Overview of the Evolution of EN 1998: Design of structures for earthquake resistance

8 September 2020

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Structure of this slide deck

- General overview of the evolution of EN 1998
- Specific overview of the evolution of EN 1998 parts:
  - *1998-1-1*
  - *1998-1-2*
  - *1998-3*
  - *1998-5*

General overview of the Evolution of EN1998: Design of structures for earthquake resistance

September 2020

Agenda – Evolution of EN 1998

- Key changes to EN 1998
- New content included in the scope of EN 1998
- How ease of use has been enhanced

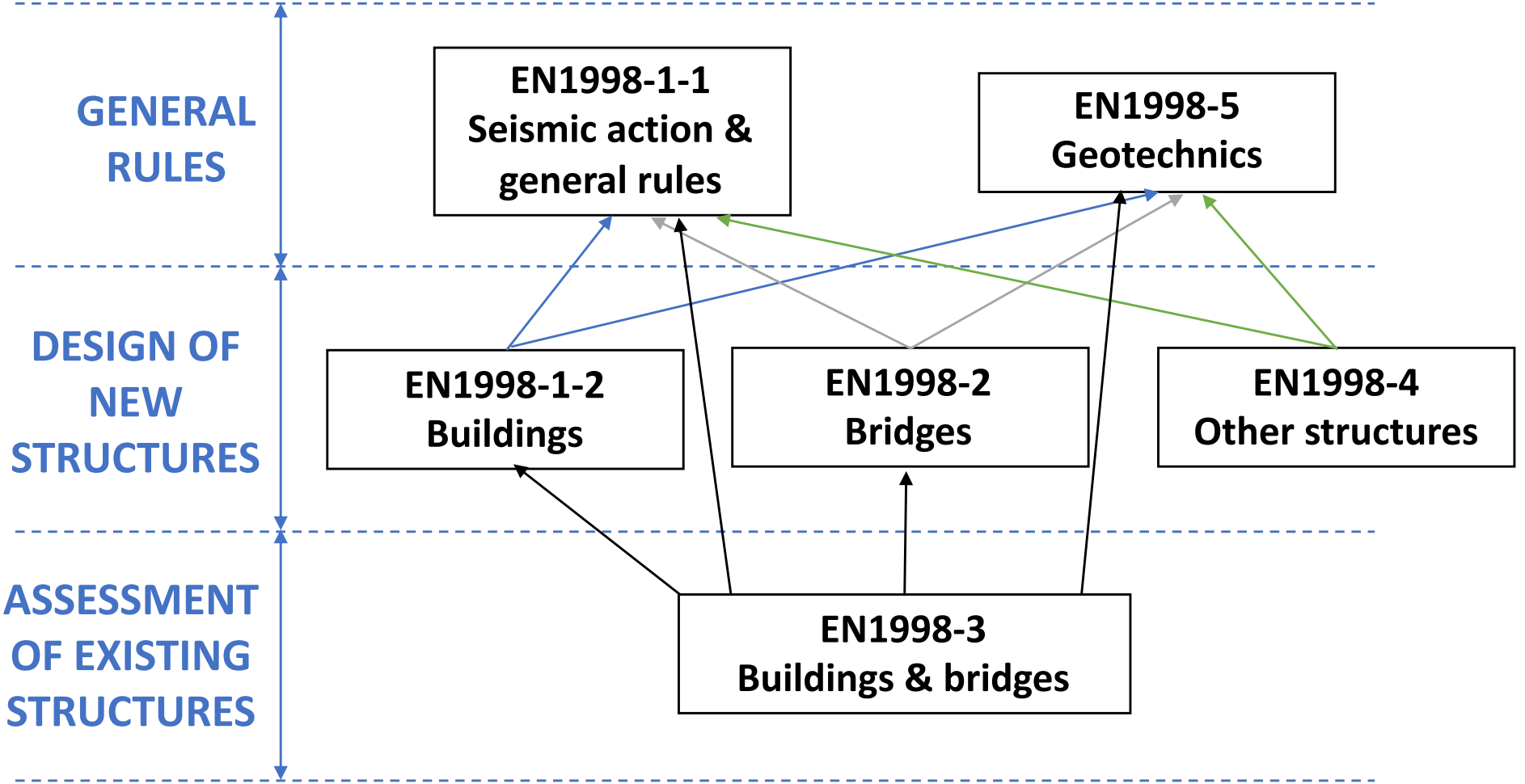
The following slides provide a general overview of the evolution of EN 1998.
Complementary slides provide greater details for individual Eurocode Parts.

Key changes to EN 1998

- *Restructuration of EN1998 parts*
- *Redefinition of seismic action*
- *Redefinition of elastic response spectrum*
- *Homogenisation of Limit States through parts and alignment with EN1990*
- *Redefinition of ductility classes and corresponding design*
- *New assessment for the q factor distinguishing overstrength, redundancy and ductility*

Example: Restructuration of EN 1998 in three levels

→ *Identification of a general part common to all other parts to avoid repetitions*



New content included in scope of EN 1998

- *Development of the displacement-based approach*
- *Introduction of bridges in part 3 (existing structures)*
- *Introduction of timber structures in part 2 (bridges) and part 3 (assessment of existing structures)*
- *Introduction of Aluminium structures in part 1-2 (new buildings)*

How ease of use has been enhanced

- *Verification that all rules may be applied without ambiguity by designers:*
  - Clarity of sentences (avoiding ambiguities)
  - Short sentences
  - Information (explanation) in requirements moved to notes or removed
  - Quantitative limits instead of qualitative
  - Only one rule for the same domain of application
- *Feed-back from members taken into account*

Examples of clarity of sentences

INITIAL	CHANGED TO
They should also have sufficient inelastic rotation capacity to accommodate the required rotation at the design storey drift	Their inelastic rotation capacity should not be lower than the required rotation at the design storey drift.
Straight links as shown in Figure 12.3 may be welded in addition to the longitudinal rebars	If longitudinal rebars are present, the straight links may be welded to these, as shown in Figure 12.3
In cross laminated timber structures, each wall panel at every floor may be composed either of only one monolithic cross laminated timber panel or of multiple panels connected to each other with rigid (as defined in **3.1.25**) vertical joints.	Multiple panels composing a wall panel should be connected to each other with rigid vertical joints.
is the gravity load per unit length….	are the non seismic actions in the seismic design situation, per unit length…
Ancillary elements of buildings (e.g. claddings, parapets, …) that might ….	Ancillary elements of buildings that might… NOTE Examples of ancillary elements are: claddings, parapets…

Overview of the Evolution of EN1998-1-1: General rules and seismic action

September 2020

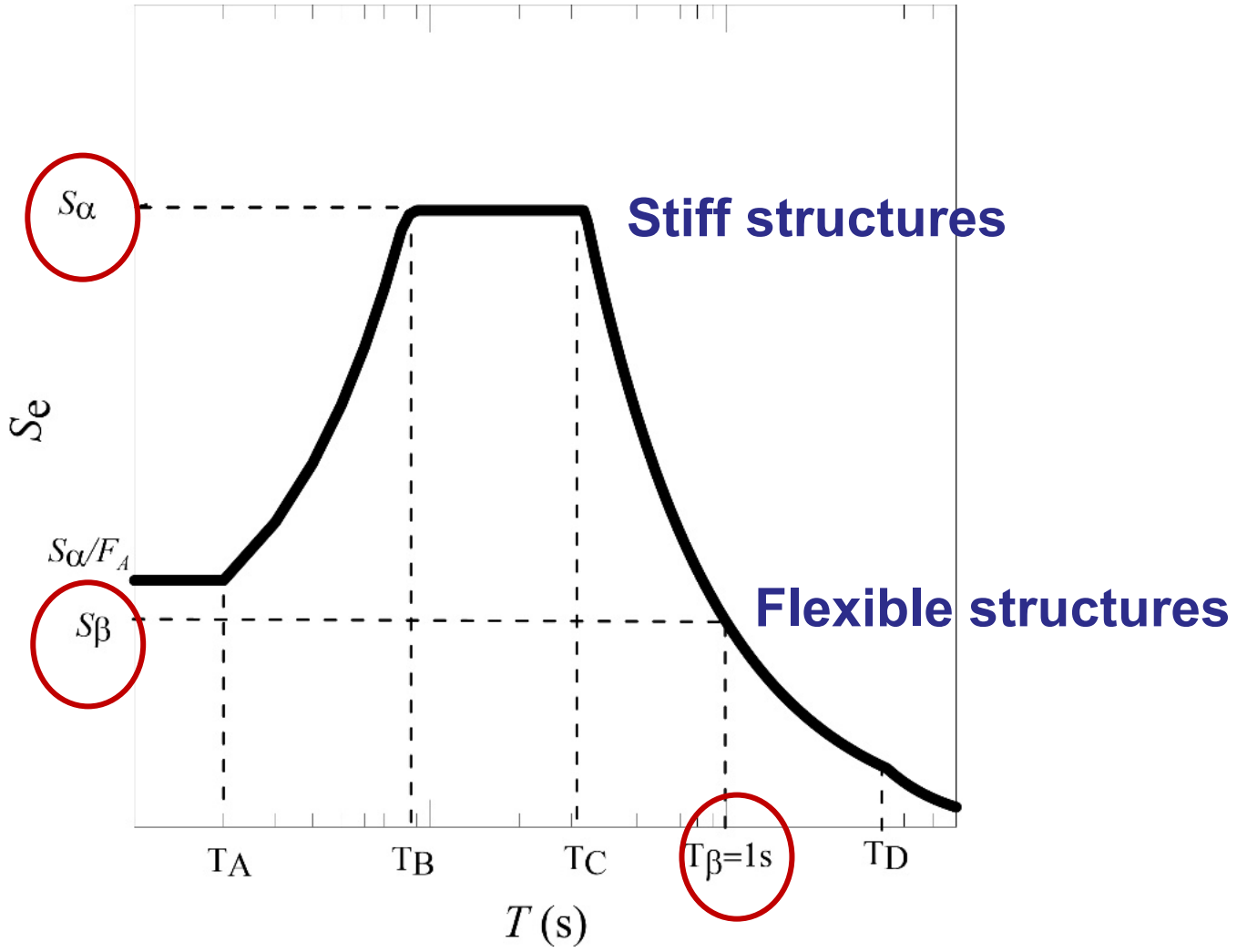
Agenda – Evolution of EN 1998-1-1: General rules and seismic action

- Key changes to EN 1998-1-1
- New content included in the scope of EN 1998-1-1
- How ease of use has been enhanced

Key changes to EN 1998-1-1

- *Simplification of the global safety choice (for Countries) through seismic action classes*
- *Alternative to the hazard level choice with the introduction of the return period*
- *Homogenisation of Limit States definition through all parts with better consistency with EN1990 (ULS and SLS)*
- *Better definition of site classification introducing the depth of the bedrock formation*
- *Redefinition of the elastic response spectrum using two parameters instead of a_g*
- *Improvement of damping and topographic effects*

Example: new definition of elastic spectrum



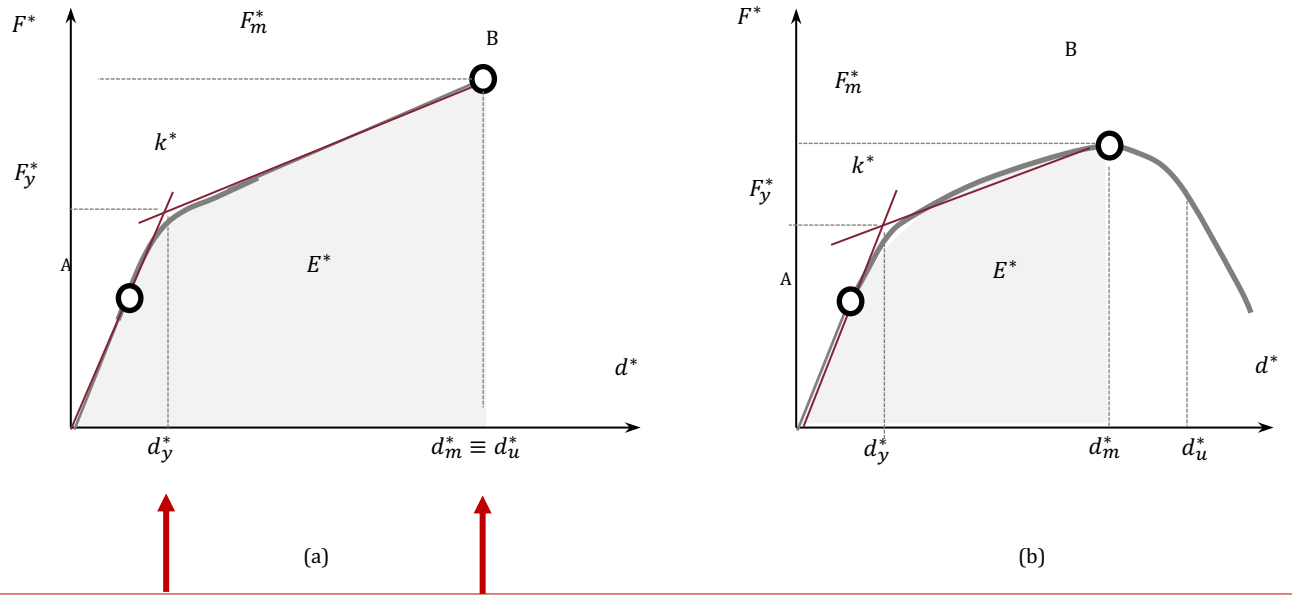
Key changes to EN 1998-1-1

- *New definition of ductility classes*
- *Better definition of the two possible approaches for analysis: force-based or displacement based*
- *Better definition of the behaviour factor (decomposed in three components)*
- *Improvement of linear analysis and simplified method*
- *Reduction of number of NDPs*

New content included in scope of EN 1998-1-1

- *Introduction of two European seismic maps (informative) for mapping the two basic spectral accelerations (issued by the European research project SERA)*
- *Spatial model of the seismic action (for long structures)*
- *Development of modelling and analysis method for displacement based analysis*
- *Verification to Limit States when using the displacement based method*
- *Deformation criteria and strength models for materials*
- *Structures equipped with antiseismic devices: design rules, modelling and analysis*
- *Reliability-based verification format*

Example: bilinear model of pushover curves



Deformation criteria developed in EN1998-1-1 for concrete and steel

How ease of use has been enhanced

→ *Application of the general method*

Overview of the Evolution of EN1998-1-2: Rules for new buildings

September 2020

Agenda – Evolution of EN 1998-1-2: Rules for new buildings

- Key changes to EN 1998-1-2
- New content included in the scope of EN 1998-1-2
- How ease of use has been enhanced

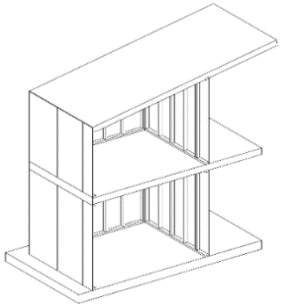
Key changes to EN 1998-1-2

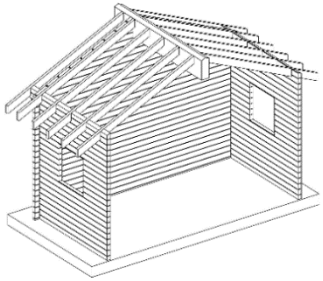
- *Clarification of treatment of secondary elements*
- *Better control of drift and 2nd order effects*
- *Procedure for deriving floor response spectra*
- *Ancillary elements reorganised and clarified*
- *Redefinition of limits for the design to DC1 (all materials)*
- *Design to DC2 and DC3 redefined according to the new definitions (all materials)*
- *Decomposition of q into several components according to the new definition (all materials)*

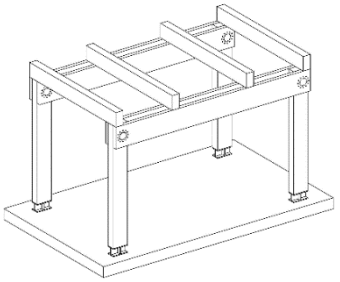
Key changes to EN 1998-1-2

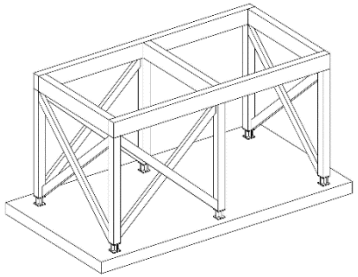
- *Concrete: verification of shear and beam-column joints*
- *Complete overhaul of the steel and composite clauses to incorporate analysis from the European Convention for Constructional Steel Works*
- *Content of the timber chapter completely reviewed in close coordination with EN1995. Re-evaluation of the building typologies.*
- *Re-writing of the masonry chapter to accommodate the variety of block production in Europe and decrease the number of NDPs*
- *Alignment of masonry rules to better consistency with the Sections on other materials*
- *Depth revision of the rules for simple buildings in masonry*

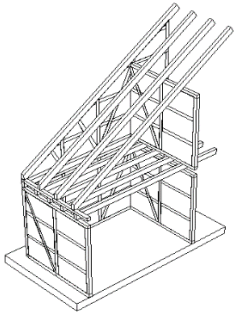
Examples of timber structures typologies
(from a total of 9 types)

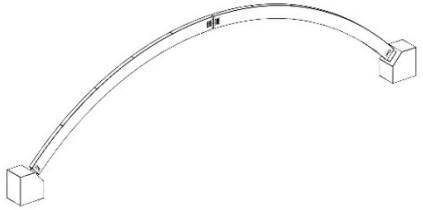












New content included in scope of EN 1998-1-2

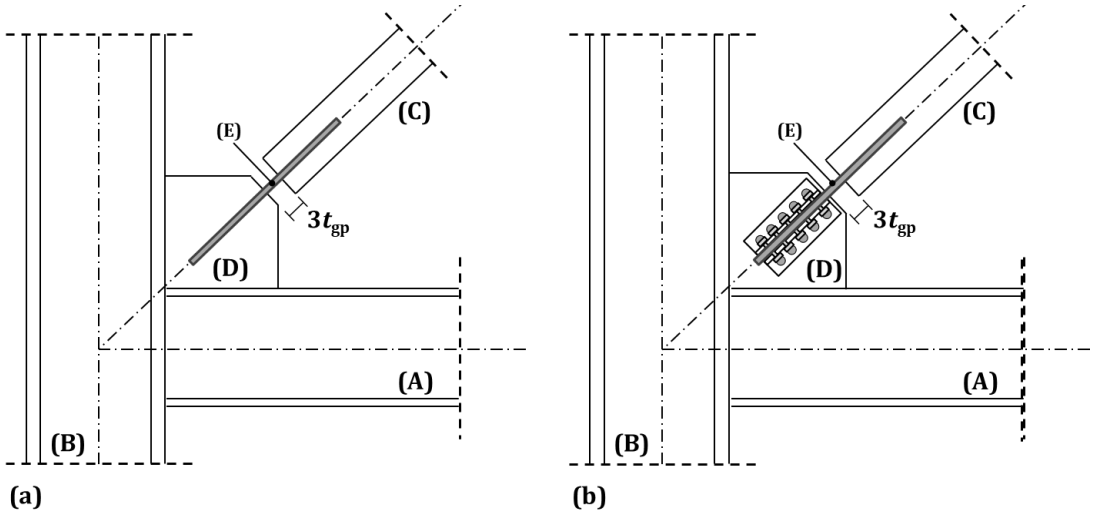
- *Design of transfer zones*
- *Verification of underground basements*
- *Design criteria for displacement-based approach (for all materials)*
- *New clause on analysis and verification of ancillary elements (infilled frames and claddings)*
- *New Clause for the design and analysis of buildings with energy dissipation systems*
- *Concrete flat slab systems*
- *Extension of the rules for precast concrete structures*

New content included in scope of EN 1998-1-2

- *Design of connections for steel and composite structures*
- *Steel light-weight structures*
- *Design of the slab and of its connection to composite steel - concrete moment resisting frames*
- *Composite timber-concrete lateral load resisting systems*
- *Prevention of out of plane collapse of masonry walls*
- *New chapter for aluminium structures*

How ease of use has been enhanced

- *Application of the general method*
- *Addition of tables for a simplified application of rules*
- *Addition of Figures with technological details for a better understanding of detailing*



Overview of the Evolution of EN1998-3: Assessment and retrofitting of buildings and bridges

September 2020

Agenda – Evolution of EN 1998-3: Assessment and retrofitting of buildings and bridges

- Key changes to EN 1998-3
- New content included in the scope of EN 1998-3
- How ease of use has been enhanced

Key changes to EN 1998-3

- *Clarification of knowledge level according to three criteria (geometry, materials, detailing)*
- *All material partial factors g_{Rd} unified based on a single fractile of the resistance distribution, depending on the knowledge level*
- *Re-writing of analysis methods in line with EN1998-1-1*
- *Verification using the displacement-based approach using local or global criteria*

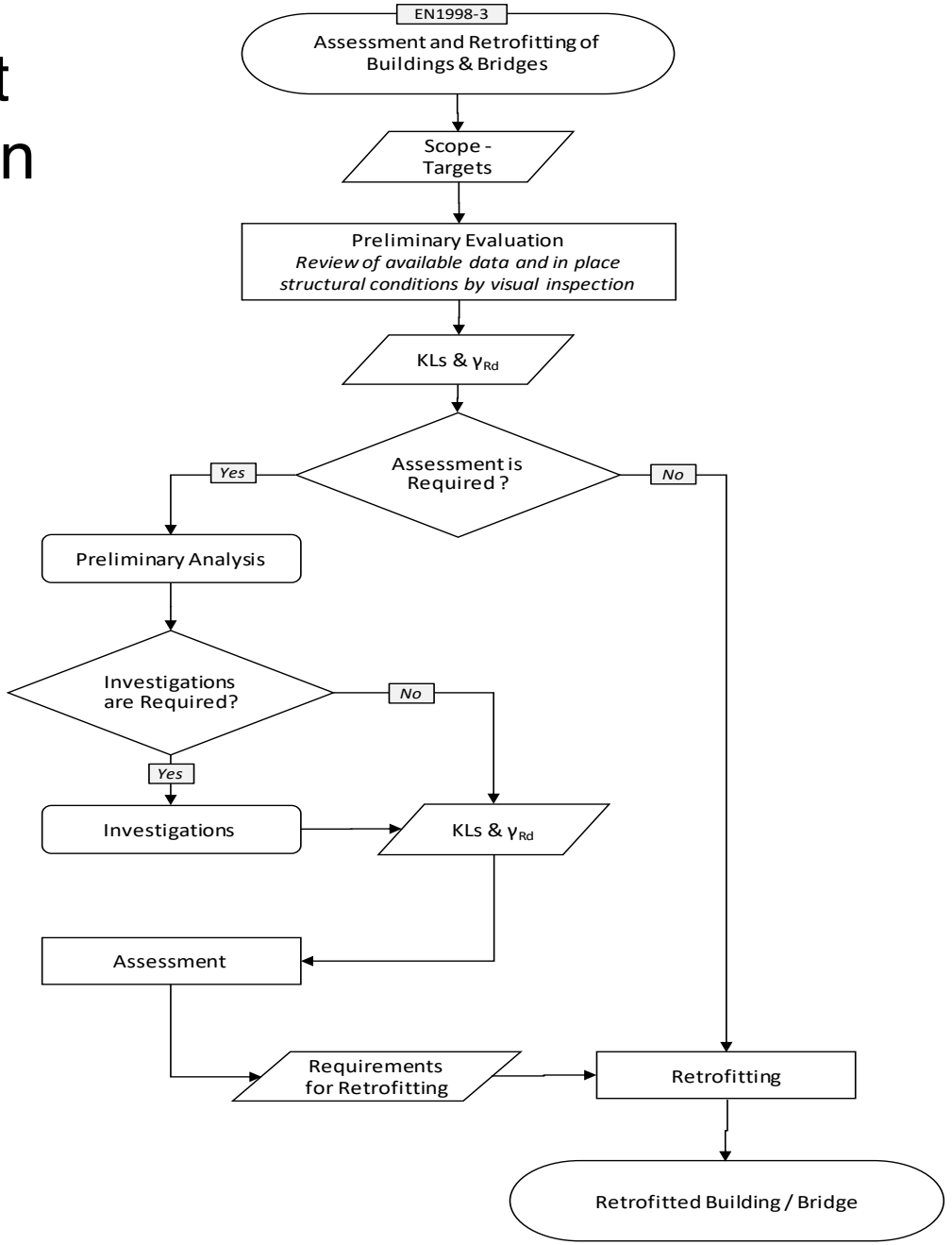
New content included in scope of EN 1998-3

- *Normative chapters for concrete, steel, and masonry for assessment (only informative annexes in the present version), completely rewritten*
- *New chapter for timber buildings*
- *Deformation criteria (yield and ultimate) of structural materials*
- *Resistance models for retrofitting introducing new methods of retrofit*
- *New chapter for bridges*

How ease of use has been enhanced

- *Application of the general method*
- *Addition of charts for the application of the code*

Example of chart for the application of the code



Overview of the Evolution of EN1998-5: Geotechnical aspects, Foundations, Retaining and Underground structures

September 2020

Agenda – Evolution of EN 1998-5: Geotechnical aspects, Foundations, Retaining and Underground structures

- Key changes to EN 1998-5
- New content included in the scope of EN 1998-5
- How ease of use has been enhanced

Key changes to EN 1998-5

- *Better consistency with EN1997*
- *Distinction between geotechnical systems and geotechnical structures*
- *Alignment of “basis of design” to the new concepts in EN1998-1-1*
- *derivation of horizontal ground acceleration from new elastic spectra*
- *Water levels according to EN1990*
- *Extension of analysis methods for liquefaction*
- *Rules for capacity design of foundations*

New content included in scope of EN 1998-5

- *Development of the displacement-based approach for all topics*
- *Development of models for Soil-Structure Interaction*
- *Rules for analysis and verification of piles*
- *New chapter on seismic action effects on underground structures (tunnels, large spaces, pipelines, etc)*

How ease of use has been enhanced

- *Application of the general method*
- *Simplified spring models*
- *Curves and tables for parameter values*

Example: spring model for tunnels