2nd generation

Decoding ^ Eurocode 7

Preparing for the 2nd generation Eurocodes

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Decoding 2nd generation Eurocode 7

Preparing for the 2nd generation Eurocodes

- The 2nd generation Eurocodes
- Key technical changes in EN 1990
- Timetable for adoption
- Summary of key points

The 2nd generation of Eurocodes

PREPARING FOR THE 2ND GENERATION EUROCODES

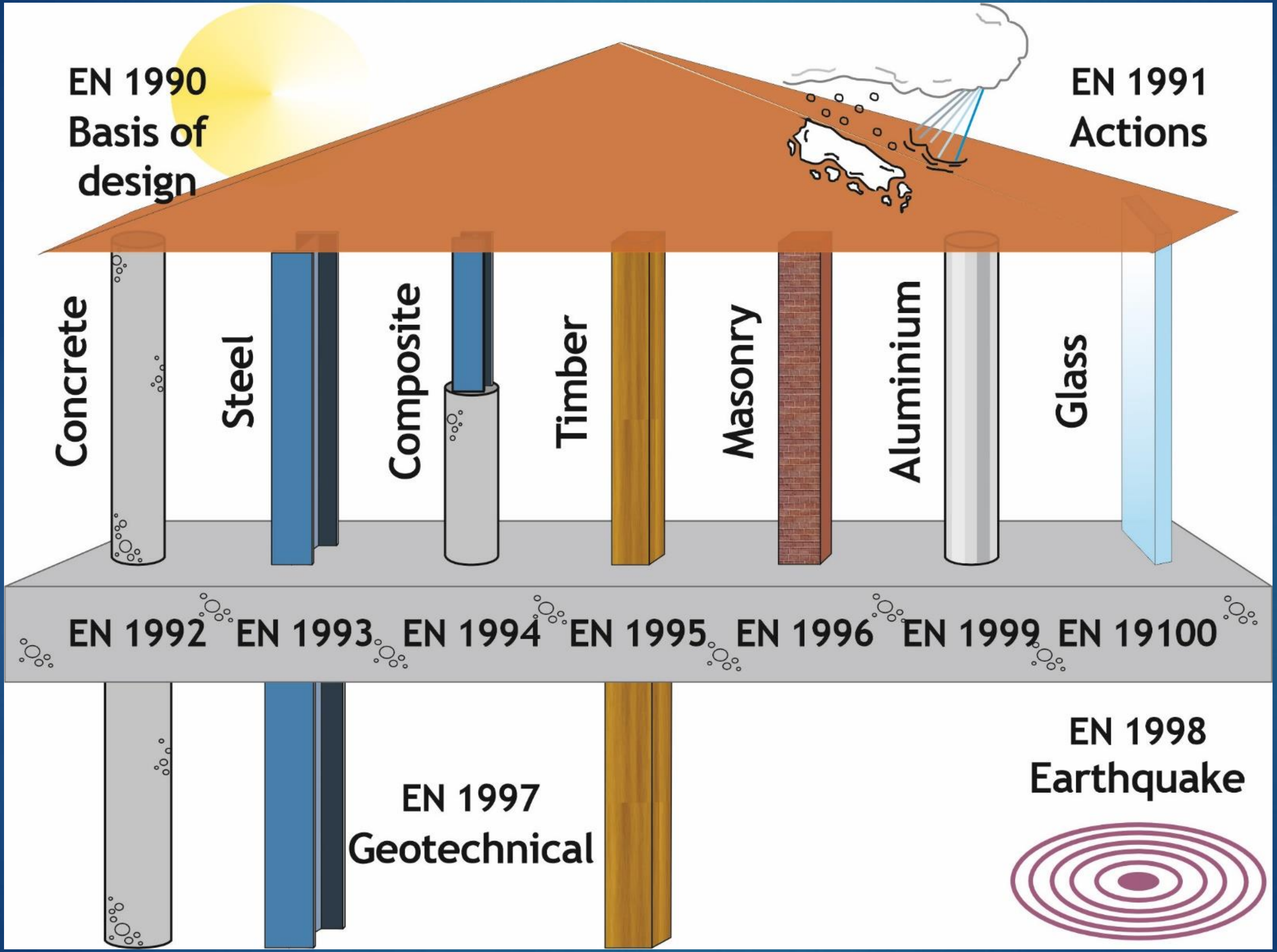
Target audience for the 2nd generation Eurocodes

- In Europe – and in many other countries of the world – **structural and geotechnical design is governed by the EN Eurocodes**
- The 1st generation of EN Eurocodes was published between 2002 and 2007 and are still current
- **The 2nd generation Eurocodes will be published in the mid 2020s**

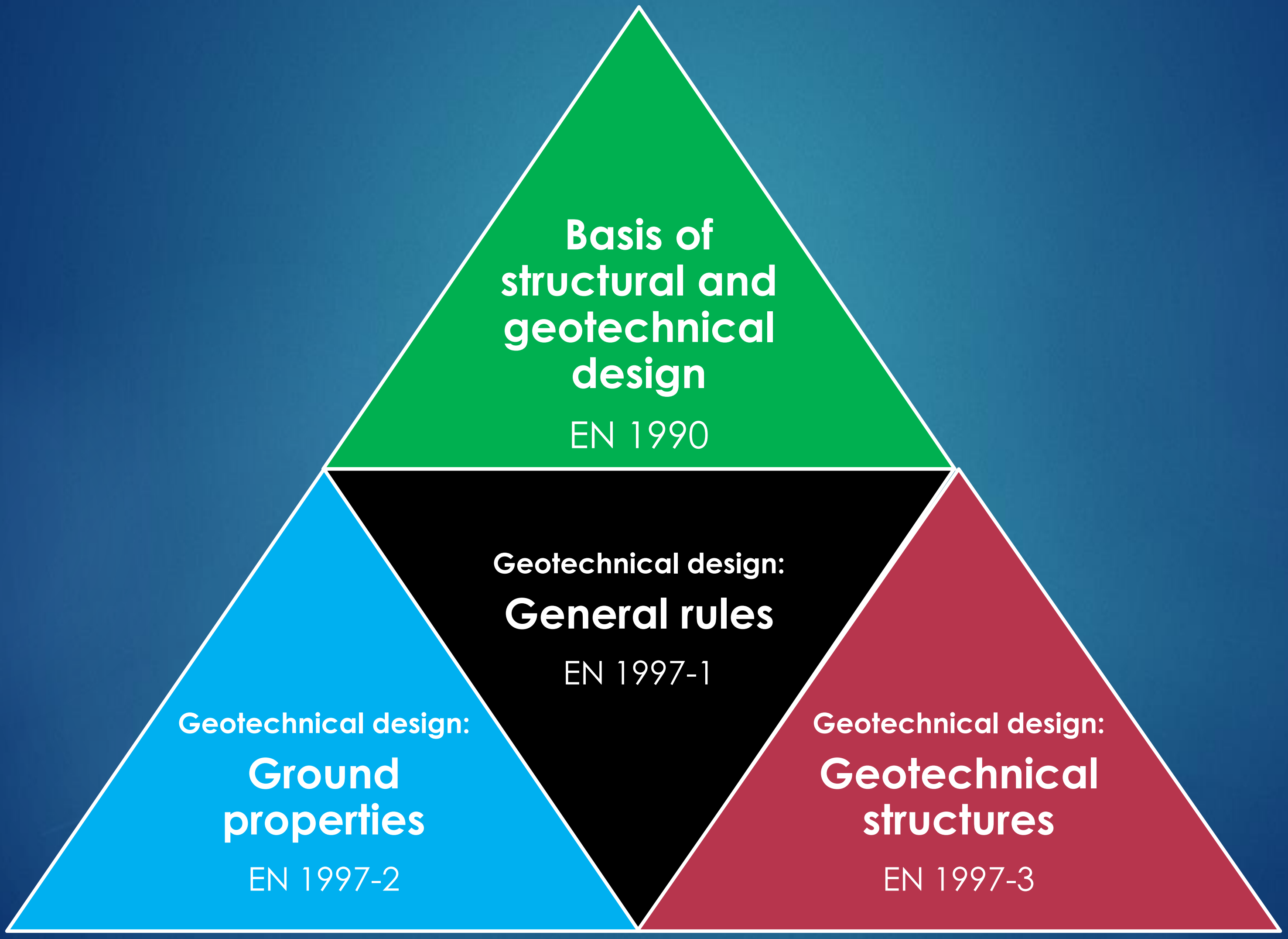
*The Eurocodes are intended for use by **designers, clients, manufacturers, constructors, relevant authorities** (in exercising their duties in accordance with national or international regulations), **educators, software developers**, and committees drafting standards for related product, testing and execution standards.*

Introduction to the Eurocodes (2nd generation)

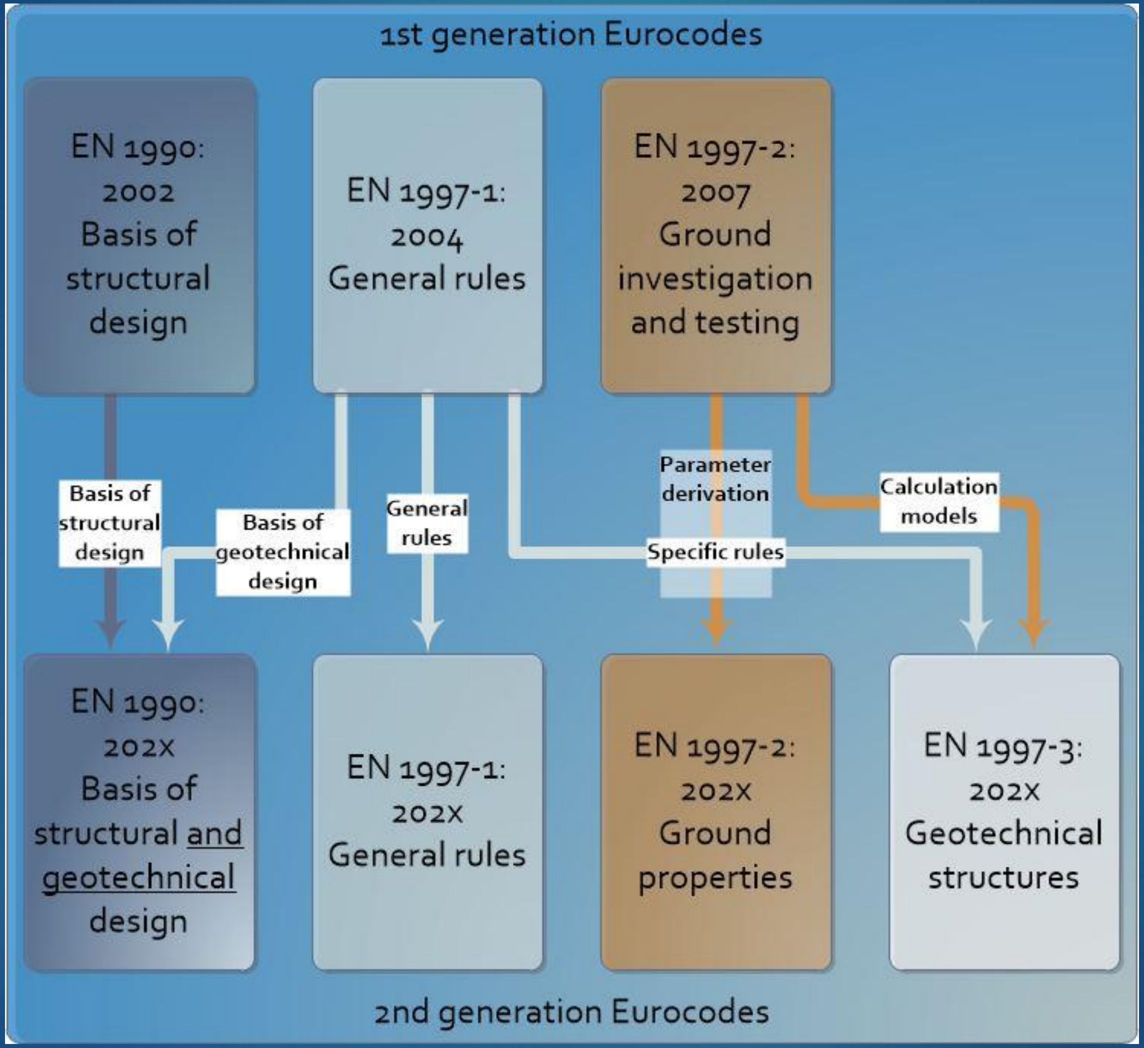
Overview of the 2nd generation Eurocode suite



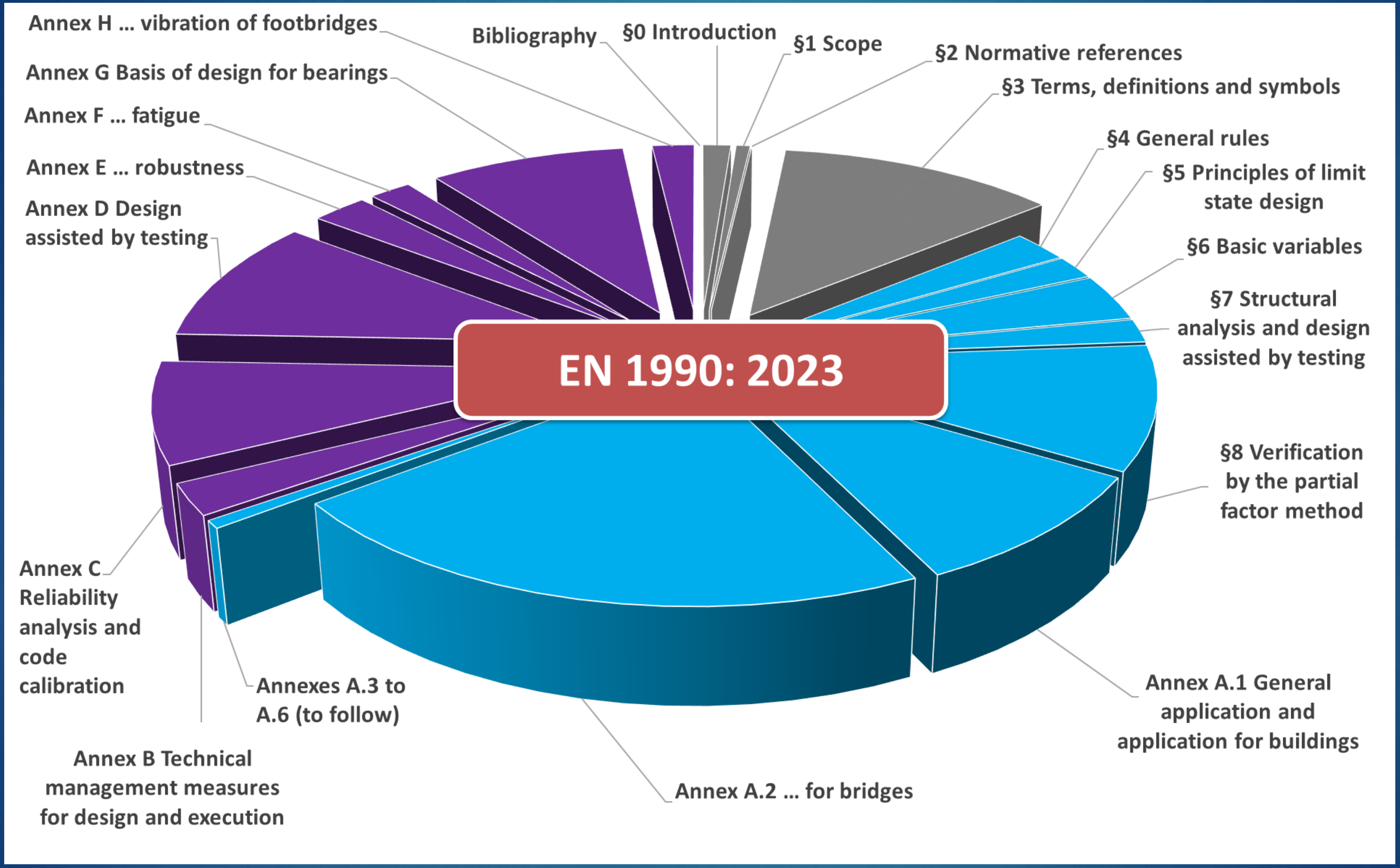
2nd generation Eurocodes
Core geotechnical design standards



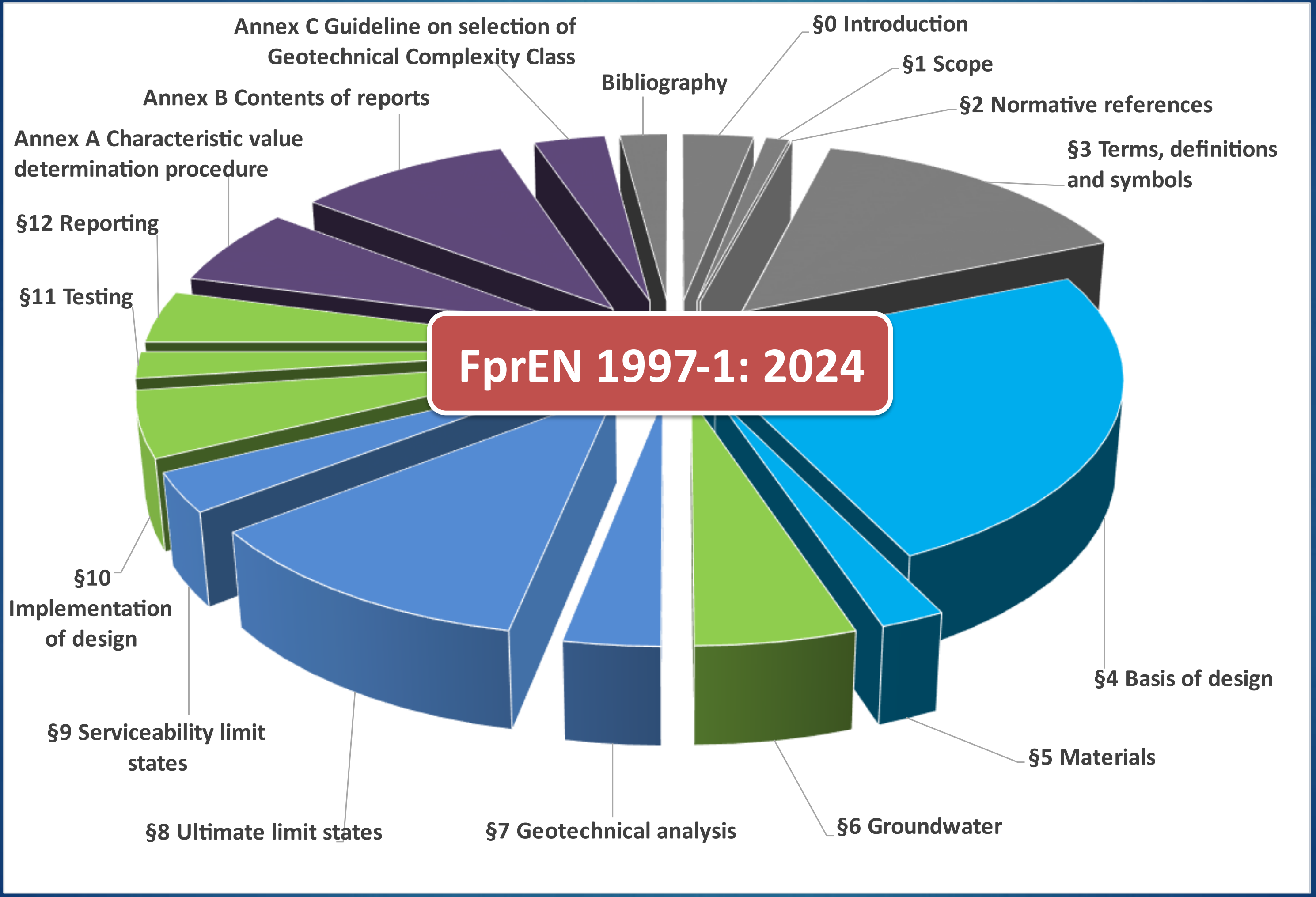
2nd generation – transformation of Eurocode 7 into 3 Parts



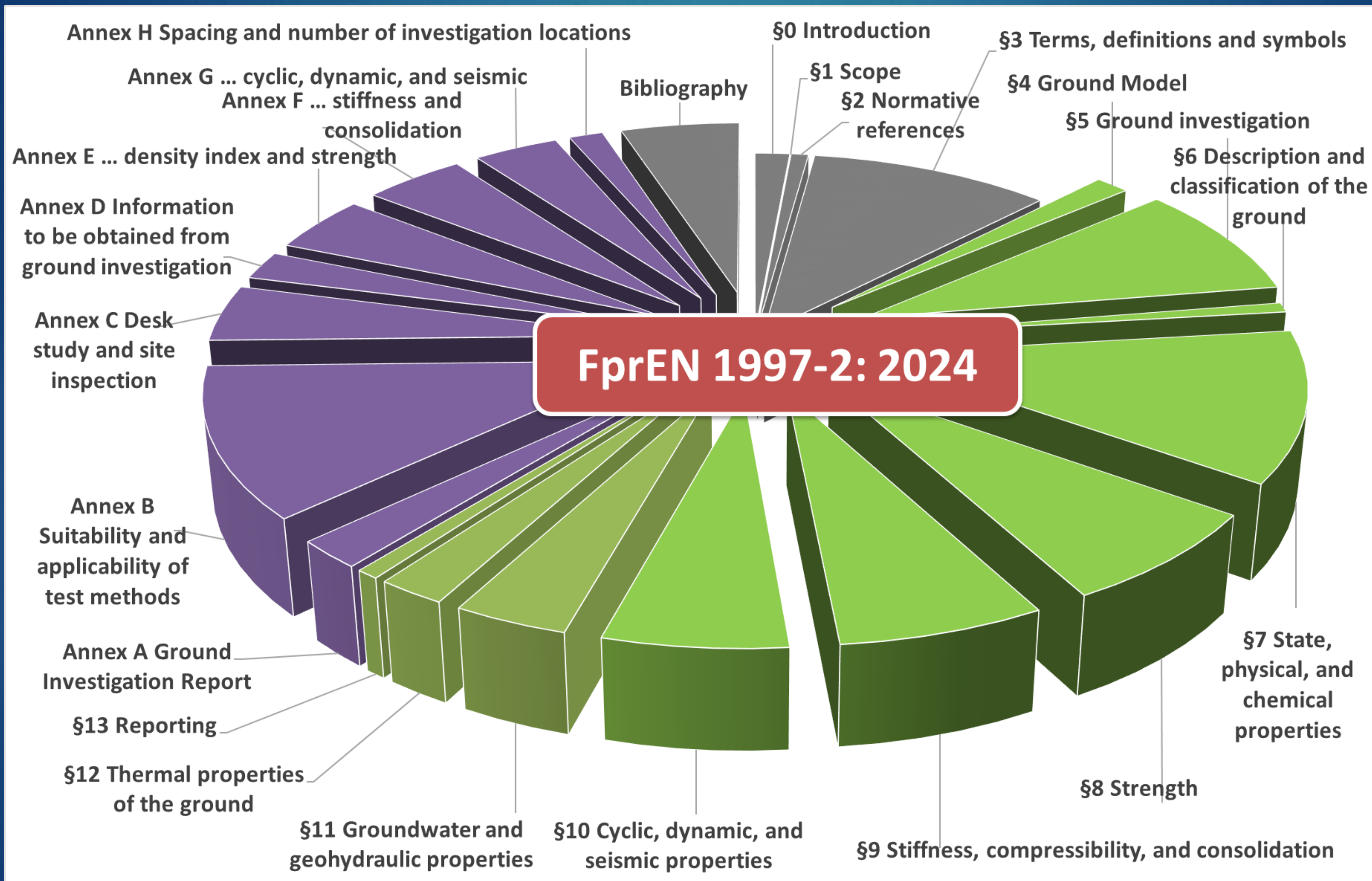
Eurocode: Basis of structural and geotechnical design



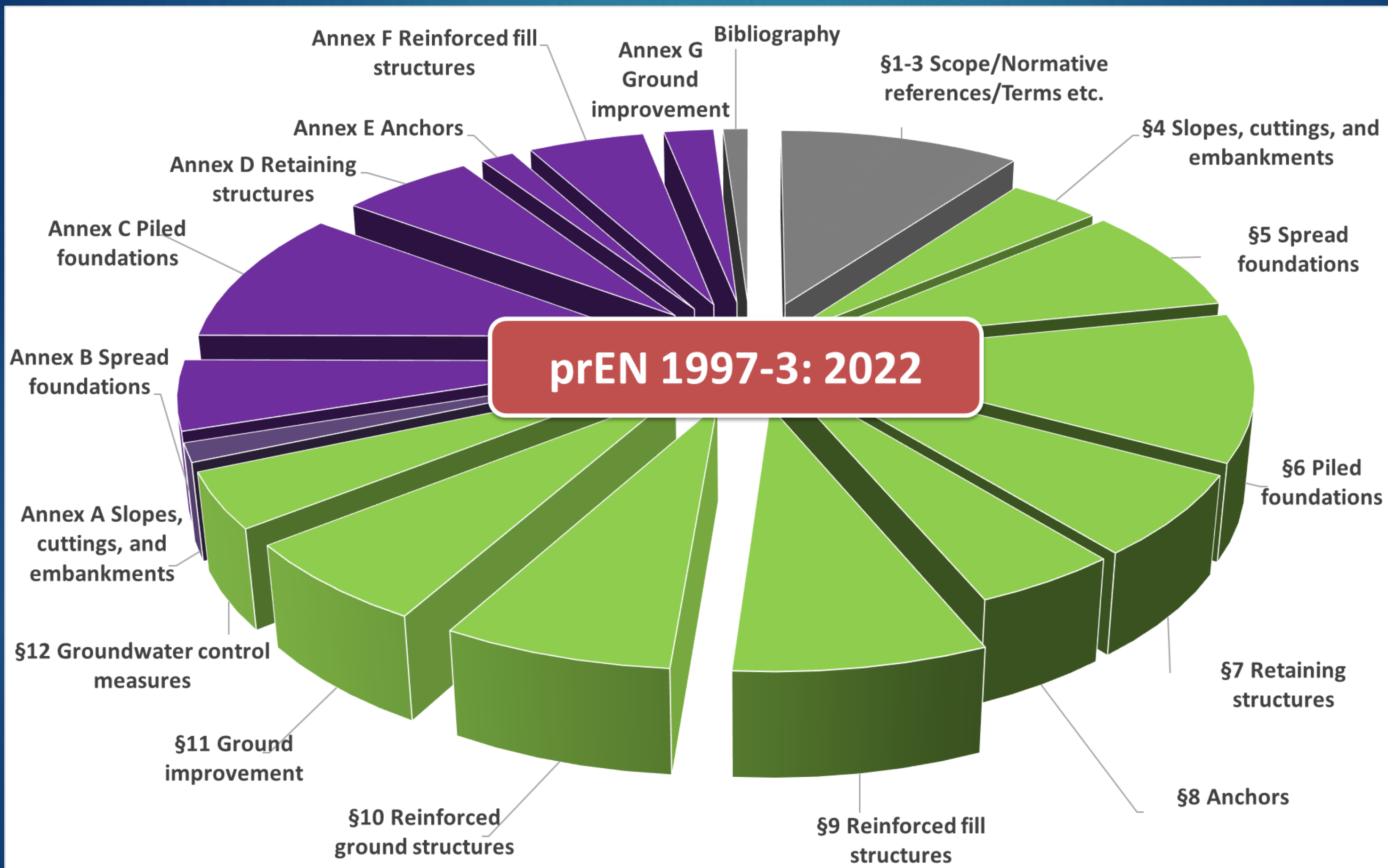
Eurocode 7 – Geotechnical design – Part 1: General rules



Eurocode 7 – Geotechnical design – Part 2: Ground properties



Eurocode 7 – Geotechnical design – Part 3: Geotechnical structures



Changes planned following latest public enquiries

EN 1990 *Basis of structural and geotechnical design* to be sub-divided into:

- **Part 1 – New structures (EN 1990-1)**
- **Part 2 – Assessment of existing structures (EN 1990-2)**

Clause 10 of prEN 1997-3 *Geotechnical structures* "Reinforced ground structures" to be divided into:

- Soil nailed structures (Clause 10)
- Rock bolts and surface support (Clause 11)
- (later clause numbers to be bumped by 1)

Key technical changes in EN 1990

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Limit states

The following ultimate limit states shall be verified, as relevant:	EN 1990:2002
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
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	

Jargon removed

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:

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

For ultimate limit states caused by excessive deformation:

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

Factor may be applied to **actions**:

Verification Cases 1-3
(Factored actions)

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

Material factor approach
(MFA)

or to **effects of actions**:

Verification Case 4
(Factored effects)

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" align="center">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" align="center">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" align="center">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>

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							

Technical management measures

Consequence class (CC)	Design qualification & experience level* (DQL)	Design check level* (DCL)	Execution class (EXC)	Inspection level* (IL)
CC3 Higher	DQL3 Complex design	DCL3 Extended independent	See relevant execution standards	IL3 Extended independent
CC2 Normal	DQL2 Advanced design	DCL2 Normal independent		IL2 Normal independent
CC1 Lower	DQL1 Simple design	DCL1 Self-checking		IL1 Self-checking

*Defined nationally
Additional project-specific requirements may be as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties

Timetable for adoption

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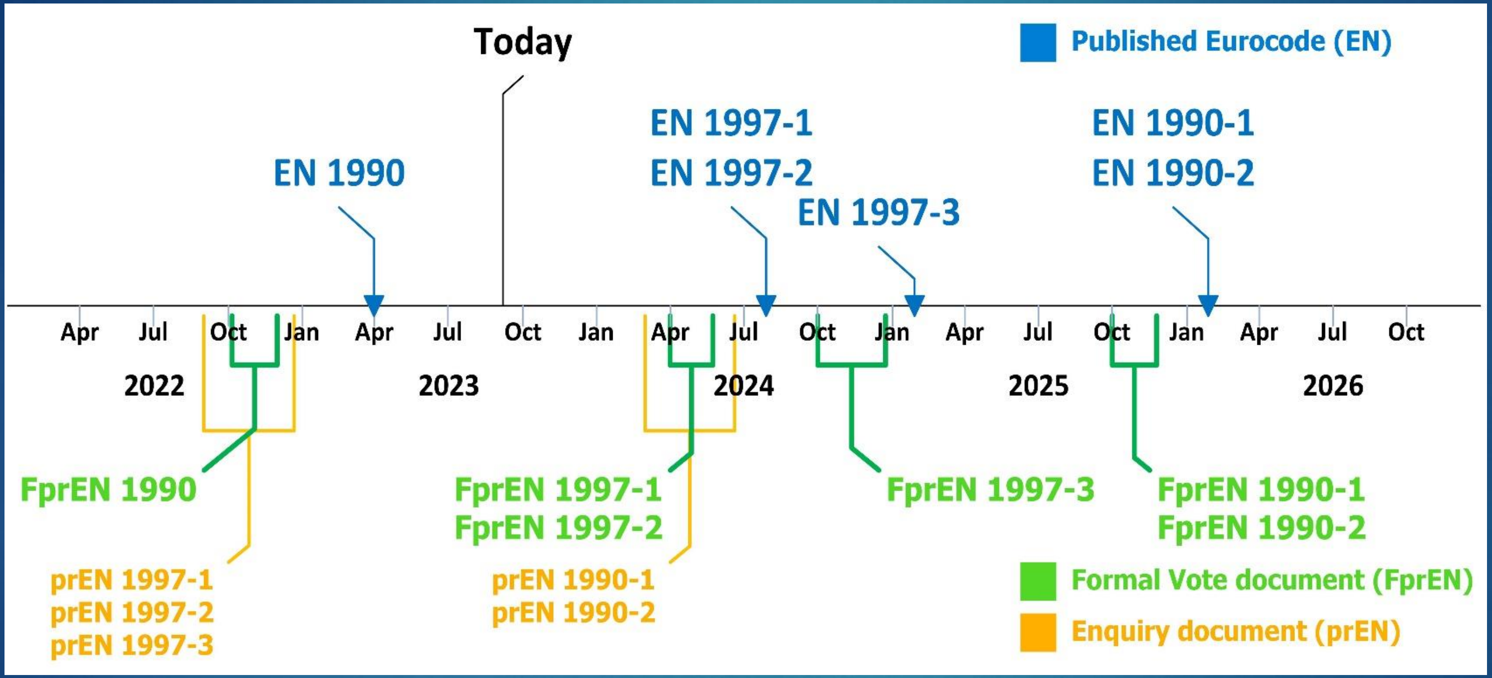
Timeline (as of September 2023)



Summary of key points

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Improvements in 2nd generation … EN 1990 *Basis of … design*

- Simplification of EQU, STR, and GEO
  - Improves treatment of combined ultimate limit states
- Catering for non-linearity and coupling
  - Incorporates basis of geotechnical design into EN 1990
  - Better treatment of non-linear structural design
- Verification Cases (VCs 1-4)
  - Simple packaging of complicated loading conditions
- Simpler presentation of combinations of actions
  - Greater clarity in the text
- Water actions
  - Clear specification of probabilities of exceedance
- Management measures to achieve the intended structural reliability
  - Flexible system that caters for national preferences

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

2nd generation

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