Update on Eurocode 7,
its implementation and maintenance

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2nd International Workshop on Evaluation of Eurocode 7, Pavia, Italy, April 2010

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Implementation

- Legal framework for the implementation
- Review of the 1st Internat. Workshop 2006
- Questionnaries on the adoption of DA and Annexes

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- Anchorages

Outlook

- Further harmonisation of Eurocodes
- Research for further harmonisation of EC 7
- User-friendliness of ECs

Provisions for the implementation of Eurocodes in the European countries

- The Eurocodes in the field of construction must be adopted and implemented by all EU member states.
- National standards are still permitted but
- national standards are not permitted to compete with European standards.
- Any national standard for which there is a corresponding European standard must therefore be withdrawn after a transitional period.

Future hierarchy of standards

Eurocode
Basis of design

Eurocode 1
Actions on structures

Eurocode 2
Design of concrete structures

Eurocode 3
Design of steel structures

EC 4

EC 5

EC 6

Eurocode 7
Geotechnical design

EC 8

EC 9

National Annex
to EC 2

National Annex
to EC 3

National Annex
to EC 7-1

DIN 19702
Stability of solid structures in water engineering

DIN 19704
Hydraulic steel structures

DIN 1054:2007
Application rules to EC 7-1

DIN 4084
Calculation of slope failure

Code of practice
Stability of embankments on federal waterways

International Workshop on the Evaluation of Eurocode 7

Trinity College, Dublin, 31 March and 1 April 2005

Overview of the solutions to examples

Example	Type	Parameter	Range of values	% range
1	Spread foundation	B	**1.4 – 2.3 m**	± 24 %
2	Spread foundation	B	**3.5 – 9.9 m**	± 48 %
3	Pile foundation	L	**10.0 – 42.8 m**	± 62 %
4	Pile foundation	N	**9 or 10**	± 5 %
5	Gravity ret. wall	D	**3.1 – 6.0 m**	± 32 %
6	Embedded ret.wall	D	**3.8 – 6.9 m**	± 29 %
7	Anchored ret.wall	D	**2.3 – 6.6 m**	± 48 %
8	Uplift	T	**0.41 – 1.11 m**	± 46 %
9	Heave	H	**4.7 – 8.1 m**	± 27 %
10	Embankment	H	**1.6 – 3.8 m**	± 41 %

from Trevor Orr, 2005

Why such large ranges of values?

- Use of different Design Approaches
- Different interpretations of EC 7
- Use of different assumptions
- Use of different calculation models
- Bad examples – insufficient or unclear information
- Calculation errors

Selection of Design Approach

Design example	No/ Incom-plete answers	Design approach of EC 7-1				
		all DAs	DA 1	DA 2	DA 2*	DA 3
Shallow foun-dation	N, CZ, M, S, LV, CY, IS, H, BG	IRL	B, UK, P, LT, I, RO	F, SK, I, EST	D, A, E, PL SLO, GR	CH, NL, DK
				SF, L		
Piles		IRL	B, UK, P, LT, I, RO	F, SK, CH, SF, D, A, E, NL, SLO, PL, DK, GR, L, EST		Not applicable (?)
Retaining struc-tures		IRL	B, UK, P, LT, I, RO	F, SK, CH, SF, D, A, E, SLO, PL, GR, L, EST		NL, DK
Slopes		IRL	B, UK, P, LT, I, EST	F,E		NL,F,SK,CH,SF,D,A, PL, DK, SLO, GR, L, RO
Total:	9	1	5 - 6	2 - 14		2 - 13

Partial factors for slope stability

	DA 1	DA 2	DA 3
Partial factors recom-mended in EC 7-1	Combination 1: γ_G = 1.35; $\gamma_{G,fav}$= 1.0; γ_Q= 1.5; Combination 2: γ_φ= γ_c= 1.25 γ_{cu}= 1.40 γ_G = 1.0 γ_Q = 1.30 $\gamma_{R;e}$= 1.0	γ_G = 1.35; $\gamma_{G;fav}$ = 1.0, γ_Q = 1.5; $\gamma_{R;e}$= 1.10 $\gamma_{\varphi'}$ =$\gamma_{c'}$ = γ_{cu}=1.0;	γ_φ = γ_c = 1.25 γ_{cu} = 1.40 γ_G = 1.0 γ_Q = 1.30 $\gamma_{R;e}$ = 1.0

Application of the annexes of EC 7-1

(as at June -2007)

Annex	Man-datory	Optional	Mandatory national standard	Future mandatory application?
Annex C: earth pressures on vertical walls		SF, F, I, PL, SK,	SF, D, SK, PL	I: presumably not
Annex D: bearing resistance calculation.		SF, F, I, PL, SK,	SF, D, SK, PL	I: presumably not
Annex E: bearing resis-tance using pressuremeter		SF, F, I, PL, SK,	SF, SK,	D: not used in Germany I: presumably not
Annex F: settlement evaluation		SF, F, I, PL, SK,	SF, D, SK, PL	I: presumably not, PL: must be changed
Annex G: bearing resis-tance foundations on rock		SF, F, I, PL, SK,	SF, D, SK,	I: presumably not, PL: must be changed
Annex H: Limiting values of foundation movement		F, I, PL, SK,	SF, SK, PL	D: not mandatory, I: presumably not
Annex J: Checklists		SF, I, PL, SK,	SF	D: cannot be mandatory I: presumably not

Maintenance

- General
- Corrigenda
- Limit state EQU
- Anchorages

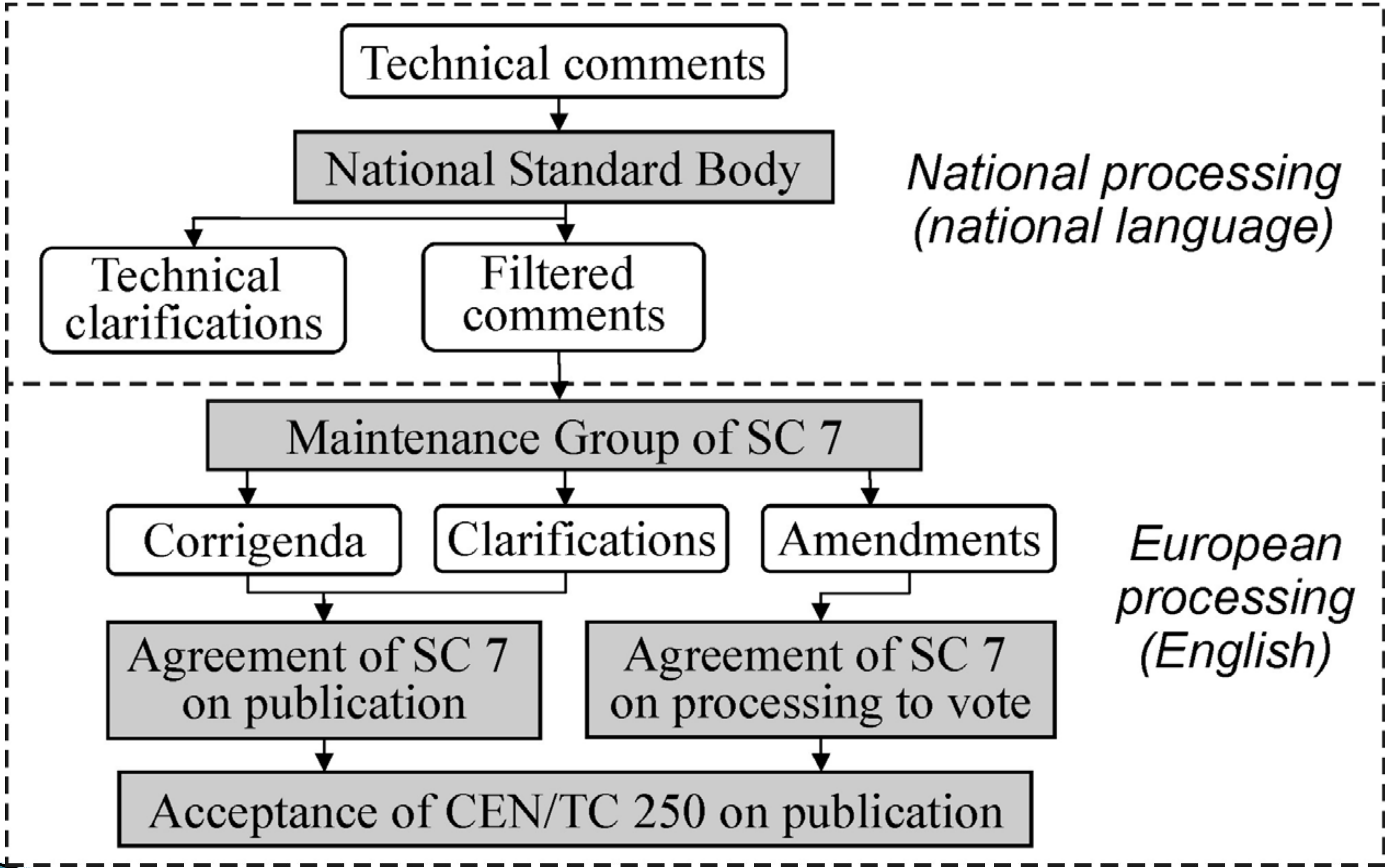
Maintenance of Eurocodes

Maintenance is the technical and editorial improvement of a Eurocode which includes

- essential technical amendments with regard to urgent matters of health,
- correcting errors and
- the resolution of questions of interpretation
- development of new items

resulting from feedback from use of Eurocodes.

Flowchart for the maintenance of Eurocodes



Maintenance Group of SC 7

Members: B. Schuppener, A. J. Bond, R. Frank, T. L. L. Orr, G. Scarpelli, J. Powell, B. Simpson, L. Buth

Type of comments	EC 7-1	EC 7-2
Urgent technical or editorial corrections	≈ 50	≈ 40
Comments regarding editorial changes for the next version of the code	≈ 150	-
Comments needing further technical discussion	≈ 200	≈ 40
Total:	≈ 400	≈ 80

Publication of corrigendum of EC 7-1: February 2009

Publication of corrigendum of EC 7-2: March 2010

Definitions of ultimate limit state EQU

EN 1997-1 - Eurocode 7: *Geotechnical Design*:
"Loss of equilibrium of the structure or the ground, considered as a rigid body, in which the strengths of structural materials and the ground are **insignificant** in providing resistance"

EN 1990 - Eurocode: *Basis of Design*:
"Loss of static equilibrium of the structure or any part of it considered as a rigid body, where:

- minor variations in the value or the spatial distribution of actions from a single source are significant, and
- the strengths of construction materials or ground are generally **not governing**."

Basic expression for the verification of ultimate limit state EQU

$$E_{d,dst} \leq E_{d,stb}$$

$E_{d,dst}$: design value of effect of destabilising actions

$E_{d,stb}$: design value of effect of stabilising actions

$$E\{\gamma_{F,dst}F_{rep,dst};X_k/\gamma_M;a_{nom}\} = E_{d,dst} \leq E_{d,stb} =$$
$$E\{\gamma_{F,stb}F_{rep,stb};X_k/\gamma_M;a_{nom}\}$$

$F_{rep,dst}$: representative destabilising actions

$F_{rep,stb}$ representative stabilising actions

$\gamma_{F,dst}$: partial factors for destabilising actions

$\gamma_{F,stb}$: partial factors for stabilising actions

Partial factors for stabilising and destabilising actions for EQU limit states

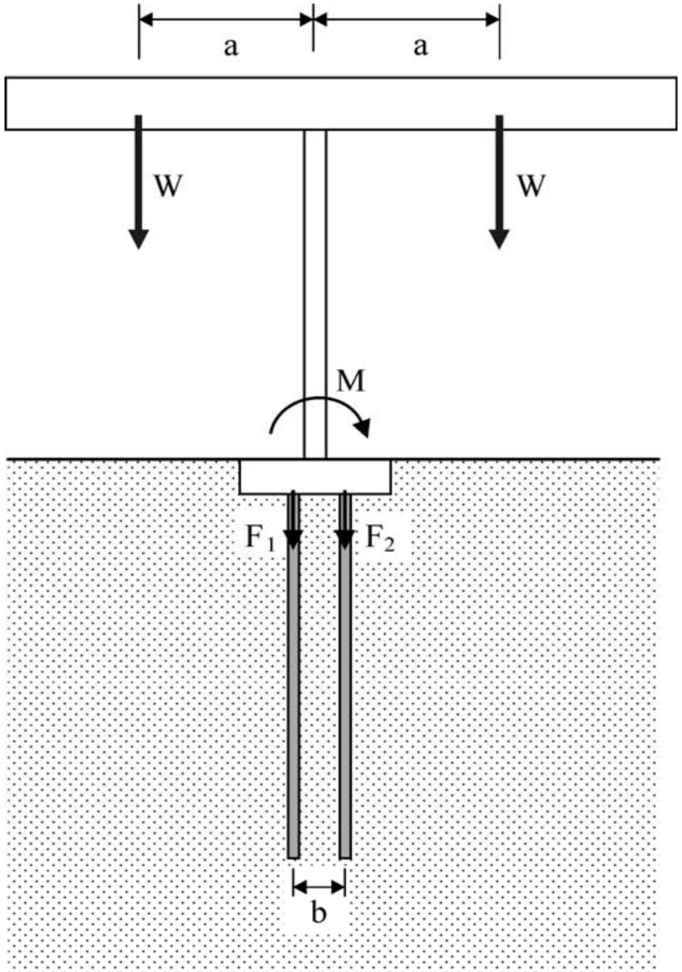
Actions	Symbol	Value	
		EN 1997-1 and EN 1990	EN 1990, NOTE 2
Permanent, destabilising	$\gamma_{G,dst}$	1.10	1.35
Permanent, stabilising	$\gamma_{G,stb}$	0.90	1.15
Variable, destabilising	$\gamma_{Q,dst}$	1.50	1.50
Variable, stabilising	$\gamma_{Q,stb}$	0	0

Concepts for the interpretation and application of EQU limit state

Concept 1 proposes verifying EQU **only** in those cases where loss of static equilibrium is physically possible for the structure or part of it, considered as a rigid body and where **no strength** of the structure ground is involved. In situations where the strength of material or ground is significant in providing resistance Concept 1 proposes verifying STR/GEO only.

Concept 2 proposes verifying EQU in **all cases**; it is interpreted as a load case. Where minor strength of material or ground is involved, the combined EQU/STR/GEO verification is used.

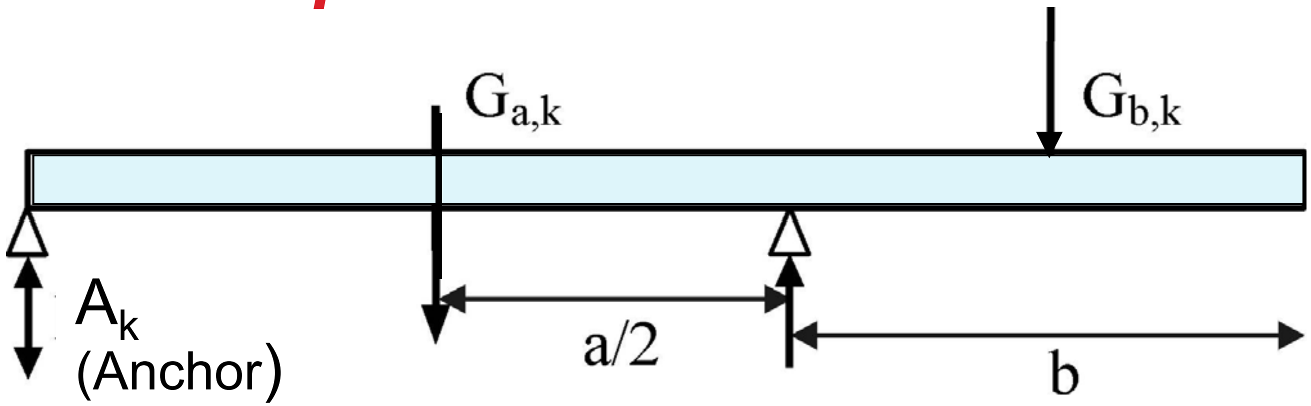
Example: Balanced structure on piled foundation



	Concept 1		Concept 2
Partial factors	STR: applying SCP	STR: dis-regarding SCP	EQU, Table A1.2(A)
	$\gamma_{G,sup}$ =1.35	$\gamma_{G,sup}$=1.35 $\gamma_{G,inf}$ = 1.00	$\gamma_{G,dst}$=1.10 (1.35) $\gamma_{G,stb}$ = 0.90 (1.15)
Design values F_1 and F_2	1.35 W	W · (1.175 ±0.35 · a/b)	W · (1 ± 0.2 · a/b)
Bending moment	0	±0.35·a·W	±0.2·a·W

SCP: Single Source Principle

Example: beam structure – static equilibrium



$$\mathbf{M_{dst,d} \leq M_{stb,d}}$$

	Concept 1	**Concept 2**
Partial factors	EN 1990: Tab. A1.2(A), Note 1 and Tab. A1.2(B)	EN1990: Table A1.2(a) Note 1
	$\gamma_{G,dst}$= 1.10, $\gamma_{G,stb}$ = 0.90, $\gamma_{G,sup}$=1.35	$\gamma_{G,stb}$=1.10, $\gamma_{G,stb}$ = 0.90
EQU-ULS	$G_k\gamma_{G,dst} \leq G_k\gamma_{G,stb} + 2\,\mathbf{A_k}\,\gamma_{G,stb}$	$G_k\gamma_{G,sup} \leq G_k\gamma_{G,inf} + 2\,\mathbf{A_d}$
Char. force A_k	$A_k \geq 0.11\ G_k$	not required
Design force A_d	$A_d = A_k\ \gamma_{G,sup}$ = $\mathbf{0.148\ G_k}$	A_d= $\mathbf{0.10\ \ G_k}$

Work on anchorages

Three standards dealing with anchorages:

- EN 1537:2001 Ground anchors (TC 288)
- EC 7-1: Section 8 Anchorages (SC 7)
- EN-ISO 22477-5: Testing of anchorages (WG 4, TC 341)

Decisions of TC 288, SC 7 and TC 341 on 13 July 2007:

- EN 1537 shall only deal with the execution of anchorages, so Annexes D (testing) and E (design) can be cancelled.
- All design issues shall be presented in EN 1997-1.
- All procedures for stress testing shall covered in EN-ISO 22477-5.
- EN-ISO 22477-5 should cover the testing procedures of all member countries.
- All definitions and symbols shall be identical.

Future contents of standards on anchorages

EN-ISO: 22477-5 **Testing of anchorages**	**EC7-1: Geotechnical design** **Part 1: General rules**	**EN 1537:** **Ground anchors**
Common: terminology, definitions and symbols		
• Scope • Equipment • Testing procedures • Test report	**Section 8 “Anchorages”** • Design situations and actions • Design and construction considerations • ULS and SLS design • All for special testing • Number, method and type of test • Requirements for proof loads, creep rates and group effects • Determination of characteristic pull-out resistance	• Scope • Information for execution • Geotechnical investigations • Materials and products • Design considerations[1)] • Execution • Supervision, monitoring and testing[2)] • Records and design life condition monitoring • Safety requirements
Annexes (informative): • Test methods including interpretation of test results	**Annex (informative)**: • Recommended partial resistance and correlation factors for pre-stressed anchorages	**Annexes (informative):** • Testing of corrosion protection an acceptance criteria • Examples of record sheets
	National annexes: • Selection of tests (number, type and method) • Requirements for proof loads, creep rates and group effects • Partial resistance and correlation factors	1) i.e. design input from execution 2) Other than stress testing, e. g. of bore holes and corrosion protection

Future tasks

- Further harmonisation of Eurocodes
- Research for further harmonisation of EC 7
- User-friendliness of ECs

Further harmonization of Eurocodes

"Member States should use the recommended values provided by the Eurocodes …. They should diverge from those recommended values only where geographical, geological or climatic conditions or specific levels of protection make that necessary."

"Member States should …compare the nationally determined parameters implemented by each Member State and assess their impact … . Member States should, at the request of the Commission, change their nationally determined parameters in order to reduce divergence from the recommended values provided by the Eurocodes."

Commission Recommendation, 11 December, 2003

Research and Development

"Member States should undertake research to facilitate the integration into the Eurocodes of the latest developments in scientific and technological knowledge. Member States should pool the national funding available for such research so that it can be used at Community level to contribute to the existing technical and scientific resources for research within the Commission, in cooperation with the Joint Research Centre, thus ensuring an ongoing increased level of protection of buildings and other civil works, specifically as regards the resistance of structures to earthquakes and fire."

Commission Recommendation, 11 December, 2003

The need for research for further harmonization of geotechnical design in Europe

by
Subcommittee 7 *Geotechnical Design*
of CEN/TC 250 *Structural Eurocodes*

Date: 29 June 2007

The need for research

Aims:

- Reduction of NDPs and their variety and a reduction of Design Approaches to come to a gradual alignment of safety levels across MS.
- Harmonization of the models used for the calculation of geotechnical actions and resistances,
- harmonization of parameter evaluation from field and laboratory tests and
- provisions for the application of numerical models (FEM) in Limit State Design.

Essential Requirements for Structures

- mechanical resistance and stability,
- safety in case of fire,
- safety in use,
- hygiene, health and the environment and
- protection against noise
- **energy economy and heat retention and**
- **sustainable use of natural resources.**

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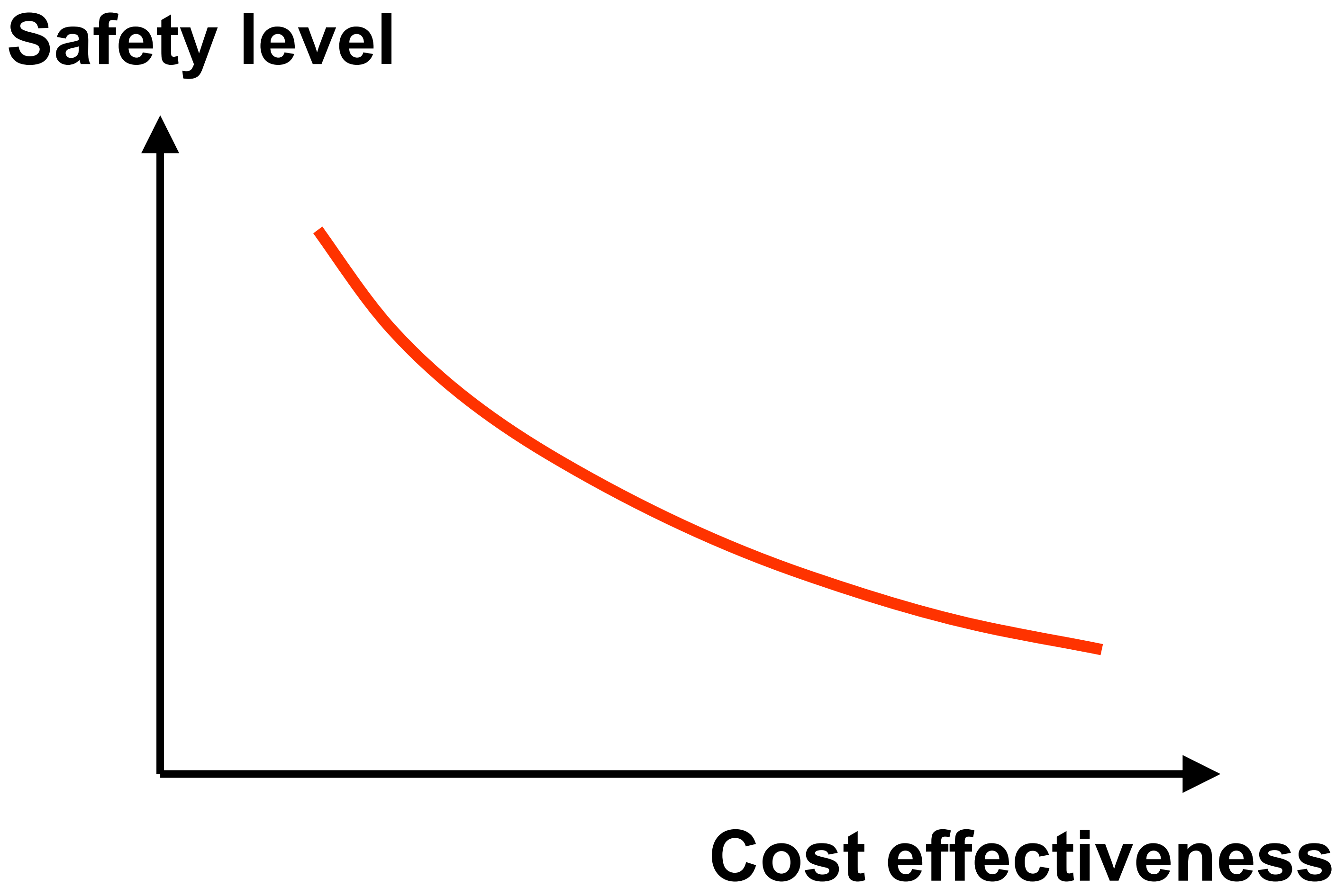
Economic efficiency and Safety Level



Eurocode 7-1

2.4 Geotechnical design by calculation

2.4.1 General

(2) It should be considered that knowledge of the ground conditions depends on the extent and quality of the geotechnical investigations. Such knowledge and the control of workmanship are usually more significant to fulfilling the fundamental requirements than is precision in the calculation models and partial factors.

Essential components of geotechnical safety

- adequate knowledge of the structure and the mechanical characteristics of the ground,
- planning carried out by qualified staff,
- a realistic design model,
- adequate calculated safety of the design and
- adequate quality control on the construction site.

Geotechnical sustainability and safety

The safety level of geotechnical structures could be considerably increased if greater emphasis were placed

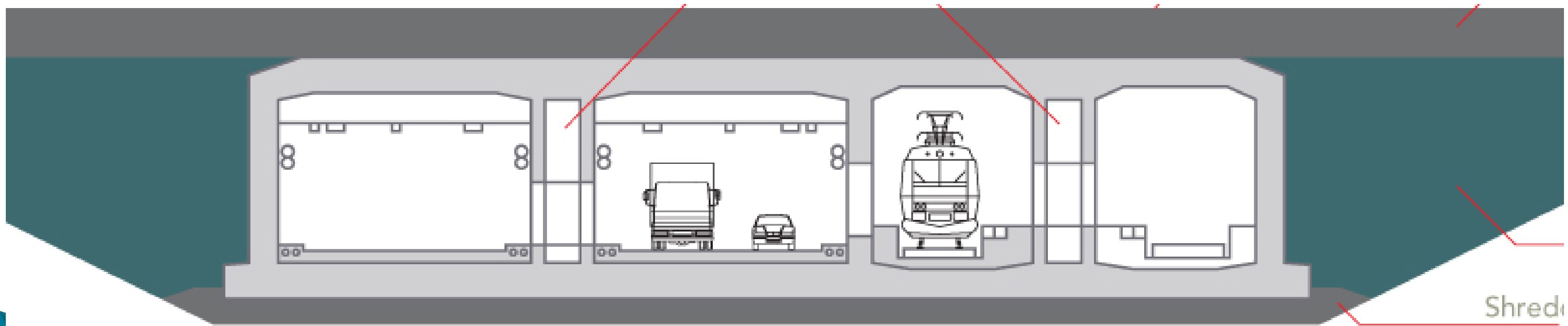
- on the extent and quality of soil investigations and
- on quality control during the construction of geotechnical engineering works.

It would then certainly be possible to discuss the reduction of the calculated safety and thus carry out construction work more economically and sustainably.

Research for Future Infrastructure Networks in Europe

refine


Fehmarn
Belt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