan tarkastelussa, jossa rajoitetaan maan lujuuden mobilisaatioastetta.

b Tarkoitettu käytettäväksi numeerisissa malleissa.

c Käytetään vain perustuksiin.

e Käytetään, kun karkeuskomponentti, aaltoilu ja koheesio jätetään huomiotta ja asetetaan arvoon 0.

f Maan ja täyttömaan osavarmuusluvuille esitettäviä arvoja voidaan käyttää heikoille, voimakkaasti halkeilleille kalliomassoille tapauksissa, joissa maamekaniikan lähestymistapa havaitaan toimivaksi.

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8.3.5.3 Partial factors applied to resistance (the "resistance factor approach", RFA)

(1) When applying partial factors to resistance, its design value R_d should be calculated from Formula (8.20):

$$R_d = \frac{R\left\{X_{rep}; a_d; \Sigma F_{Ed}\right\}}{\gamma_R} = \frac{R\left\{\eta X_k; a_d; \Sigma F_{Ed}\right\}}{\gamma_R} \qquad (8.20)$$

where, further to symbols already defined for Formula (8.18)

X_{rep} denotes the representative values of material properties, defined as ηX_k;

γ_R is defined in 8.3.5.1(2).

8.3.6 Design values of material properties

(1) The design value of a material property X_d should be calculated from Formula (8.23):

$$X_d = \frac{X_{rep}}{\gamma_M} = \frac{\eta X_k}{\gamma_M} \qquad (8.23)$$

where, in addition to the symbols defined for Formulae (8.19)

X_{rep} is the representative value of material or product property.

NOTE Values for η and γ_M are given in the other Eurocodes.

(2) Provided that the level of reliability is no less than that implied by the use of Formula (8.23), the design value of a material property may be determined directly from:

— empirical or theoretical relations with measured physical properties;

— physical and chemical composition;

— from previous experience;

— in geotechnical design, prescriptive measures;

— in geotechnical design, the most unfavourable value that the parameter could practically adopt;

— values given in European Standards or other documents that are specified in the other Eurocodes;

— reliability analysis, see Annex C for further guidance; or

— results of tests, see Annex D for further guidance.

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Table A.1.8 (NDP) — Partial factors on actions and effects for verification cases VC1 to VC4 for persistent and transient (fundamental) design situations

Action or effect				Partial factors γ_F and γ_E for verification cases				
Type	Group	Symbol	Resulting effect	Structural resistance[a]	Static equilibrium and uplift[b]		Geotechnical design	
Verification case				VC1[a]	VC2(a)[b]	VC2(b)[b]	VC3[c]	VC4[d]
Permanent action (G_k)	All[f]	γ_G	unfavourable /destabilizing	$1{,}35k_F$	$1{,}35k_F$	1,0	1,0	G_k is not factored
	Water[l]	γ_{Gw}		$1{,}2k_F$	$1{,}2k_F$	1,0	1,0	
	All[f]	$\gamma_{G,stb}$	stabilizing[g]	not used	1,15[e]	1,0	not used	
	Water[l]	$\gamma_{Gw,stb}$			1,0[e]	1,0		
	All	$\gamma_{G,fav}$	favourable[h]	1,0	1,0	1,0	1,0	
Prestressing (P_k)		γ_P[k]						
Variable action (Q_k)	All[f]	γ_Q	unfavourable	$1{,}5k_F$	$1{,}5k_F$	$1{,}5k_F$	1,3	$\gamma_{Q,red}$[j]
	Water[l]	γ_{Qw}		$1{,}35k_F$	$1{,}35k_F$	$1{,}35k_F$	1,15	1,0
	All	$\gamma_{Q,fav}$	favourable	0				
Effects of actions (E)		γ_E	unfavourable	γ_E is not applied				$1{,}35k_F$
		$\gamma_{E,fav}$	favourable					1,0

[a] Verification case VC1 is used both for structural and geotechnical design. Formula (8.4) is used for VC1.

[b] Verification case VC2 is used for the combined verification of strength and static equilibrium, when the structure is sensitive to variations in permanent action arising from a single-source. Values of γ_F are taken from VC2(a) or VC2(b), whichever gives the less favourable outcome. See 8.3.3.1(5). Formula (8.4) is used for VC2.

[c] Verification case VC3 is typically used for the design of slopes and embankments, spread foundations, and gravity retaining structures. See the relevant part of EN 1997 for details. Formula (8.4) is used for VC3.

[d] Verification case VC4 is typically used for the design of transversally loaded piles and embedded retaining walls and (in some countries) gravity retaining structures. See EN 1997 (all parts) for details. Formula (8.5) is used for VC4.

[e] The values of $\gamma_{G,stb}$ = 1,15 and 1,0 are based on $\gamma_{G,inf}$ = 1,35 ρ and 1,2 ρ with ρ = 0,85.

[f] Applied to all actions except water actions.

[g] Applied to the stabilizing part of an action originating from a single source.

[h] Applied to actions whose entire effect is favourable and independent of the unfavourable action.

[j] $\gamma_{Q,red} = \gamma_{Q,1} / \gamma_{G,1}$ where $\gamma_{Q,1}$ = corresponding value of γ_Q from VC1 and $\gamma_{G,1}$ = corresponding value of γ_G from VC1.

[k] For the definition of γ_P where γ_P is materially dependent, see other relevant Eurocodes.

[l] For water actions induced by waves and currents, see Clause A.6.

Ja sitten laskemaan!

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Kiitos mielenkiinnostanne !
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