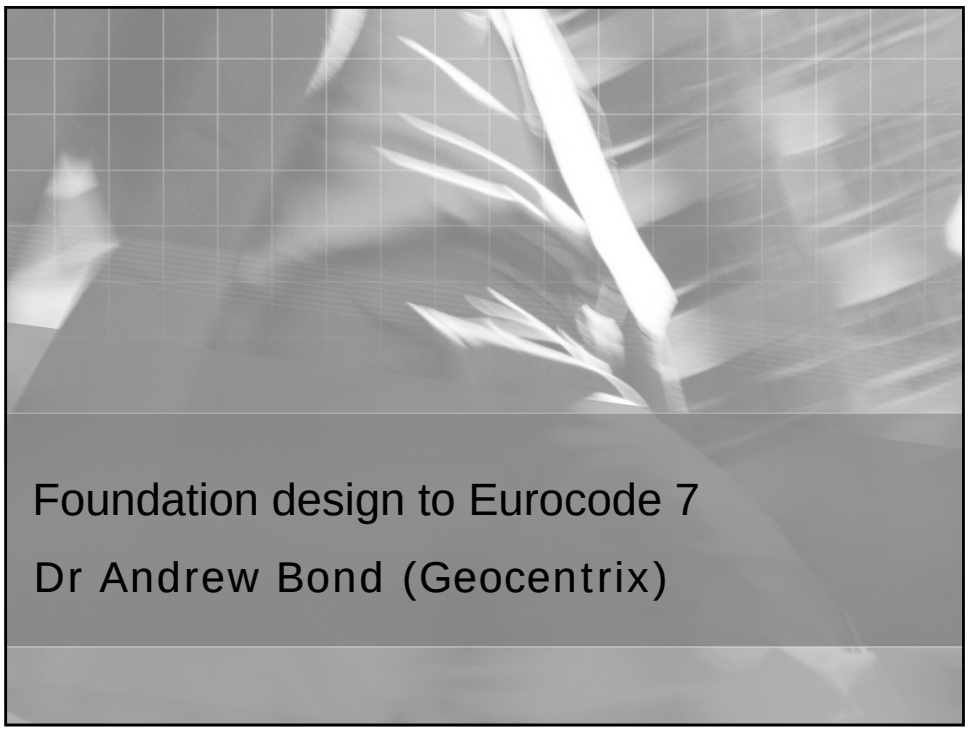


Foundation design to Eurocode 7

Dr Andrew Bond (Geocentrix)

Outline of talk

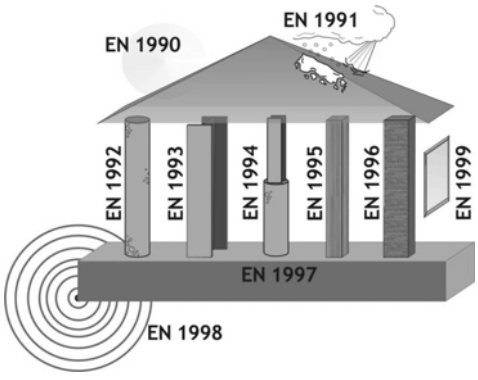
- Overview of Eurocode 7
- New principles for geotechnical design
- Impact on retaining wall design
- Impact on pile design
- Benefits of Eurocode 7

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

Foundation design to Eurocode 7

Overview of Eurocode 7

Structural Eurocodes suite

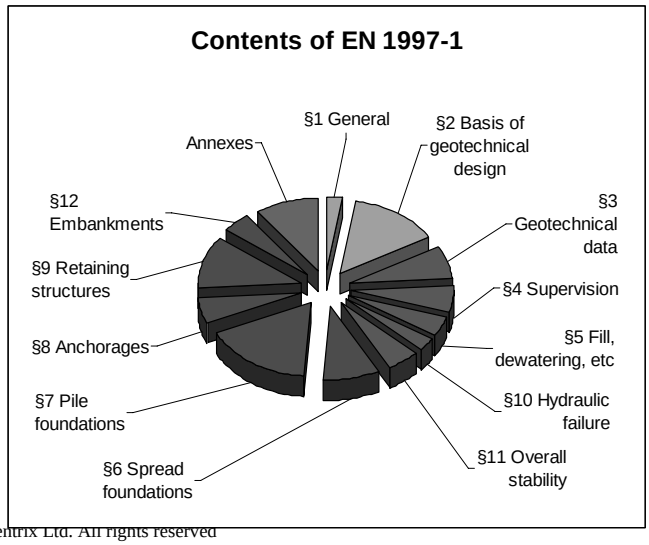


- Main resistance Eurocodes:
  - Same Principles, different Rules
- Eurocode 7:
  - Same Rules, different Principles

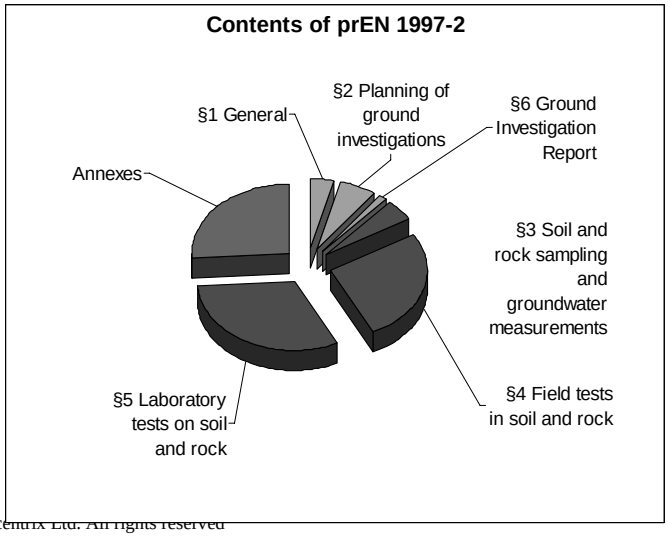
Eurocode 7 timetable

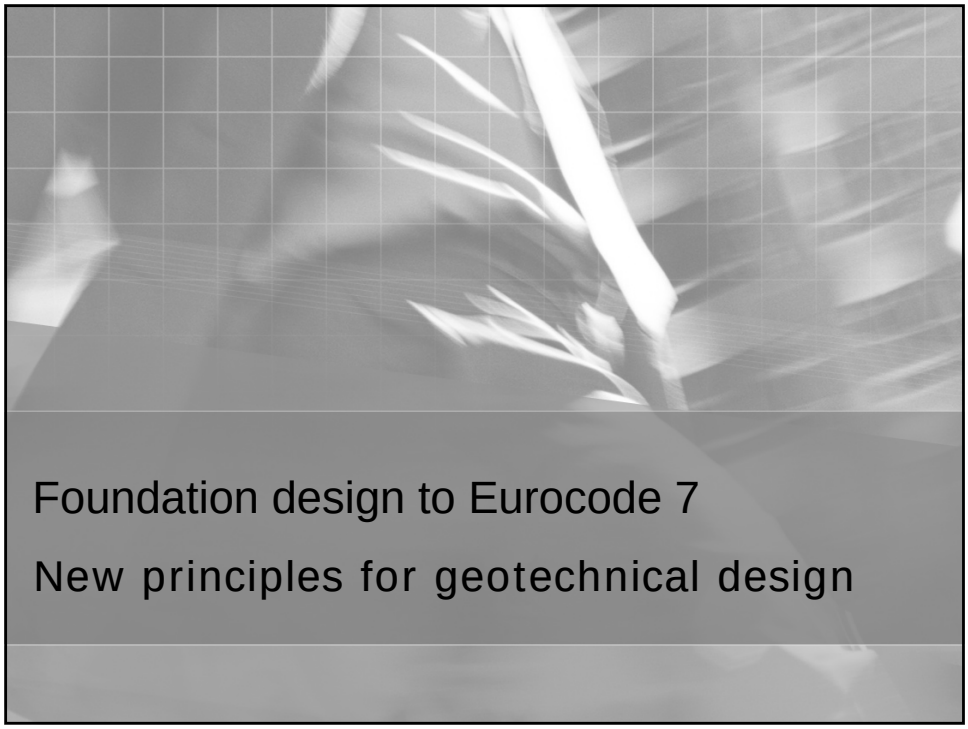
- Prospective standards for provisional application (ENVs)
  - ENV 1997-1: 1994 General rules
  - ENV 1997-2: 1999 Field testing
  - ENV 1997-3: 1999 Lab. testing
- Full European standards (ENs)
  - EN 1997-1 published December 2004
  - prEN 1997-2 available 2005
  - EN 1997-2 to be published late 2006?

Contents of EN1997-1 General rules



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





§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

Geotechnical categories

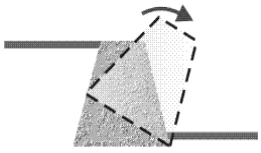
GC	Includes…	Design requirements	Design procedure
1	Small and relatively simple structures… **with negligible risk**	Negligible risk of instability or ground movements Ground conditions known No excavation below water table	Routine design & construction methods
2	Conventional types of structure & foundation **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	

Example geotechnical categories

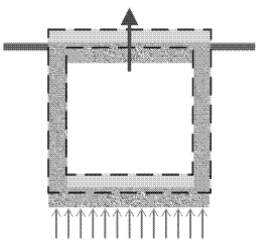
GC	Includes…	Examples
1	Small and relatively simple structures… **with negligible risk**	*None given in Eurocode 7*
2	Conventional types of structure & foundation **with no exceptional risk** or difficult soil or loading conditions	§2.1(19) Spread; raft; & pile foundations; walls & other structures retaining or supporting soil or water; excavations; bridge piers & abutments; embankments & earthworks; ground anchors & other tie-back systems; and tunnels in hard, non-fractured rock and not subjected to special water tightness or other requirements.
3	Structures or parts of structures not covered above	§2.1(21) Very large or unusual structures; structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions; structures in highly seismic areas; and structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures

Ultimate limit states for stability

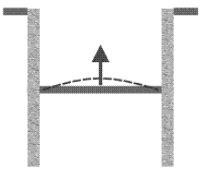
EQU
Loss of static equilibrium



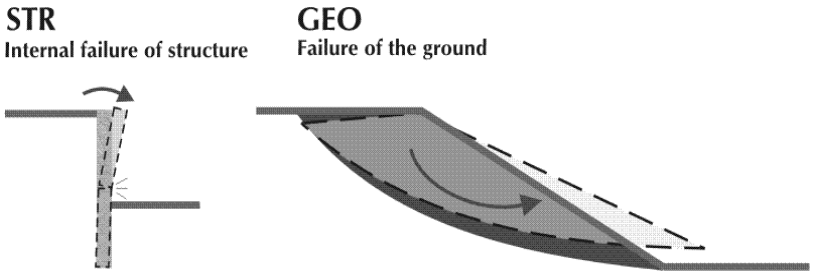
UPL
Uplift by water pressure



HYD
Hydraulic heave/erosion



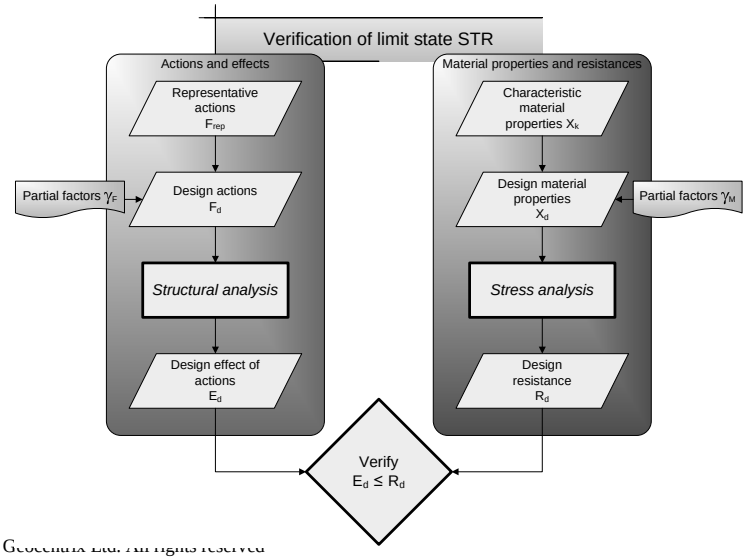
Ultimate limit states for strength



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

Structural verification of strength (STR)



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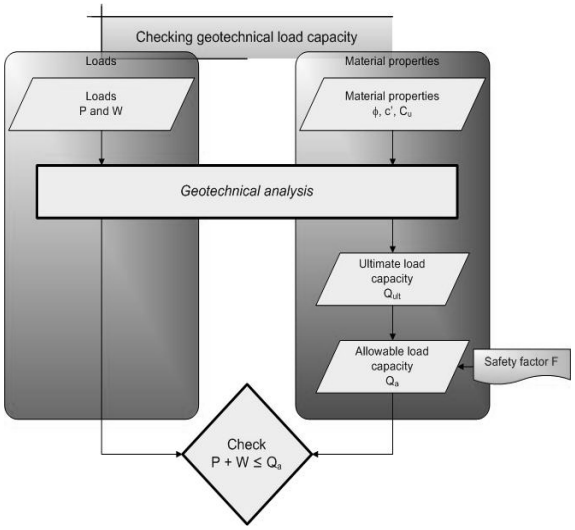
Allowable stress design procedure



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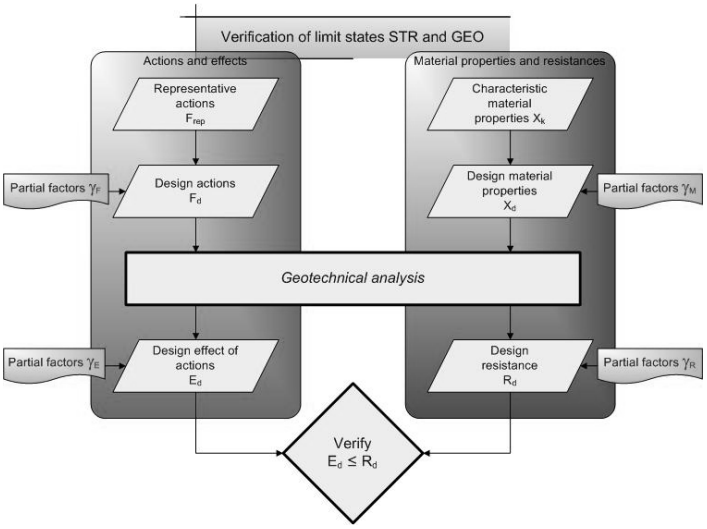
Verification of strength for GEO/STR

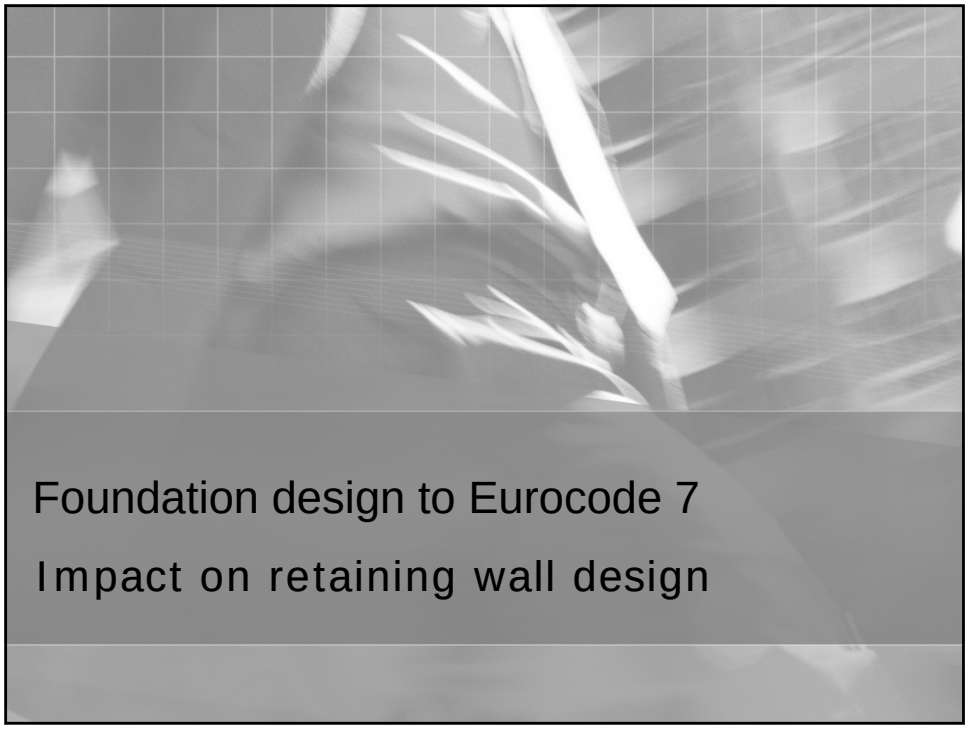


§2.4.7.3.4 Design Approaches

- (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

Design approaches for STR/GEO

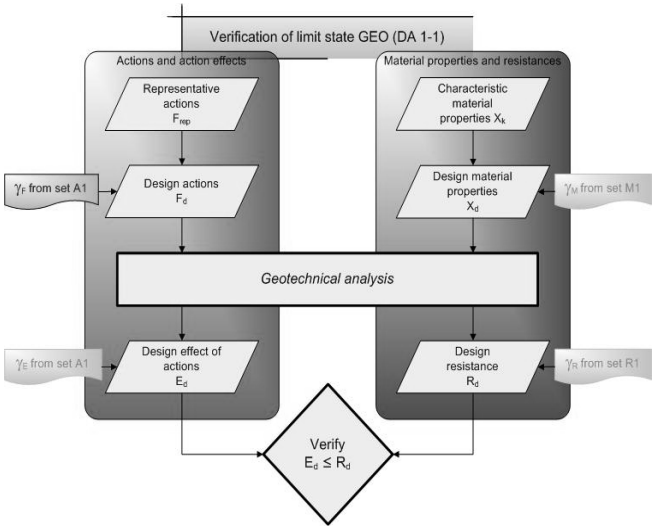
Structure	***Design Approach***			
	1		***2***	***3***
	Combination 1	***Combination 2***		
Axially loaded piles and anchors	Actions	Resistances	Actions & resistances	Actions & material properties & resistances
Other structures		Material properties		
Slopes			Effects of actions & resistances	Effects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



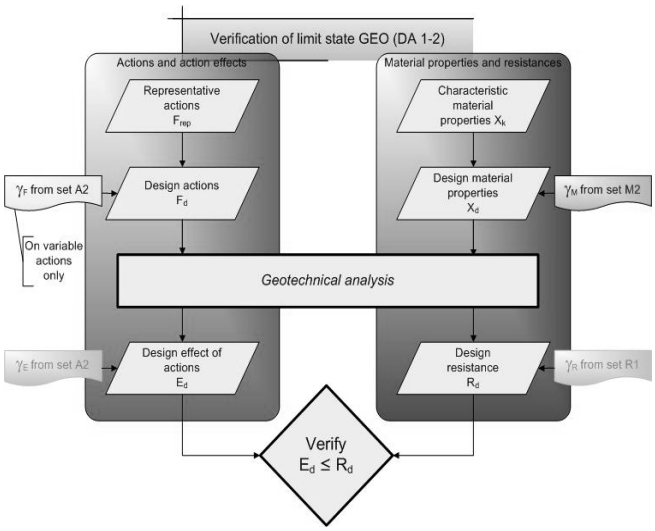
Contents of Section 9

§9.1 General
§9.2 Limit states
§9.3 Actions, geometrical data and design situations
§9.4 Design and construction considerations
§9.5 Determination of earth pressures
§9.6 Water pressures
§9.7 Ultimate limit state design
§9.8 Serviceability limit state design

Design Approach 1-1 for retaining structures

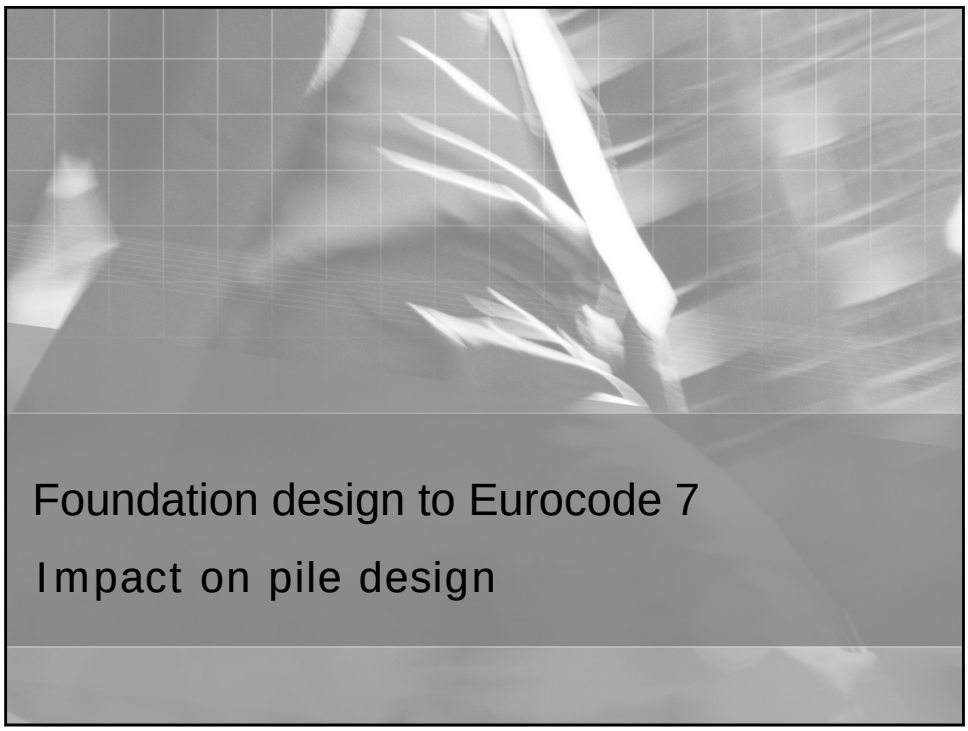


Design Approach 1-2 for retaining structures



Supervision, monitoring, and testing

- There are no clauses in EN1997 that specifically cover supervision, monitoring, and maintenance of retaining structures
- However, separate European execution standards give valuable information
  - EN 1536: 2000 (bored piles)
  - EN 12063: 1999 (sheet pile walls)
  - EN 12699: 2001 (displacement piles)
  - BS EN 1537: 2000 (ground anchors)
  - BS EN 1538: 2000 (diaphragm walls)

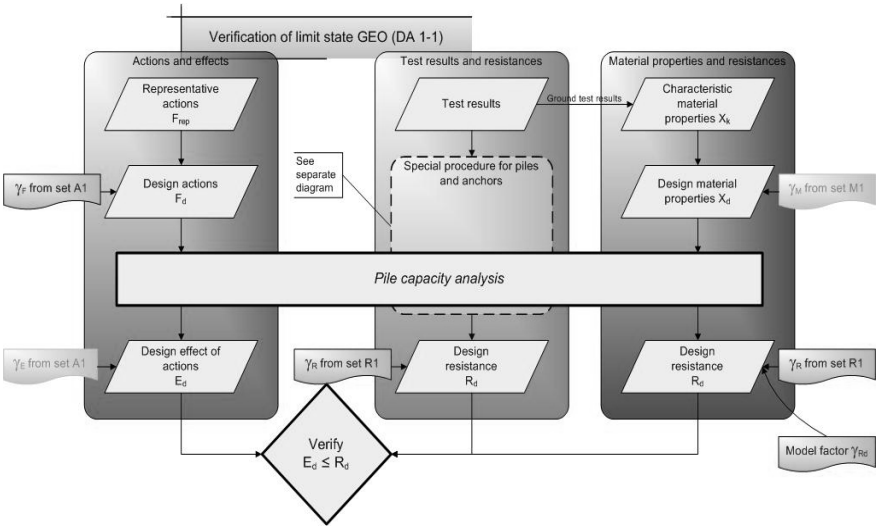


Contents of Section 7

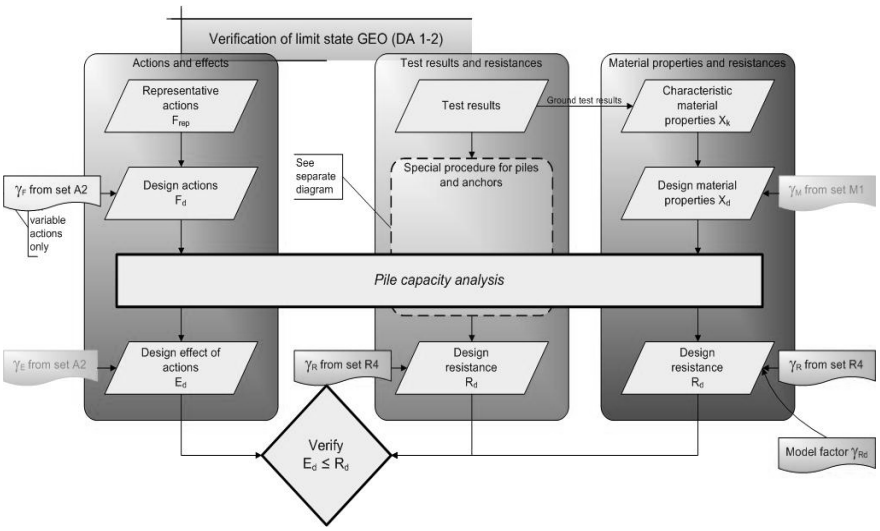
Design methods for pile foundations

Method	Description	Constraints
Calculation	Use empirical or analytical calculation methods or results of dynamic load tests	Validity must be demonstrated by static load tests in comparable situations
Testing	Use results of static load tests, provided consistent with relevant experience	Validity must be demonstrated by calculation or other means
Observation	Use observed performance of comparable pile foundation	Must be supported by results of site investigation and ground testing

Design Approach 1-1 for pile foundations



Design Approach 1-2 for pile foundations

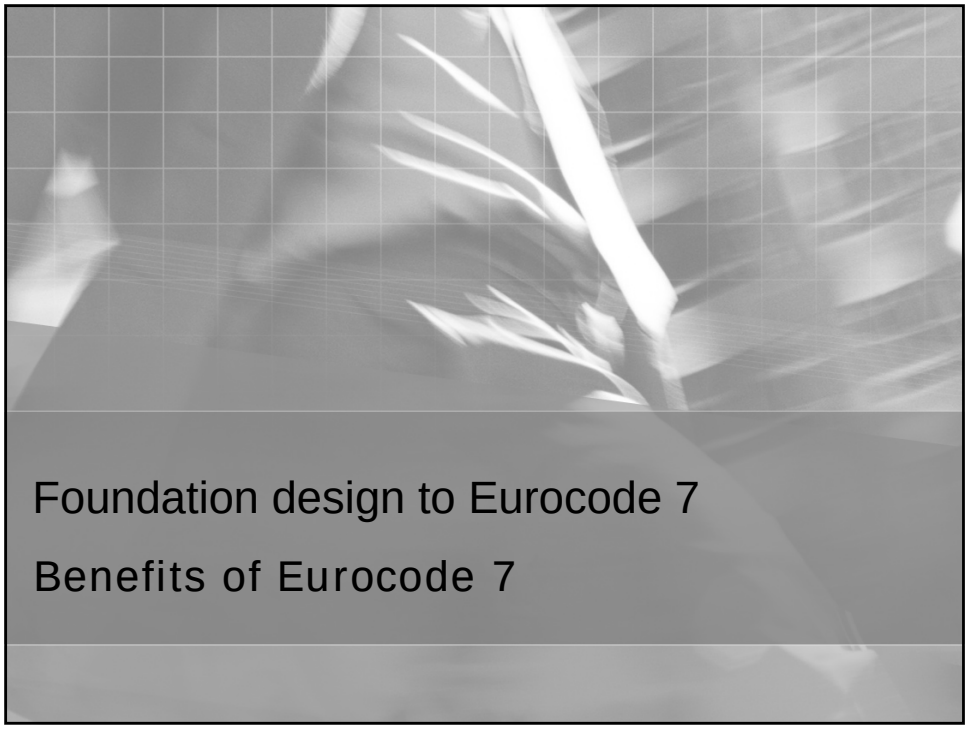


Correlation factors for pile foundations

Static load tests			Ground tests			Dynamic impact tests		
Number	Mean	Min.	Number	Mean	Min.	Number	Mean	Min.
	ξ_1	ξ_2		ξ_3	ξ_4		ξ_5	ξ_6
1	1.4	1.4	1	1.4	1.4	≥ 2	1.6	1.5
2	1.3	1.2	2	1.35	1.27	≥ 5	1.5	1.35
3	1.2	1.05	3	1.33	1.23	≥ 10	1.45	1.3
4	1.1	1.0	4	1.31	1.20	≥ 15	1.42	1.25
≥ 5	1.0	1.0	5	1.29	1.15	≥ 20	1.4	1.25
			7	1.27	1.12			
			10	1.25	1.08			

Supervision, monitoring, and testing

- …installation of all piles [shall be] monitored and records … made as the piles are installed
- The records for each pile should include aspects of construction covered in the relevant execution standards
  - EN 1536: 2000 (bored piles)
  - EN 12063: 1999 (sheet pile walls)
  - EN 12699: 2001 (displacement piles)
  - prEN 14199: 2001 (micro-piles)
    - now published as EN 14199: 2005



More pile load tests?

"…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"

- Reference: David Puller, chief engineer at Bachy Soletanche, Ground Engineering Talking Point (October 2004)

Unified principles for geotechnical design

"[Eurocode 7 Part 1] introduces … important changes in … design practices …:

- for the first time, a unified set of Principles for all geotechnical design
- bridges the philosophical divide between geotechnical design and superstructure design
- clear distinction between … ultimate limit state [and] serviceability limit state
- requires more systematic thought about … uncertainty in … geotechnical material parameters …
- introduces a degree of compulsion by indicating that certain (Principle) activities 'shall' be undertaken"

- Reference: forthcoming CIRIA Report RP701

Impact of Eurocode 7

"…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"

- Reference: National Strategy for Implementation of the Structural Eurocodes: Design Guidance, IStructE (April 2004)

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