Second Generation of Eurocode 8

WEBINAR 4: Silos, tanks, pipelines, towers masts and chimneys – General overview of EN 1998-4

Christoph Butenweg - SDA engineering GmbH

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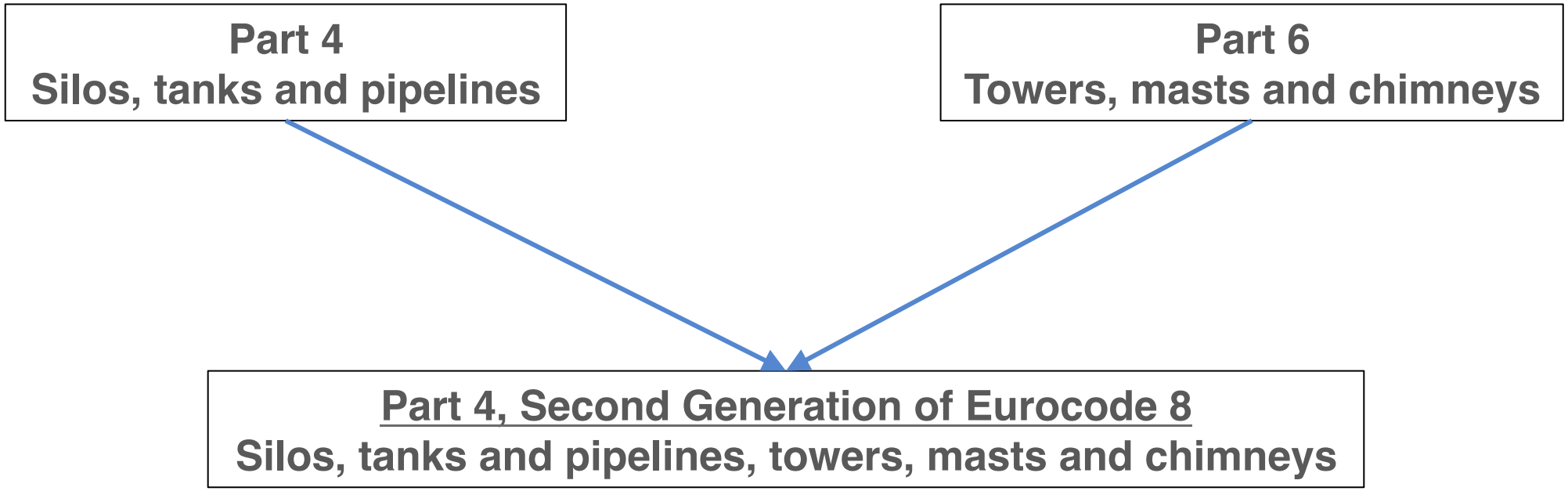
EN 1998-4 – MERGING PART 4 + 6



Project team (PT5): C. Rebelo, D. Vamvatsikos, R. Nascimbene, C. Fernandez, C. Butenweg (L)

EN 1998-4 – SCOPE

- Silos – elevated/on-ground
- Tanks – elevated/on-ground
- Pipeline systems – above-ground/buried
- Towers, masts and chimneys
- Ancillary elements attached to the structures or in industrial facilities.

EN 1998-4 – CONTENT

(4) Basis of design

(5) Rules for silos

(6) Rules for tanks

(7) Rules for above-ground pipelines

(8) Rules for buried pipelines

(9) Rules for ancillary elements in industrial facilities

(10) Rules for towers masts and chimneys

EN 1998-4 – CONTENT

Annex A: Tables for the seismic design of tanks (normative)

Annex B: Soil-structure interaction effects of tanks (informative)

Annex C: General design consideration for buried pipelines (informative)

Annex D: Modelling of soil-structure interaction of buried pipelines (informative)

Annex E: Design differential surface displacement at pipeline – fault crossing (informative)

EN 1998-4 – PERFORMANCE REQUIREMENTS

- Protection of human lives and personal injury
- Lifeline systems important for civil protection to remain operational
- Protection of environment
- Prevention of induced damage to connected plant components, nearby buildings and adjacent facilities to avoid cascading effects
- Limitation of damage to preserve the full or limited functionality
- Minimisation of economic and social consequences

EN 1998-4 – LIMIT STATES

- **SD:** The structure and its ancillary elements are significantly damaged, but both retain their structural integrity with controlled leakage of contents.
- **DL:** Extent and amount of damage is limited. After operations for damage checking and control, the capacity of the system can be restored up to a predefined level of operation. Liquid-filled systems should remain leak-proof.
- **OP:** The considered system, including a specified set of ancillary elements, remains fully serviceable under the relevant seismic action. Liquid filled systems should remain leak-proof.
- ***NC:*** *Not covered in the EN 1998-4. Values are given for completeness and can be used for existing structures.*

EN 1998-4 – CONSEQUENCE CLASSES CC3 and CC4

Class 3-b: Should be chosen if the integrity of the structure, including ancillary elements, is of vital importance for the public safety and environment or can induce damage to connected plant components, nearby buildings or adjacent facilities.

CC3-b: Should be selected for all structures and systems which could jeopardise the operational civil protection services in the immediate post-earthquake period. (e.g. energy and water supply, systems, emergency routes, hospitals, fire stations, telecommunication, safety systems).

CC4: The consequence class CC4 for large risk structures is not covered. But the principles of calculation and design can also be applied for structures with CC4.

EN 1998-4 – RETURN PERIODS AND PERFORMANCE FACTORS

Return periods (NDP)

Limit state	Consequence class			
	CC1	CC2	CC3-a	CC3-b
NC	800	1600	2500	5000
SD	250	475	1300	2500
DL	50	60	150	250

Performance factors (NDP)

Limit state	Consequence class			
	CC1	CC2	CC3-a	CC3-b
NC	1,2	1,5	1,8	2,2
SD	0,8	1,0	1,4	1,8
DL	0,4	0,5	0,7	0,8

EN 1998-4 – SEISMIC ACTION CLASS – COEFFICIENT δ

The coefficient δ required to determine the seismic action index S_δ depends on the consequence class.

	Consequence class (CC)			
	CC1	CC2	CC3-a	CC3-b
δ	0,60	1,0	1,4	1,8

S_δ defines the seismic action classes: very low, low, moderate and high.

$$S_\delta = \delta F_\alpha F_T S_{\alpha,475}$$

EN 1998-4 – STRUCTURAL MODELLING AND ANALYSIS

Structural modelling and types of analysis should be applied according to EN 1998-1-1:2022, 6, and EN 1998-1-2:2022, 5:

- Force-based approach
- Non-linear static analysis
- Response-history analysis

Modelling rules are provided in clauses 5 to 10 for each specific structural type.

EN 1998-4 – Combination of the components of seismic actions

For **axisymmetric structures in plan** (e.g. on-ground vertical cylindrical silos and tanks, tubular towers), only the vertical and one horizontal component of seismic action should be evaluated, where the latter should be multiplied by a factor of 1,12. The action effect due to the combination of the vertical and horizontal component should be calculated as follows:

$$1{,}12\ E_{Edx}\ "+"\ 0{,}30\ E_{Edz}$$

$$0{,}34\ E_{Edx}\ "+"\ 1{,}00\ E_{Edz}$$

Note: The factor 0,34 is the result of 0,30 x 1,12 using the combination according to EN 1998-1-1:2022

EN 1998-4 – Materials and ductility classes

Structural type	Material	Structural analysis	Ductility class
Silos and Tanks	steel, reinforced concrete/prestressed precast reinforced concrete	**Force based** Non-linear RHA	DC1
Above-ground pipelines	steel, unreinforced or reinforced concrete	**Force based** Non-linear static analysis Non-linear RHA	DC1 – DC2
Buried pipelines	steel, unreinforced concrete, reinforced concrete and prestressed precast	**Non-linear RHA** Non-linear static analysis	-
Towers, masts and chimneys	Steel, reinforced concrete, masonry	**Force based** Non-linear static analysis Non-linear RHA	DC1 – DC3

Note: Substructures may be designed according to ductility classes DC1, DC2 or DC3

EN 1998-4 – VERIFICATION TO LIMIT STATES

SD limit state should be verified according to clauses 5 to 10. Partial factors according to EN 1998-1-2:2022, 8 to 15, not lower than 1, should be used,

- If appropriate, DL, OP limit states should be verified according to clauses 5 to 10
- Verification for NC limit state is not required
- **Exception:** Total base shear in the seismic design situation is less than the corresponding base shear in other design situations. The total base shear should be calculated with a behaviour factor of q = 1,0 using the elastic design spectrum given in EN 1998-1-1 (e.g. wind action > seismic action).

EN 1998-4 – Mandate and major changes

- Merging EN 1998-4 + 6 and reduction of NDP from 10 to 4
- Standard procedure: Force-based approach
- Simplification of tank calculation procedures with pressure functions (Annex A)
- Improved consistency to EN 1992 and EN 1993
- Additional design rules for horizontal cylindrical tanks, elevated tanks and silos, consideration of permanent ground motions for pipelines, detailed design rules for buried pipelines, definition of limit states and consequence classes
- Basics of EN 1998-4 are described in 5 background documents for silos, tanks, pipelines, ancillary elements and towers masts and chimneys

Thank you for your attention!