2nd generation

Decoding ^ Eurocode 7

Eurocode 7

2nd-generation update

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Decoding 2nd generation Eurocode 7

Eurocode 7 – 2nd-generation update

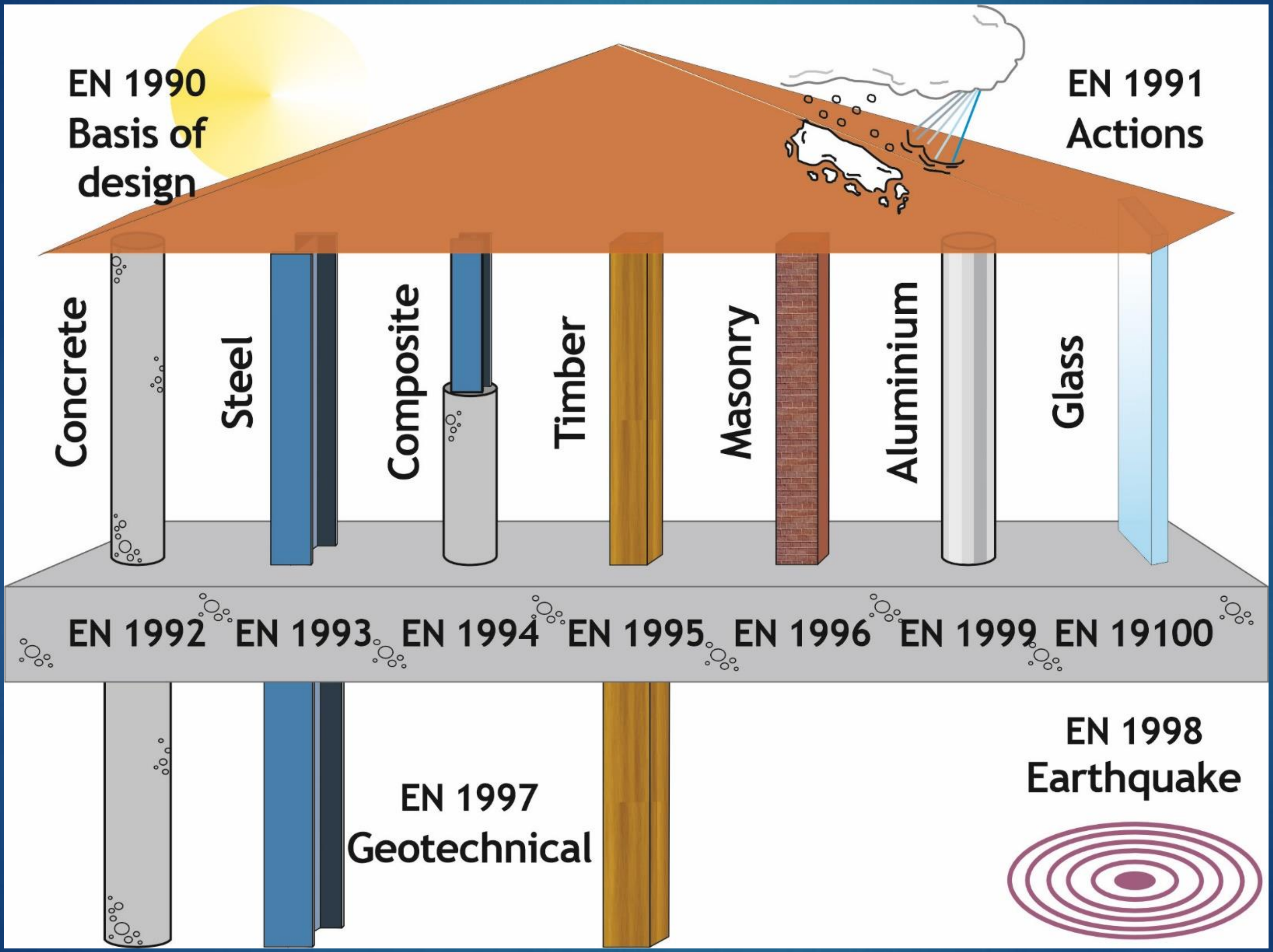
- What and when?
- Key technical changes
- Summary of key points

What and when?

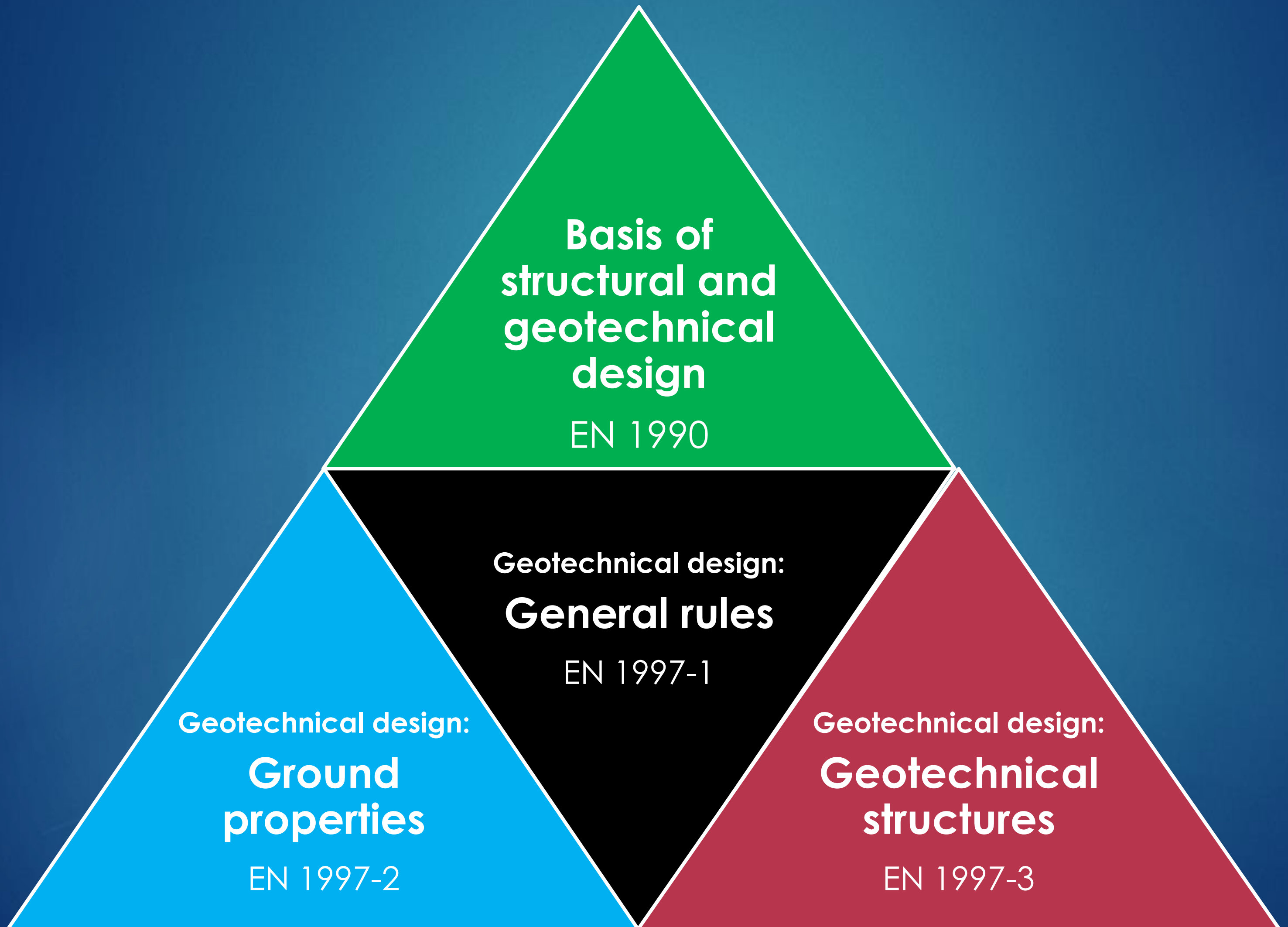
EUROCODE 7

2ND-GENERATION UPDATE

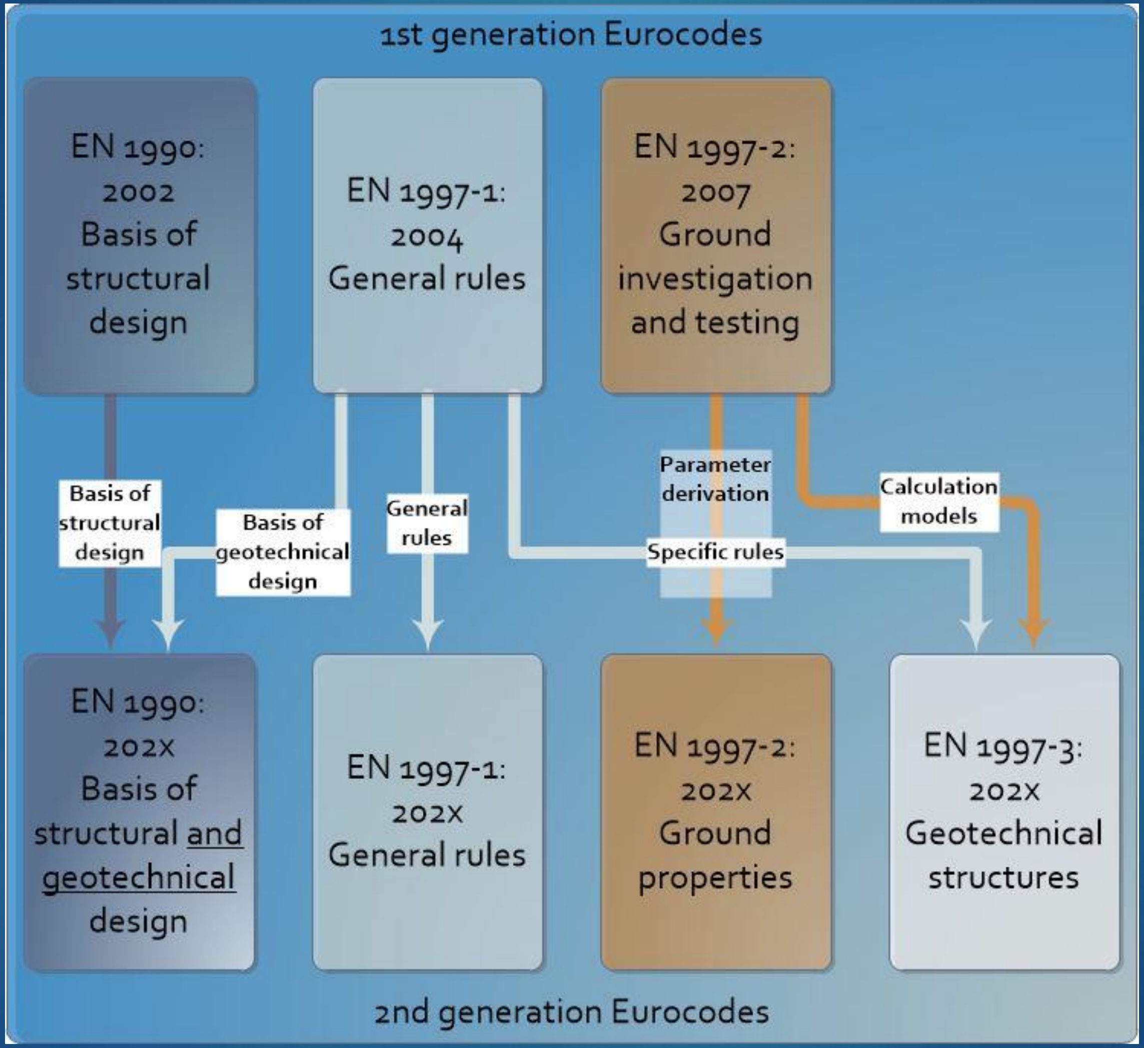
Overview of the 2nd generation Eurocode suite



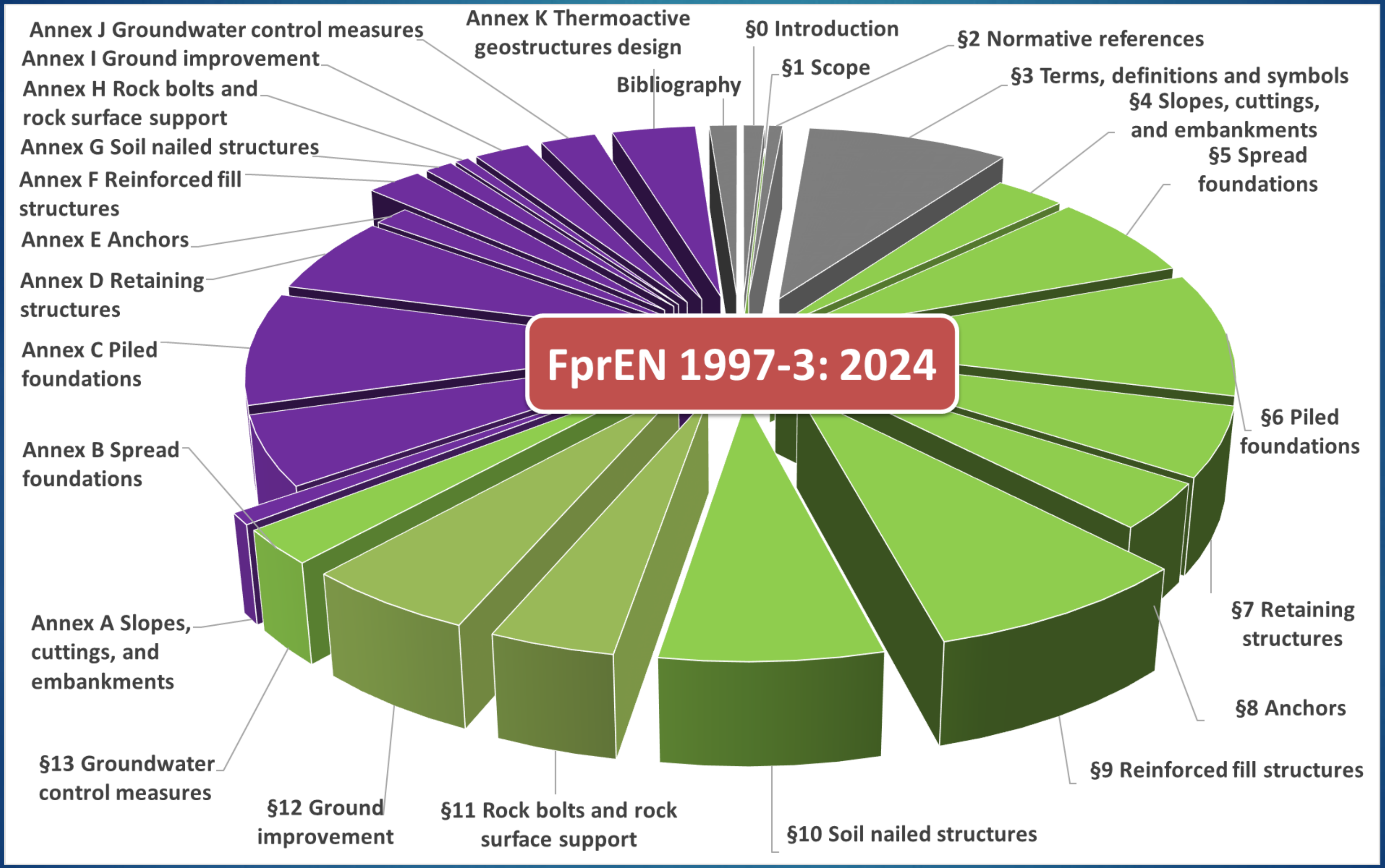
2nd generation Eurocodes
Core geotechnical design standards



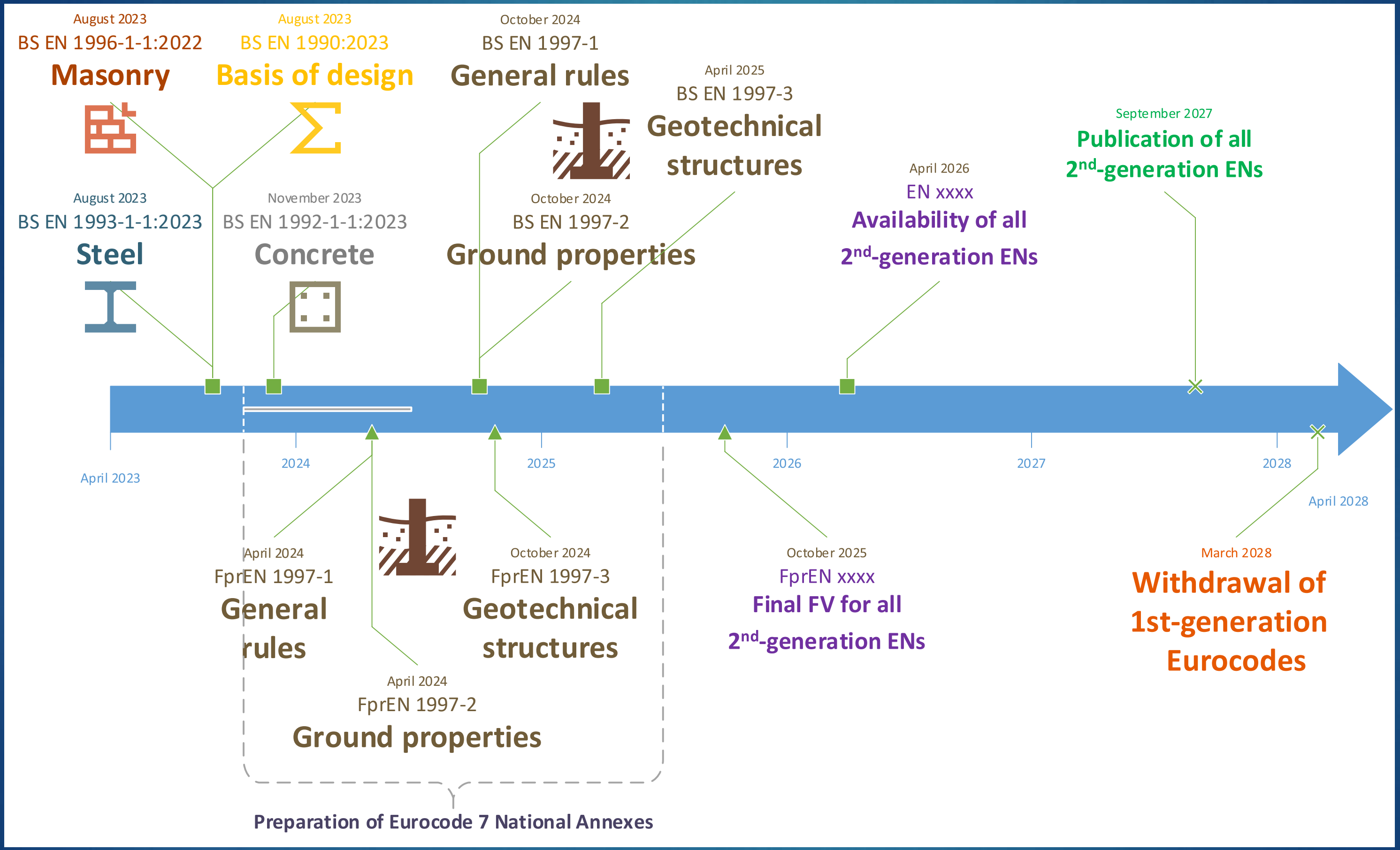
2nd generation – transformation of Eurocode 7 into 3 Parts



Contents of Eurocode 7 Part 3: *Geotechnical structures*



Timeline for the second-generation Eurocodes



Key technical changes in Eurocode 7 from the 1st-generation

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2ND-GENERATION UPDATE

Assumptions made by EN 1997

In addition to the assumptions given in EN 1990, EN 1997 (all parts) assumes:

- **ground investigations** are planned by individuals or organizations **knowledgeable about potential ground and groundwater conditions**

  New

- ground investigations are executed by individuals with appropriate skill and experience
- evaluation of test results and derivation of ground properties from ground investigation are carried out by individuals with **appropriate geotechnical experience and qualifications**

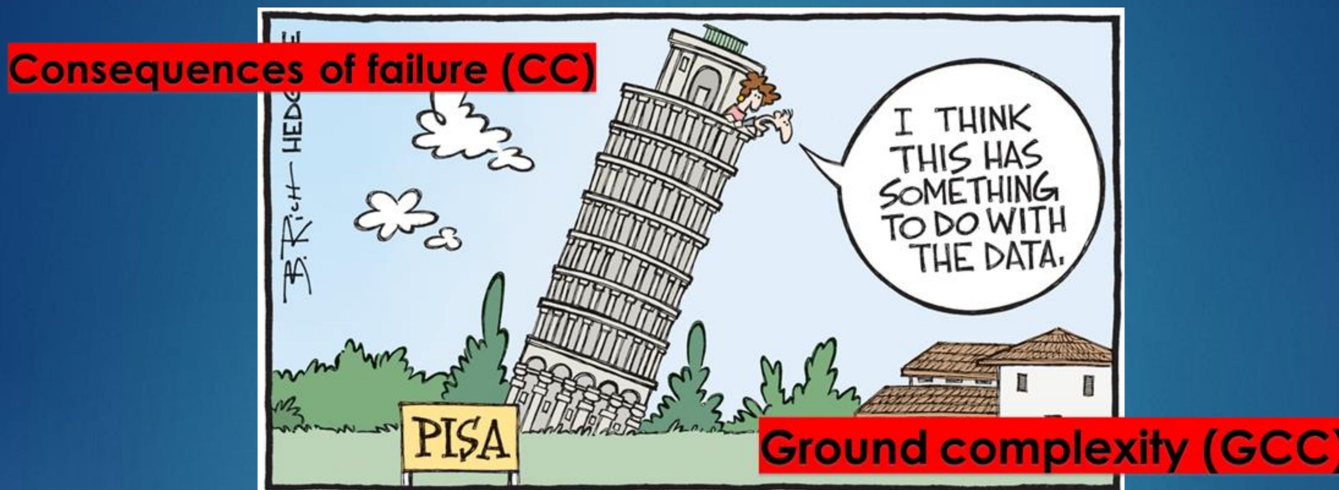
  New

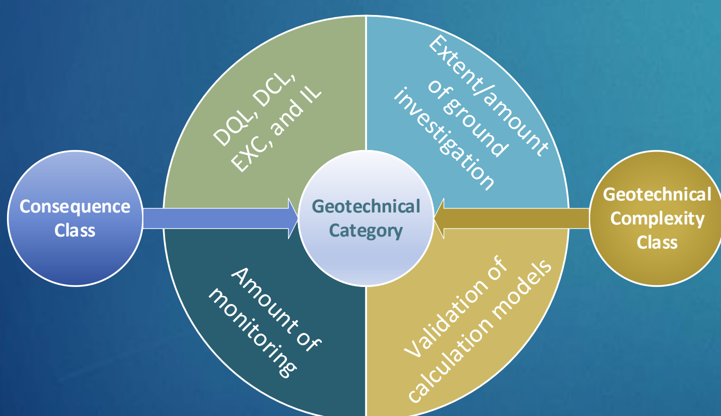
- data required for design are collected, recorded, and interpreted by appropriately qualified and experienced individuals
- geotechnical structures are designed and verified by individuals with **appropriate qualifications and experience in geotechnical design**

  New

- adequate continuity and communication exist between individuals involved in data-collection, design, verification and execution

Revised definition of the Geotechnical Category





Consequence Class	Geotechnical Complexity Class (GCC)		
	Lower (GCC1)	Normal (GCC2)	Higher (GCC3)
CC3			**GC3**
CC2		**GC2**	
CC1	**GC1**		

Consequences of failure

New

New

Consequence class/ Description		Loss of human life*	Economic, social or environ-mental*	Examples of buildings where…	Factor k_F	Reliab-ility index, β_{50}	Prob-ability of failure, $P_{f,50}$
CC4	Highest	Extreme	Huge	Additional provisions can be needed			
CC3	Higher	High	Very great	people assemble e.g. grandstands, concert halls	1.1	4.3	$\sim 10^{-5}$
CC2	Normal	Medium	Consider-able	people normally enter e.g. residential and office buildings	1.0	3.8	$\sim 10^{-4}$
CC1	Lower	Low	Small	people do not normally enter e.g. agricultural buildings, storage buildings	0.9	3.3	$\sim 10^{-3}$
CC0	Lowest	Very low	Insignificant	Alternative provisions may be used			

*CC is chosen based on the more severe of these two columns

Basic requirements of EN 1997-1

The following models shall be used to verify the requirements for safety, serviceability, robustness, and durability of geotechnical structures:

- **Ground Model** ← New
- **Geotechnical Design Model** ← New

Ground Model

- site specific outline of the disposition and character of the ground and groundwater based on results from ground investigations and other available data

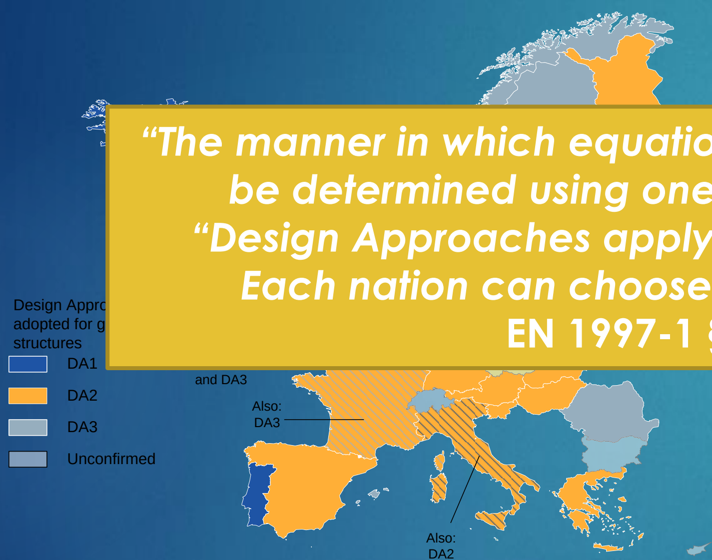
Geotechnical Design Model

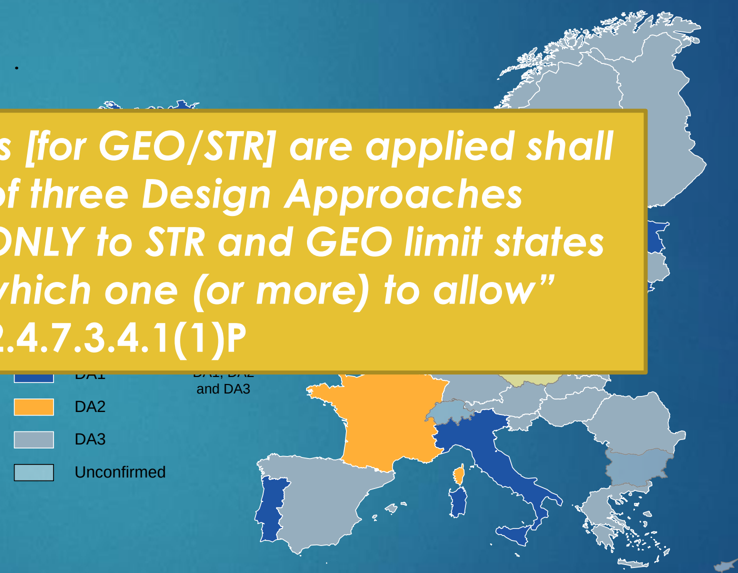
- conceptual representation of the site derived from the ground model for the verification of each appropriate design situation and limit state

Limit states

The following ultimate limit states shall be verified, as relevant:	1st-gen
failure of the structure or the ground, or any part of them including supports and foundations, by • **rupture** • **excessive deformation** • transformation into a mechanism • buckling	STR/GEO **Jargon removed**
loss of static equilibrium of the structure or any part of it	EQU
failure of the ground by **hydraulic heave, internal erosion, or piping** caused **by excessive hydraulic gradient**	HYD
failure caused by fatigue	FAT
failure caused by vibration	
failure caused by other time-dependent effects	

No single Design Approach – even in a country! (Bond and Harris, 2008)





"The manner in which equations [for GEO/STR] are applied shall be determined using one of three Design Approaches

"Design Approaches apply ONLY to STR and GEO limit states Each nation can choose which one (or more) to allow"

EN 1997-1 §2.4.7.3.4.1(1)P

Verification of ultimate limit states

Ultimate limit states must be verified using:

$$E_{\mathrm{d}} \leq R_{\mathrm{d}}$$

For ultimate limit states caused by excessive deformation:

$$E_{\mathrm{d}} \leq C_{\mathrm{d,ULS}}$$

Factor may be applied to **actions**:

Verification Cases 1-3
(Factored actions)

or to **effects of actions**:

Verification Case 4
(Factored effects)

Factors may be applied to **material properties**:

Material factor approach
(MFA)

or to **resistance**:

Resistance factor approach
(RFA)

Partial factors for fundamental design situations (general application)

Action or effect				Partial factors γ_F and γ_E for Verification Cases 1-4				
Type	Group	Symbol	Resulting effect	Struct-ural*	Static equilibrium and uplift**		Geotechnical design	
				VC1	VC2(a)	VC2(b)	VC3	VC4
Permanent action (G_k)	All	γ_G	unfavourable/ destabilizing	**On actions**				G_k is not factored
	Water	$\gamma_{G,w}$						
	All	$\gamma_{G,stb}$	stabilizing					
	Water	$\gamma_{Gw,stb}$						
	(All)	$\gamma_{G,fav}$	favourable					
Prestressing (P_k)		γ_P						**On effects**
Variable action (Q_k)	All	γ_Q	unfavourable					
	Water	γ_{Qw}						
	(All)	$\gamma_{Q,fav}$	favourable					
Effects-of-actions (E)		γ_E	unfavourable	γ_E is not applied				
		$\gamma_{E,fav}$	favourable					

*Also used for geotechnical design; **Less favourable outcome of (a) and (b) applies
Values taken from prEN 1990:2022, Annex A.1

Partial factors for fundamental design situations (ground properties)

<table>
<tr><th>Ground property</th><th>Symbol</th><th>M1</th><th>M2</th></tr>
<tr><td colspan="4">Soil</td></tr>
<tr><td>Shear strength in effective stress analysis (τ_f)</td><td>$\gamma_{\tau f}$</td><td rowspan="6">1.0</td><td rowspan="3">1.25 k_M</td></tr>
<tr><td>Coefficient of peak friction (tan φ'_p)</td><td>$\gamma_{\tan\varphi,p}$</td></tr>
<tr><td>Peak effective cohesion (c'_p)</td><td>$\gamma_{c,p}$</td></tr>
<tr><td>Coefficient of friction at critical state (tan φ'_{cs})</td><td>$\gamma_{\tan\varphi,cs}$</td><td rowspan="2">1.1 k_M</td></tr>
<tr><td>Coefficient of residual friction (tan φ'_r)</td><td>$\gamma_{\tan\varphi,r}$</td></tr>
<tr><td>Shear strength in total stress analysis (c_u)</td><td>γ_{cu}</td><td>1.4 k_M</td></tr>
<tr><td colspan="4">Rock</td></tr>
<tr><td>Unconfined compressive strength (q_u)</td><td>γ_{qu}</td><td colspan="2">Same as γ_{cu}</td></tr>
<tr><td>Shear strength of rock (τ_r)</td><td>$\gamma_{\tau r}$</td><td rowspan="2">1.0</td><td>1.25 k_M</td></tr>
<tr><td>Unconfined compressive strength of rock (q_u)</td><td>γ_{qu}</td><td>1.4 k_M</td></tr>
<tr><td colspan="4">Discontinuities</td></tr>
<tr><td>Shear strength of rock discontinuities (τ_{dis})</td><td>$\gamma_{\tau dis}$</td><td rowspan="2">1.0</td><td>1.25 k_M</td></tr>
<tr><td>Coefficient of residual friction (tan $\varphi'_{dis,r}$)</td><td>$\gamma_{\tan\varphi,dis,r}$</td><td>1.1 k_M</td></tr>
</table>

Summary of key points

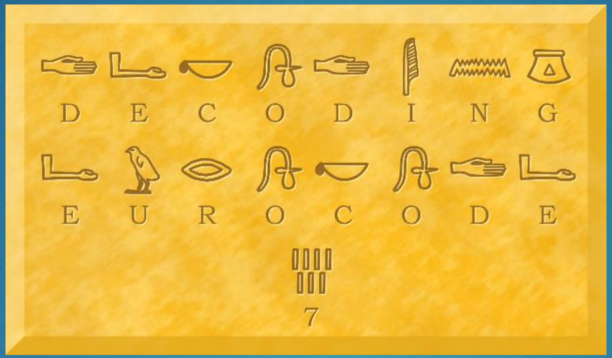
EUROCODE 7

2ND-GENERATION UPDATE

Improvements in 2nd generation … EN 1997 *Geotechnical design*

- Organizational changes to Eurocode 7
  - Clearer layout aids ease-of-navigation
  - Greater consistency with EN 1990 aids ease-of-use
- No more Design Approaches!
  - Simpler choice of partial factors
  - Material Factor or Resistance Factor Approach
- Catering for different groundwater conditions
  - Better specification of groundwater pressures
- Separating consequence from hazard
  - Clear distinction between consequence of failure and complexity of the ground
  - Geotechnical Categories now drive meaningful decisions

Decoding 2nd generation Eurocodes
www.geocentrix.co.uk/training



Our **2nd generation** courses include …

- Decoding Eurocode 7 –
  - Basis of geotechnical design
  - Ground properties (and ground investigation)
  - Shallow foundations
  - Deep foundations
- Decoding Eurocode 3 – Steel foundations

References

Steve Denton, David Nethercot, Andrew Bond, and Mariapia Angelino (2024), *Eurocodes evolution: latest developments and UK approach*, The Structural Engineer, Volume 102, Issue 3, pp12-14

Bond (2023), *Technical note: Timeline and improvements for the second generation of Eurocodes*, Ground Engineering, 14th November 2023 (http://tinyurl.com/y73ypban)

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