Eurocode 7 is coming

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Outline of talk

- The Structural Eurocodes programme
- The new principles of Eurocode 7
- The bigger picture
- Impact of Eurocode 7

This presentation is available from:
www.geocentrix.co.uk/eurocode7

References

1. National Strategy for Implementation of the Structural Eurocodes: Design Guidance, IStructE (April 2004)
   Nethercott et al., IStructE
2. PP 1990: 2004. Guide to the Structural Eurocodes for students of structural design
   Bright et al. (§7 by Bond and Harris), BSI
3. EC7 – implications for UK practice (in preparation)
   Driscoll, Powell, et al., CIRIA Report RP701

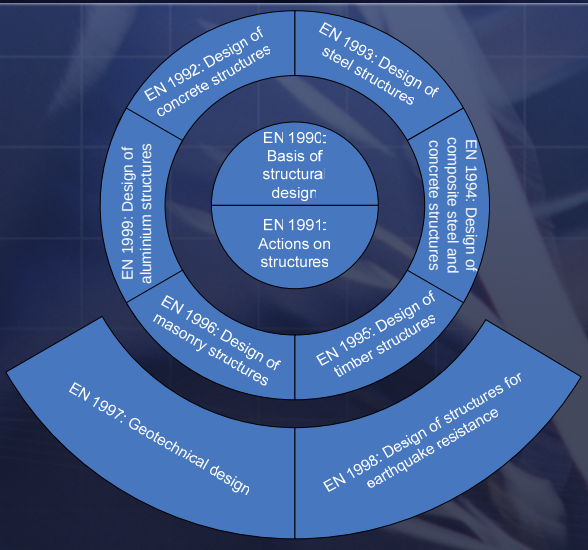
Eurocode 7 is coming

The Structural Eurocodes programme

What are the Eurocodes?

- The structural Eurocodes are a European suite of codes for structural design … developed over … twenty-five years[1]
- By 2010 they will have effectively replaced the current British Standards as the primary basis for designing buildings and civil engineering structures in the UK
- They [will be] used as an acceptable basis for meeting compliance with UK Building Regulations and the requirements of other public authorities

Structural Eurocodes programme



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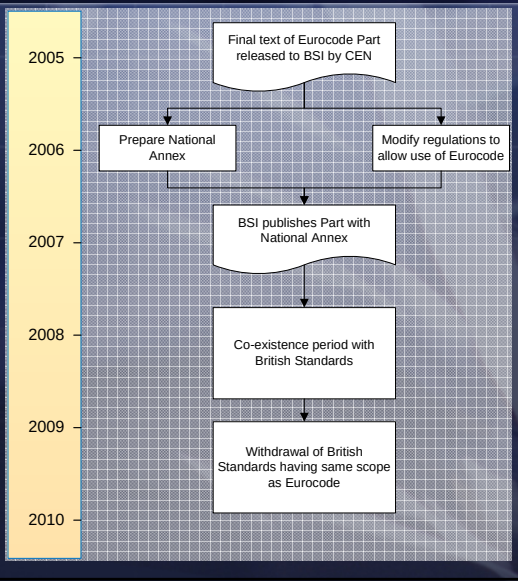
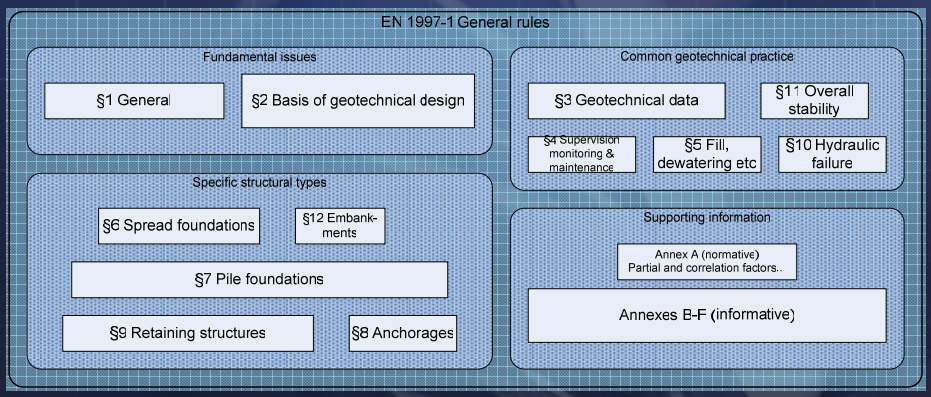
- Prospective standards for provisional application (ENVs)
  - ENV 1997-1: 1994
  - ENV 1997-2: 1999
  - ENV 1997-3: 1999
- Full European standards (ENs)
  - EN 1997-1 published December 2004
  - prEN 1997-2 available, EN 1997-2 to be published anytime soon

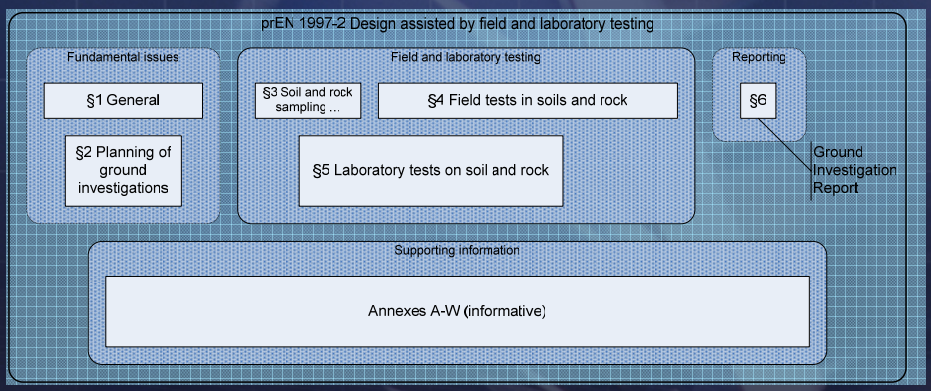
Timetable for introduction



Contents of EN1997-1 General rules



Contents of prEN 1997-2
Design assisted by field and laboratory testing



Principles and Application Rules

- Principles
  - General statements and definitions for which there is no alternative
  - Requirements and analytical models for which no alternative is permitted unless specifically stated
  - Principles are preceded by the letter (P)
  - Verb used is “shall”
- Application Rules
  - Examples of generally recognised rules, which follow the Principles and satisfy their requirements
  - Verbs used are “should”, “may”, “can”, etc.

§2.1 Design requirements

- (1)P For each geotechnical design situation it shall be verified that no relevant limit state … is exceeded
- (4) Limit states should be verified by
  - Use of calculations
  - Adoption of prescriptive measures
  - Experimental models and load tests
  - An observational method

Complexity of design

- §2.1(8)P The complexity of each geotechnical design shall be identified together with associated risks … a distinction shall be made between:
  - light and simple structures and small earthworks … with negligible risk*
  - other geotechnical structures
- *May be designed on basis of past experience and qualitative geotechnical investigations

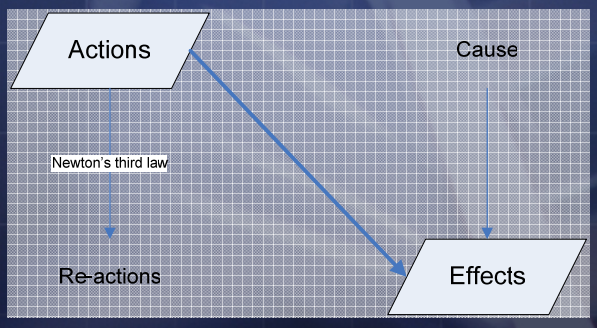
Geotechnical categories

GC	Includes…	Design requirements	Design procedure
1	Small and relatively small structures… **with negligible risk**	Negligible risk of instability or ground movements Ground conditions known No excavation below water table	Routine design & construction methods
2	Conventional types of structure & foundation **with no exceptional risk** or difficult soil or loading conditions	Quantitative geotechnical data & analysis to ensure fundamental requirements are satisfied	Routine field & lab testing Routine design & execution
3	Structures or parts of structures not covered above	Use alternative provisions and rules to those in Eurocode 7	

Actions and effects (from EN 1990)

- Action (F)
  - Direct action
    - Set of forces (loads) applied to the structure
  - Indirect action
    - Set of imposed deformations or imposed accelerations caused for example, by temperature changes, moisture variation, uneven settlement or earthquakes
- Effect of action (E)
  - On structural members
    - e.g. internal force, moment, stress, strain
  - On the whole structure
    - e.g. deflection, rotation

Cause and effect

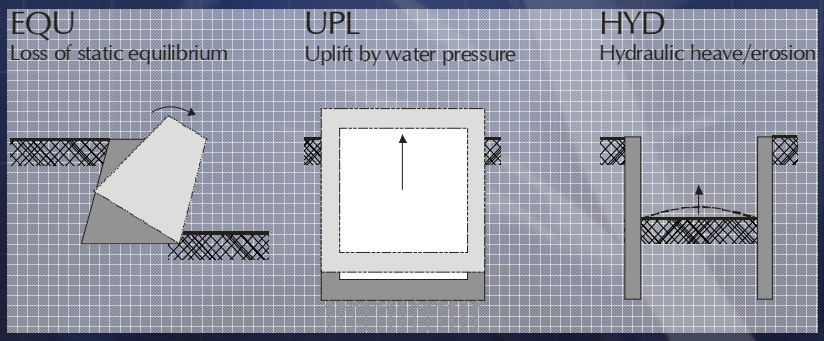


- "For every action, there is an equal and opposite re-action"
  - Sir Isaac Newton, Principia Mathematica Philosophiae Naturalis (1686), third law of motion

Duration of actions (from EN 1990)

- Permanent action (G)
  - Likely to act throughout design situation
  - Variation with time is negligible and monotonic
- Variable action (Q)
  - Unlikely to act throughout design situation
  - Variation with time is neither negligible nor monotonic
- Accidental action (A)
  - Unlikely to occur with significant magnitude during design situation
- Seismic action (A_E)
  - Due to earthquake ground motions

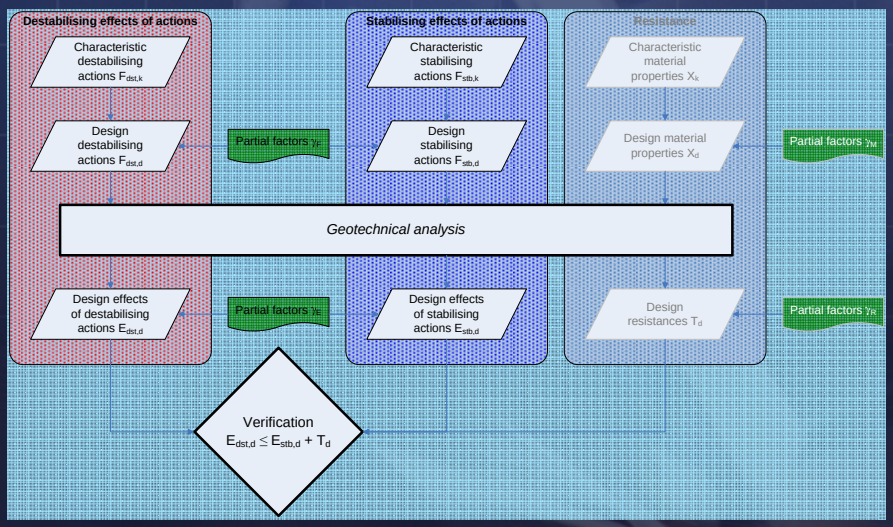
Ultimate limit states for stability



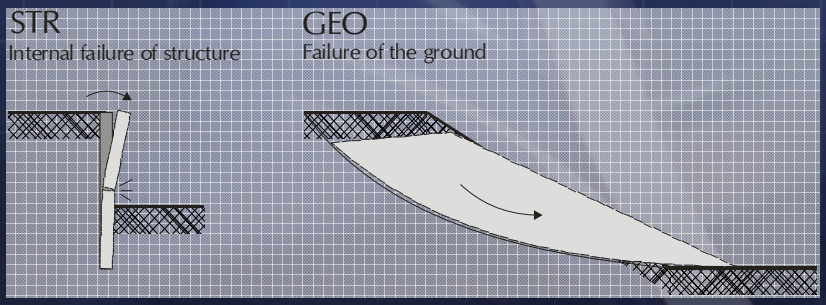
Limit states EQU, UPL, and HYD

- Definition of limit state EQU
  - 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
- Definition of limit state UPL
  - Loss of equilibrium of the structure or the ground, due to uplift by water pressure (buoyancy) or other vertical actions
- Definition of limit state HYD
  - Hydraulic heave, internal erosion and piping in the ground caused by hydraulic gradients

Verification of stability for EQU



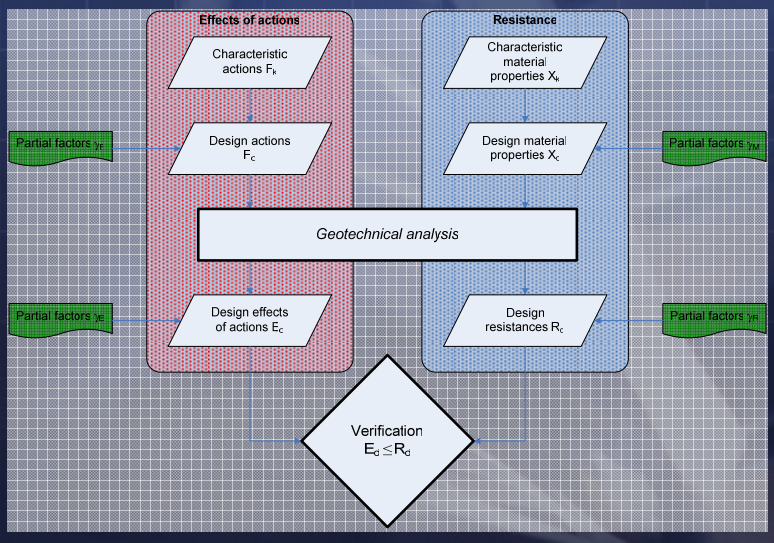
Ultimate limit states for strength



Limit states GEO and STR

- Definition of limit state GEO
  - Failure or excessive deformation of the ground, in which the strength of soil or rock is significant in providing resistance
    - often critical to sizing structural elements in foundations or retaining structures
- Definition of limit state STR
  - Internal failure or excessive deformation of the structure or structural elements … in which the strength of structural materials is significant in providing resistance
    - includes (for example) footings, piles, and basement walls

Verification of strength for GEO/STR



§2.4.7.3.4 Design Approaches

- (1)P The manner in which [GEO and STR are applied] shall be determined using one of three Design Approaches
  - Design Approaches are ONLY relevant to limit states STR and GEO
- NOTE 1 Particular Design Approach to be used may be given in the National Annex
  - UK/Denmark prefer DA1
  - Germany/France prefer DA2
  - Some countries will allow a choice

Partial factors on input parameters

- Geometrical parameters
  - Add tolerance Δ_a
  - $a_d = a_{nom} + \Delta_a$
- Actions
  - Multiply by partial factors for actions γ_F
  - $F_d = \gamma_F F_{rep} = \gamma_F \psi F_k$
- Material properties
  - Divide by partial factors for material properties γ_M
  - $X_d = X_k / \gamma_M$

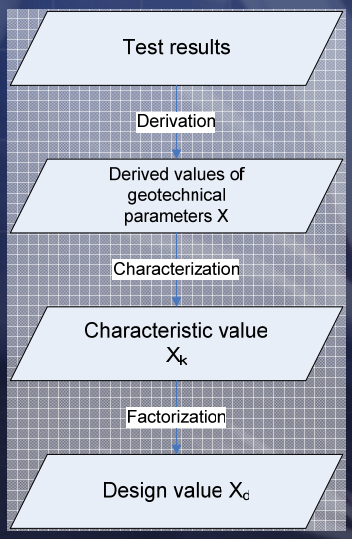
Partial factors on output parameters

- Effects of actions
  - Multiply actions by γ_F
    - $E_d = \mathcal{E}(F_d, X_d, a_d)$
  - (or) multiply effects of actions by γ_F
    - $E_d = \gamma_E \mathcal{E}(F_{rep}, X_d, a_d)$
  - (but not both)
- Resistance
  - Divide material properties by γ_M
    - $R_d = \mathcal{R}(F_d, X_d, a_d)$
  - (or) divide resistance by γ_R
    - $R_d = \mathcal{R}(F_d, X_k, a_d) / \gamma_R$
  - (or) both
    - $R_d = \mathcal{R}(F_d, X_d, a_d) / \gamma_R$

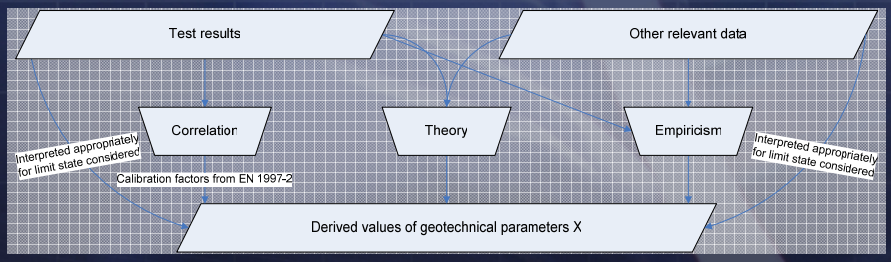
Provision of safety[2] in DAs 1-3

Structure	***Design Approach***			
	1		***2***	***3***
	Combination 1	***Combination 2***		
Axially loaded piles and anchors	Actions	Resistances	Actions & resistances	Actions & material properties & resistances
Other structures		Material properties		
Slopes			Effects of actions & resistances	Effects of actions & material properties & resistances

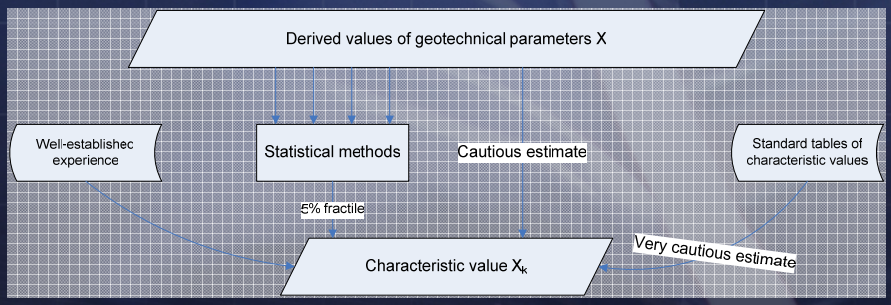
Design material properties



Derived geotechnical parameters



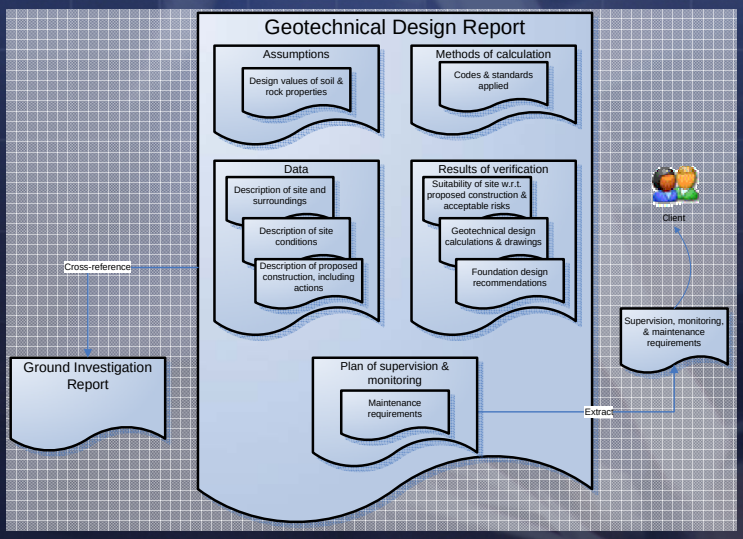
Characteristic material properties



Geotechnical Design Report

- §2.8(1)P The assumptions, data, methods of calculation and results of the verification of safety and serviceability must be recorded in a Geotechnical Design Report
  - Level of detail depends on type of design
  - Single sheet may be sufficient

Contents of GDR



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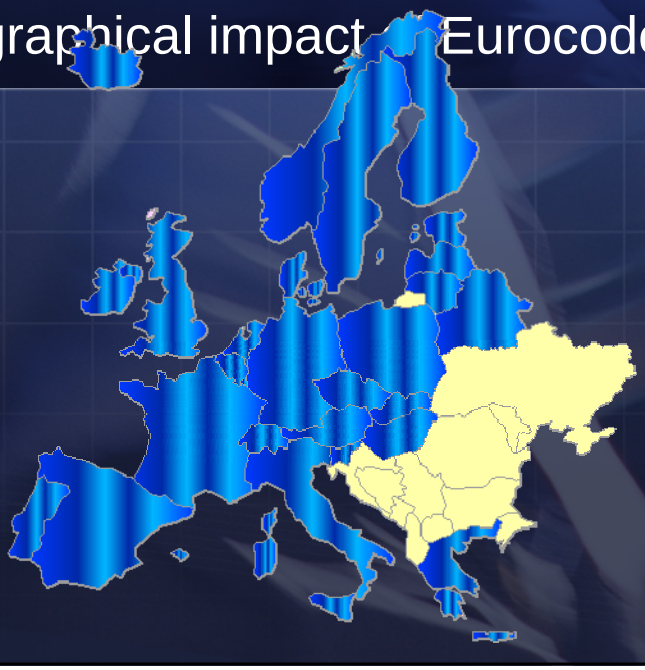
The bigger picture

Geographical impact Eurocodes



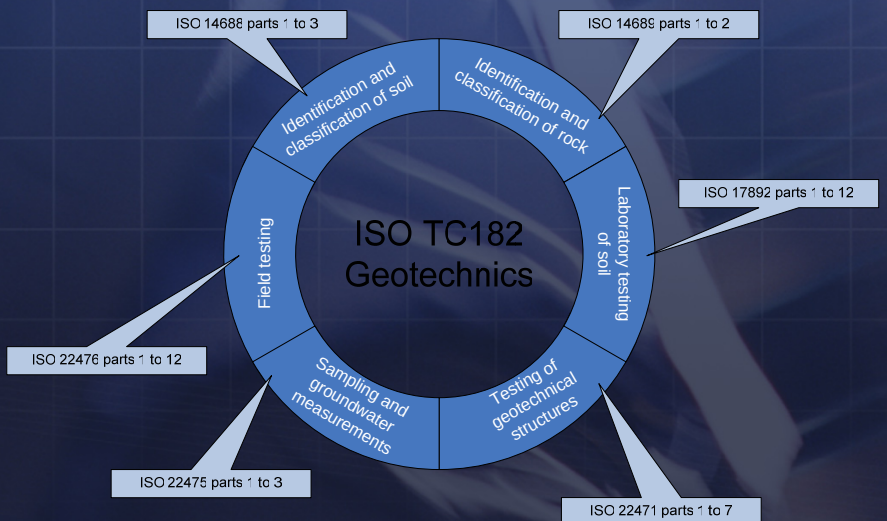
Geotechnical standardization movement

- Comité Européen de Normalisation (CEN)
  - TC250: Structural Eurocodes
    - Eurocode 7 covered by SC7
  - TC288: execution of special geotechnical works
  - TC342: laboratory and field testing standards
- International Standards Organization (ISO)
  - TC182: geotechnical investigation and testing

Work of CEN TC288

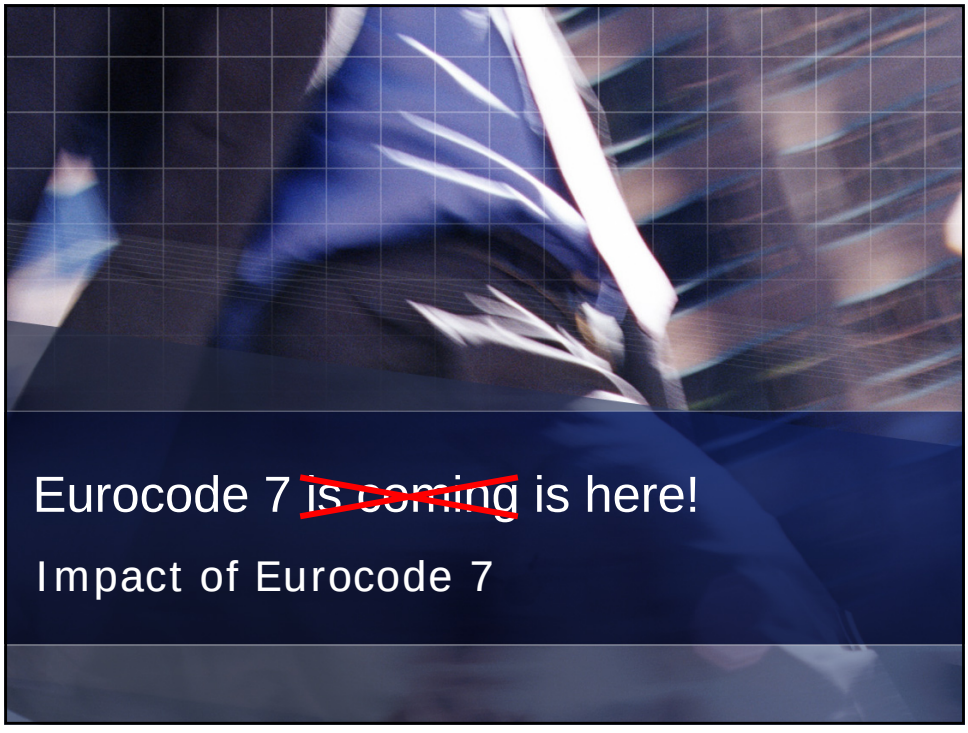
- Execution of special geotechnical work(s)
  - Bored piles (BS EN 1536: 2000)
  - Diaphragm walls (BS EN 1538: 2000)
  - Displacement piles (BS EN 12699: 2001)
  - Ground anchors (BS EN 1537: 2000)
  - Grouting (BS EN 12715: 2000)
  - Jet grouting (BS EN 12716: 2001)
  - Sheet pile walls (BS EN 12063: 1999)
- Standards currently in preparation
  - Micropiles (prEN 14199: 2001)
  - Soil nailing (prEN 14490: 2002)
  - Reinforced fill (prEN 14475: 2002)
  - Deep mixing (prEN 14679: 2003)
  - Ground treatment by deep vibration (prEN 14731: 2003)
  - Deep drainage (prEN xxxxx)

Work of ISO TC182 Geotechnics



Impact on British Standards[3]

Existing British Standard	EN 1997-1	prEN 1997-2	Execution standard
BS 1377: 1990, Methods of test for soils for civil engineering purposes			
BS 5930: 1999, Site investigations	§3	§1-6	
BS 6031: 1981, Earthworks	§5, 11-12		
BS 8002: 1994, Earth retaining structures	§3		EN 1538, 12063
BS 8004: 1986, Foundations	§6-7		EN 1536, 12063, 12699, prEN 14199
BS 8006: 1995, Strengthened/reinforced soils and other fills			prEN 14475
BS 8008: 1996 Construction and descent of machine-bored shafts for piling	§7		EN 1536, 12063
BS 8081: 1989, Ground anchorages	§8		EN 1537



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Impact of Eurocode 7

Reaction to the Eurocodes

- David Puller, chief engineer at Bachy Soletanche, Ground Engineering Talking Point (October 2004)
  - …the scourge of the UK construction industry will soon be upon us with … the Eurocodes and specifically EC7
  - …factors of safety [to] derive safe pile load capacity are … inversely proportional to the number of soil profiles available
  - As a result there will be a direct design benefit from carrying out a comprehensive site investigation. Put crudely, more boreholes will mean lower factors of safety

The challenge ahead[1]

- [The] construction industry … has not previously faced the challenge of implementing a complete suite of new codes encompassing all the major materials and loading requirements
- This burden will not be eased by the format and terminology of the Eurocodes both of which are different from British Standards

Impact of Eurocode 7[1]

- …within the UK, the extent to which geotechnical design has been codified [is] much less than in other sectors
- … the introduction of EN 1997 (Geotechnical design) will represent a marked change in UK practice
- … the needs of geotechnical designers … to adapt … will be significant

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