*2nd generation*

# Decoding ^ Eurocode 7

# Eurocode 7 2nd-generation update


DR ANDREW BOND (GEOCENTRIX)

CHAIR B/526 GEOTECHNICS

PAST-CHAIR TC250/SC7 GEOTECHNICAL DESIGN

## Eurocode 7 – 2nd-generation update



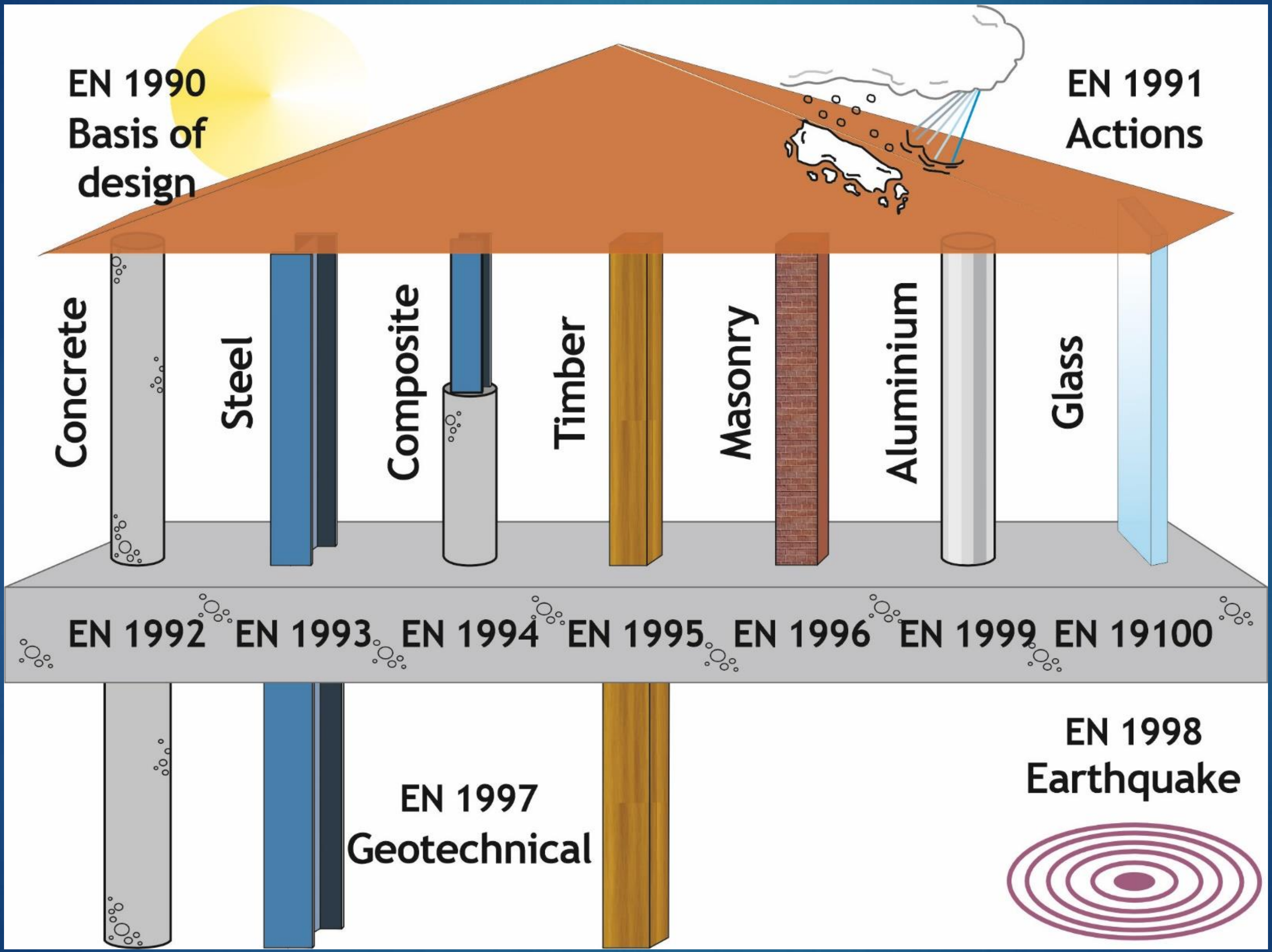
- What and when?
- Key technical changes
- Summary of key points

# What and when?

## EUROCODE 7
## 2ND-GENERATION UPDATE

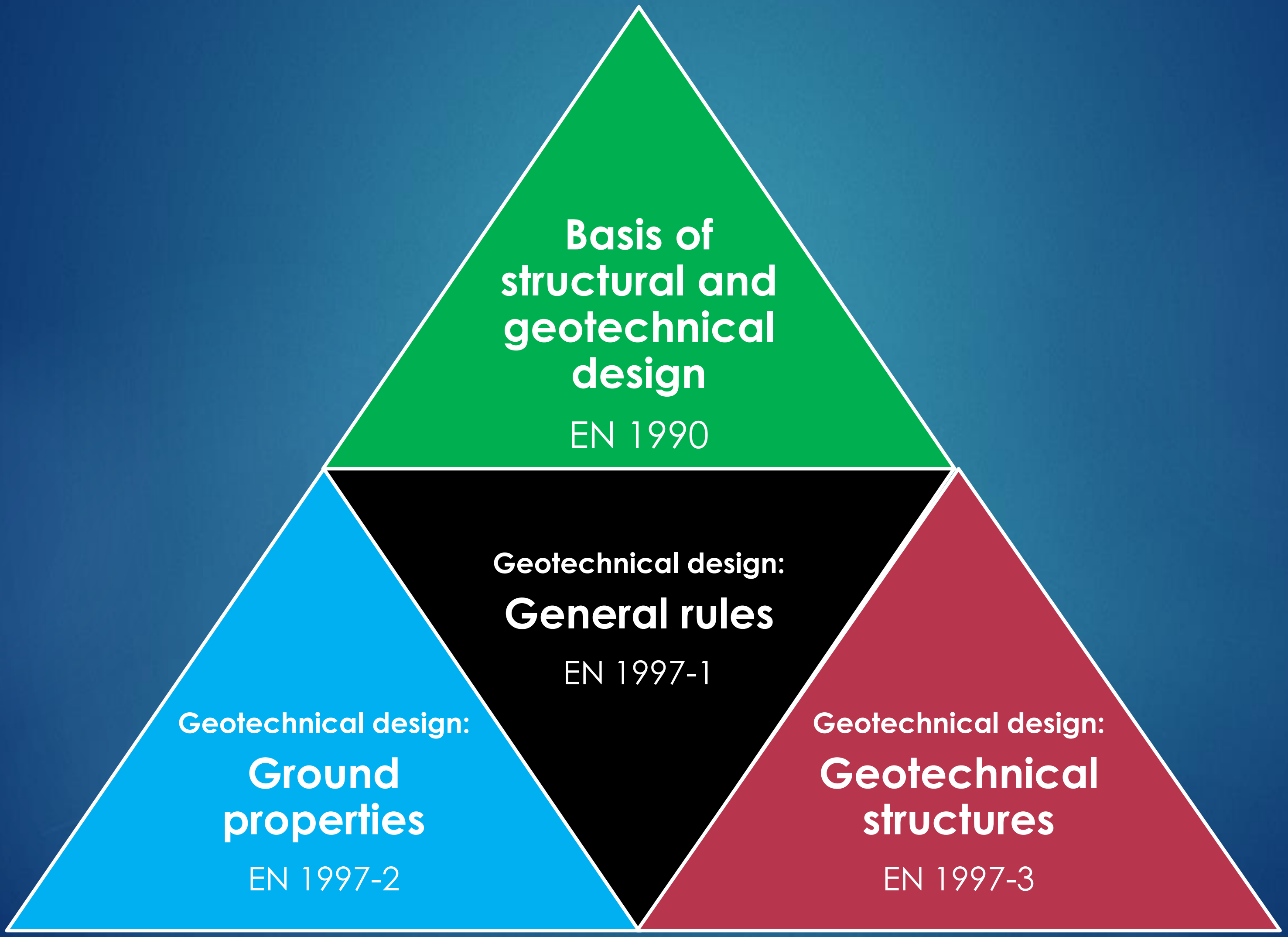
# Overview of the 2nd generation Eurocode suite





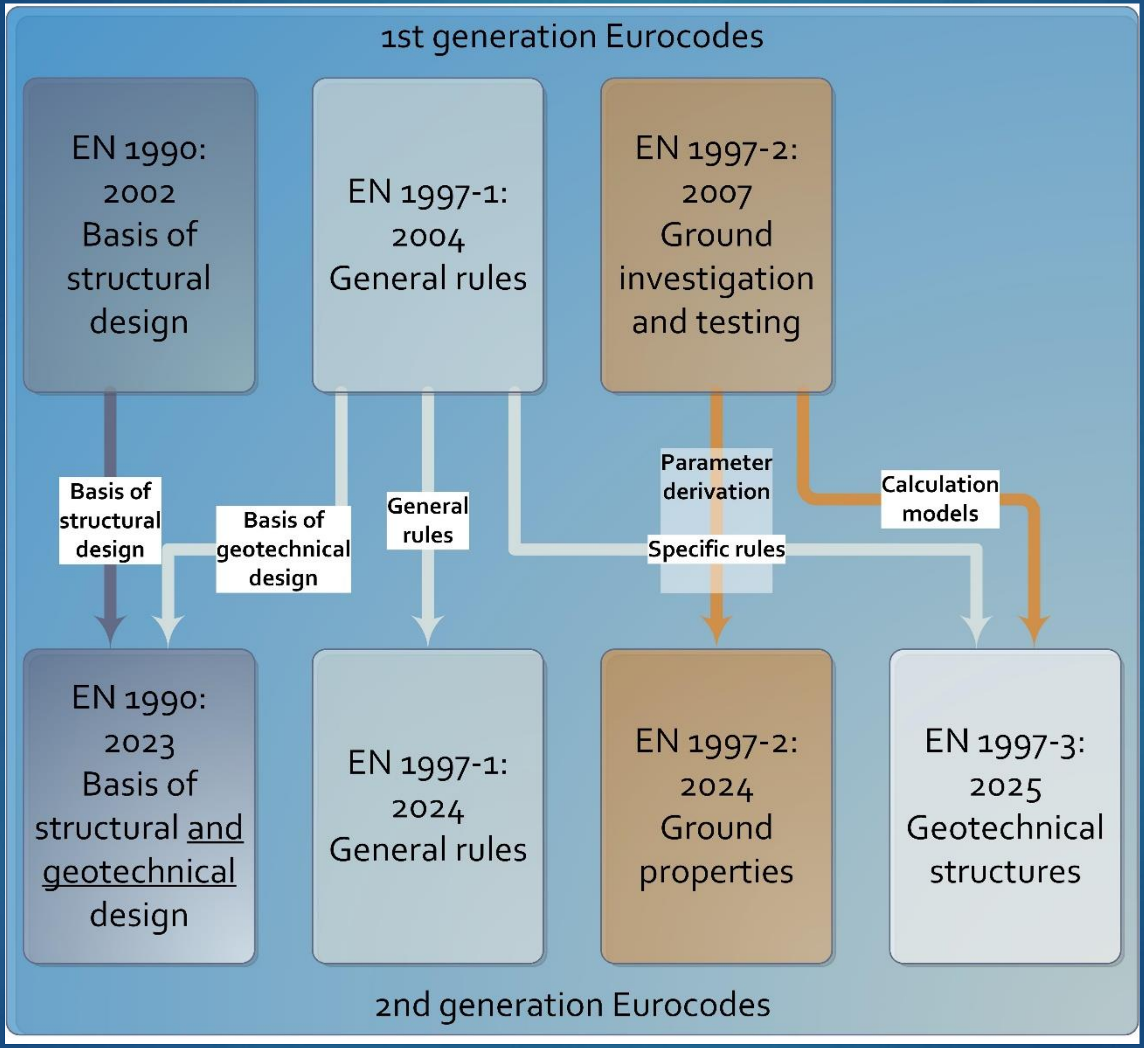
# 2nd generation Eurocodes
# Core geotechnical design standards





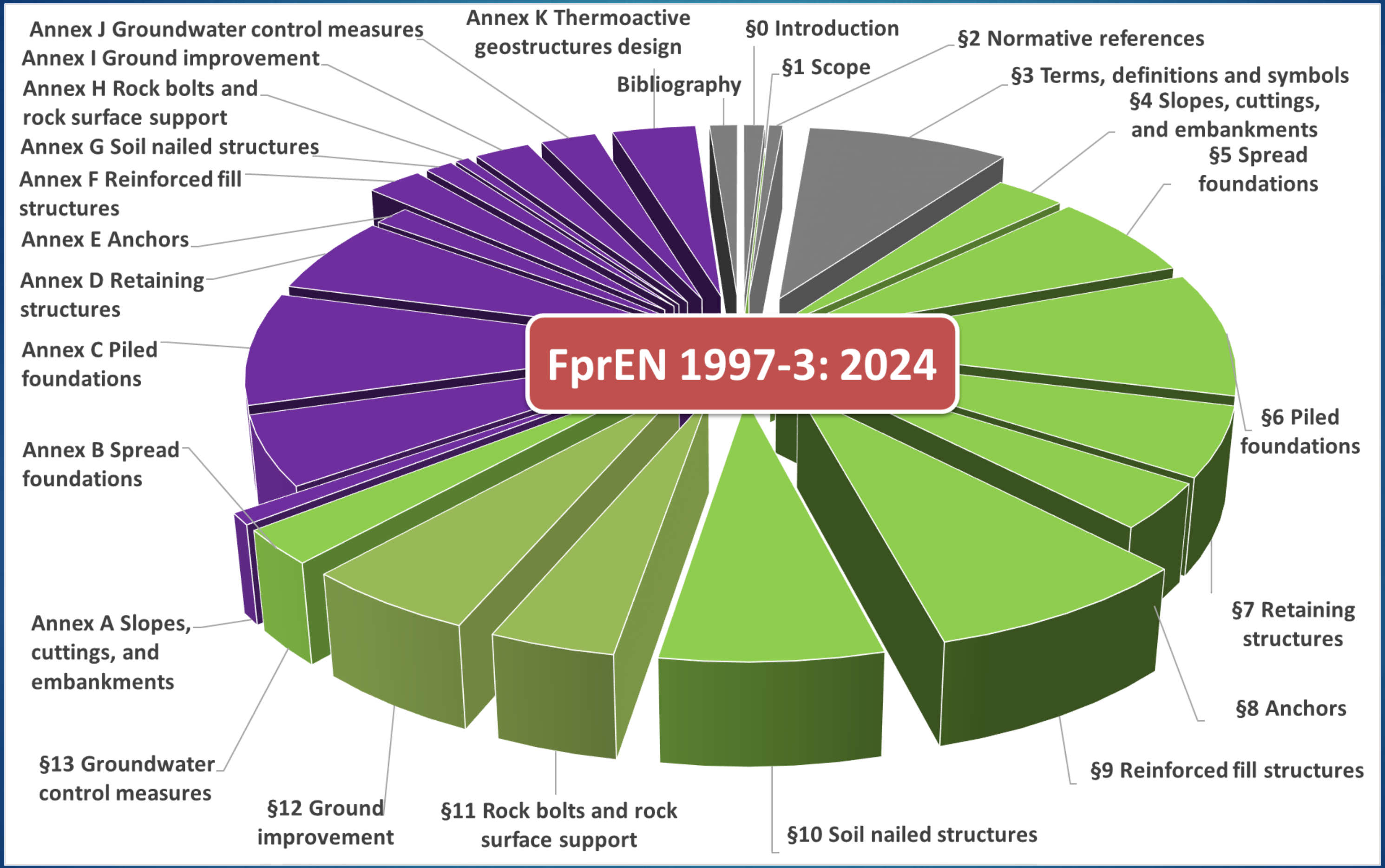
# 2nd generation – transformation of Eurocode 7 into 3 Parts





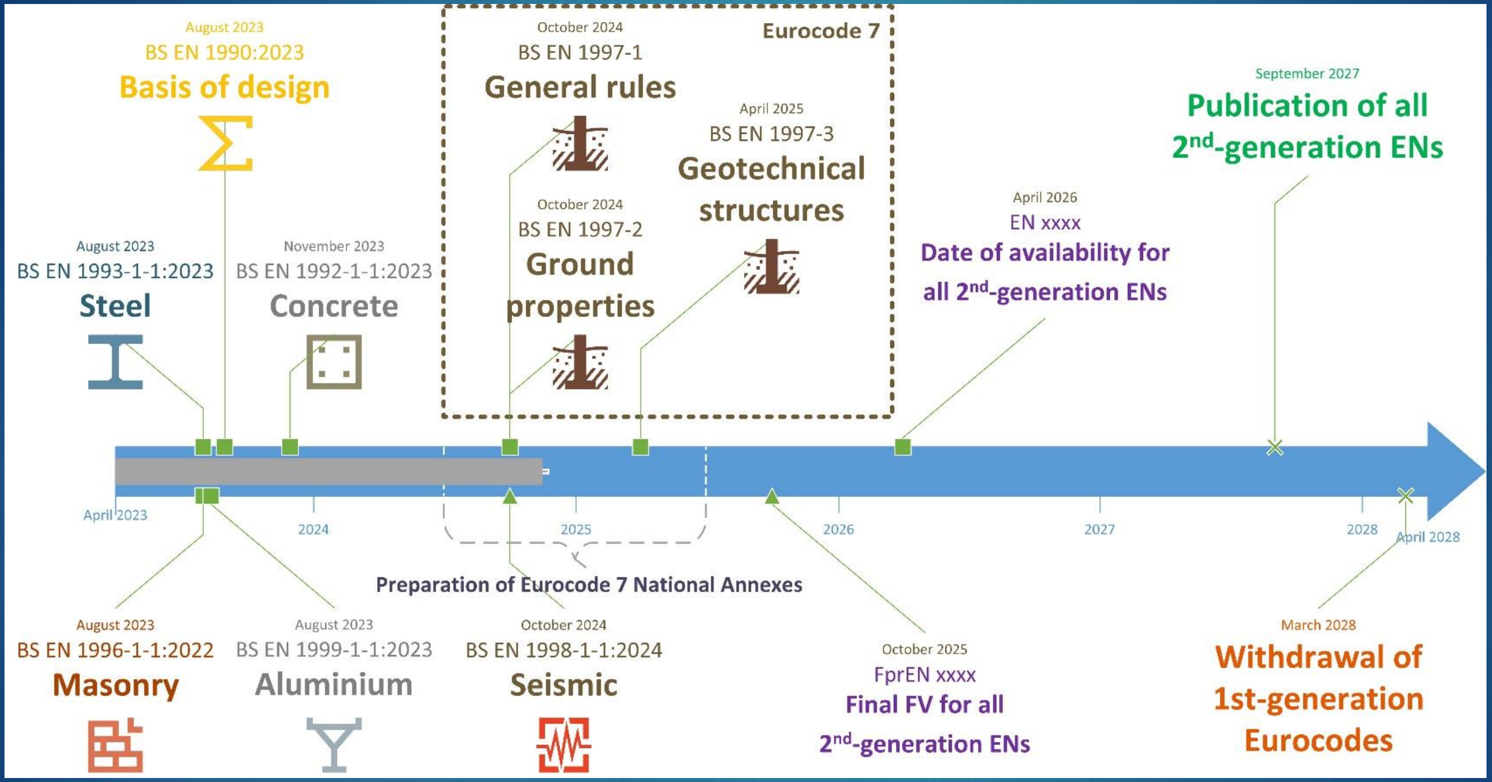
# Contents of Eurocode 7 Part 3: *Geotechnical structures*





# Timeline for the second-generation Eurocodes





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

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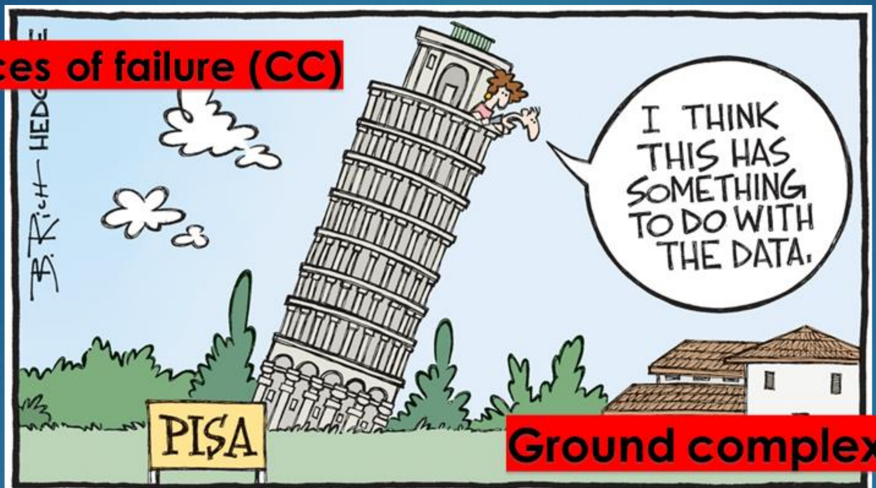
# Assumptions made by EN 1997

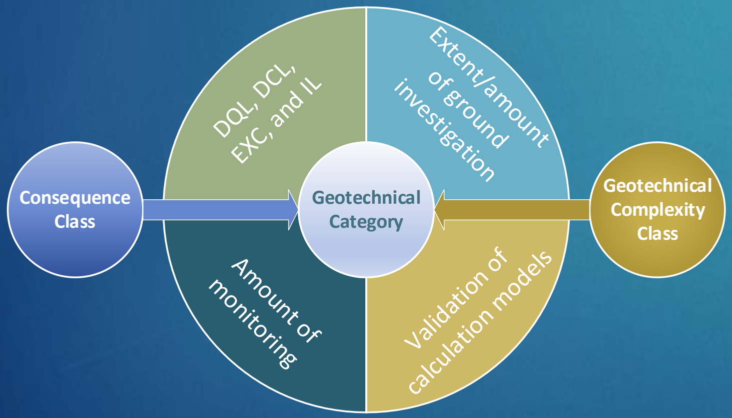
In addition to the assumptions given in EN 1990, EN 1997 (all parts) assumes:

- **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, $\beta_{50}$ | 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

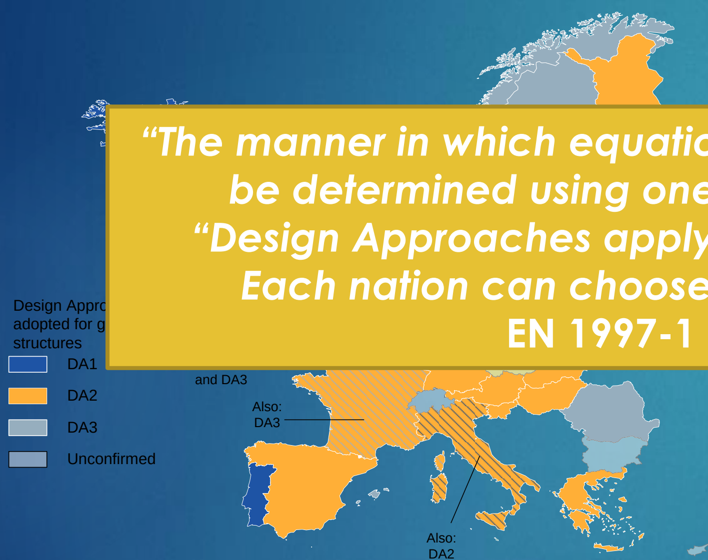
**Geotechnical Design Model**

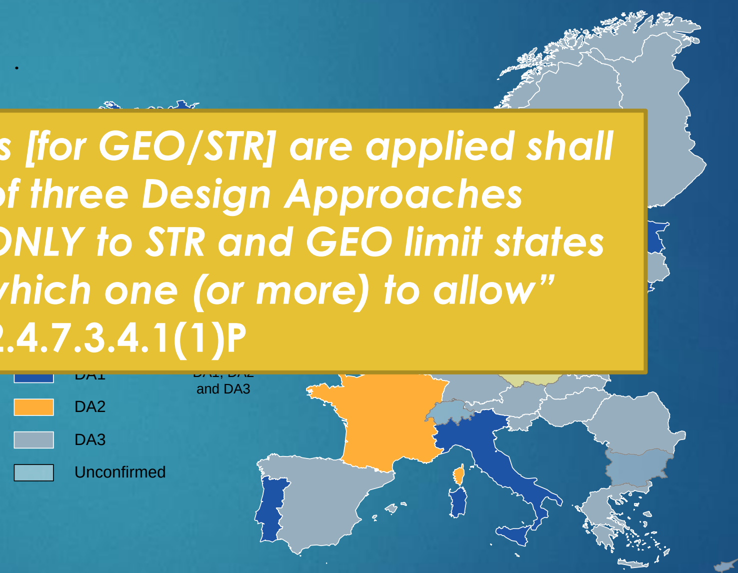
- conceptual representation of the site derived from the ground model for the verification of each appropriate design situation and limit state

# 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<br>• **rupture**<br>• **excessive deformation**<br>• transformation into a mechanism<br>• 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 | |

# 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 $\gamma_F$ and $\gamma_E$ for Verification Cases 1-4 | | | | |
|---|---|---|---|---|---|---|---|---|
| Type | Group | Symbol | Resulting effect | Structural* | Static equilibrium and uplift** | | Geotechnical design | |
| | | | | VC1 | VC2(a) | VC2(b) | VC3 | VC4 |
| Permanent action ($G_k$) | All | $\gamma_G$ | 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 ($P_k$) | | $\gamma_P$ | | | | | | **On effects** |
| Variable action ($Q_k$) | All | $\gamma_Q$ | unfavourable | | | | | |
| | Water | $\gamma_{Qw}$ | | | | | | |
| | (All) | $\gamma_{Q,fav}$ | favourable | | | | | |
| Effects-of-actions (E) | | $\gamma_E$ | unfavourable | $\gamma_E$ 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)



| Ground property | Symbol | M1 | M2 |
|---|---|---|---|
| ***Soil*** | | | |
| Shear strength in effective stress analysis ($\tau_f$) | $\gamma_{\tau f}$ | 1.0 | 1.25 $k_M$ |
| Coefficient of peak friction ($\tan \varphi'_p$) | $\gamma_{\tan\varphi,p}$ | | |
| Peak effective cohesion ($c'_p$) | $\gamma_{c,p}$ | | |
| **Coefficient of friction at critical state ($\tan \varphi'_{cs}$)** | $\gamma_{\tan\varphi,cs}$ | | **1.1 $k_M$** |
| **Coefficient of residual friction ($\tan \varphi'_r$)** | $\gamma_{\tan\varphi,r}$ | | |
| Shear strength in total stress analysis ($c_u$) | $\gamma_{cu}$ | | 1.4 $k_M$ |
| ***Rock*** | | | |
| Unconfined compressive strength ($q_u$) | $\gamma_{qu}$ | Same as $\gamma_{cu}$ | |
| Shear strength of rock ($\tau_r$) | $\gamma_{\tau r}$ | 1.0 | 1.25 $k_M$ |
| Unconfined compressive strength of rock ($q_u$) | $\gamma_{qu}$ | | 1.4 $k_M$ |
| ***Discontinuities*** | | | |
| Shear strength of rock discontinuities ($\tau_{dis}$) | $\gamma_{\tau dis}$ | 1.0 | 1.25 $k_M$ |
| Coefficient of residual friction ($\tan \varphi'_{dis,r}$) | $\gamma_{\tan\varphi,dis,r}$ | | 1.1 $k_M$ |

# Summary of key points

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# 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
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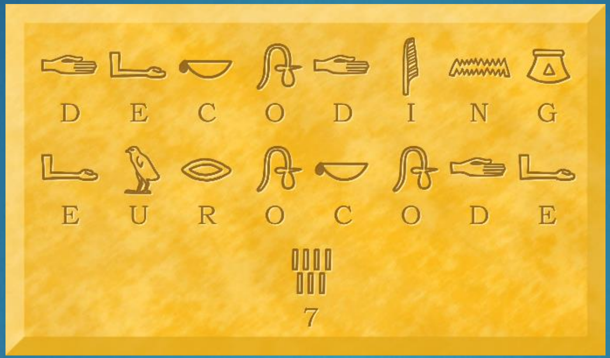


Our **2nd generation** courses include …

- 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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# Eurocode 7

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