



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II



IUSS

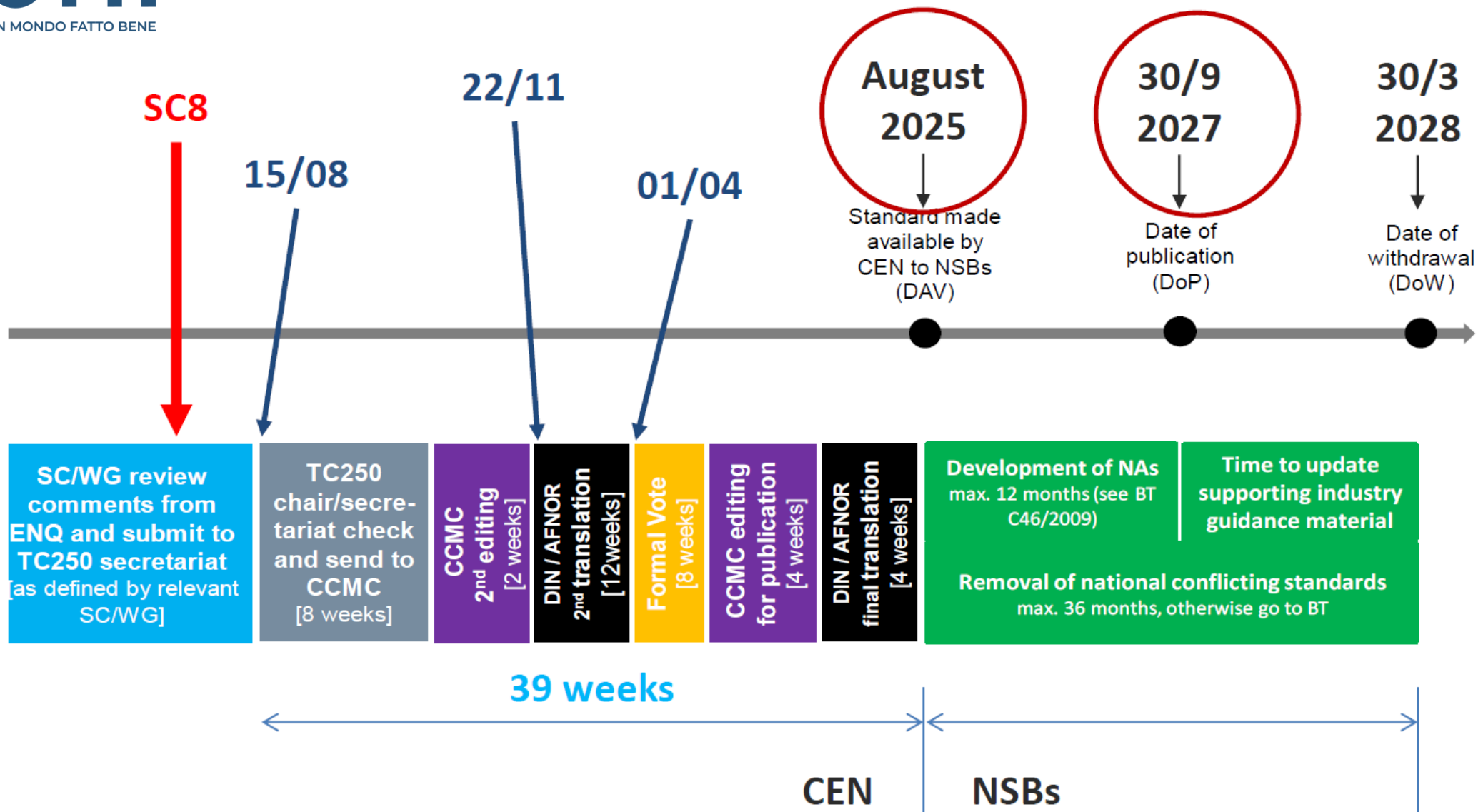
Scuola Universitaria Superiore Pavia

La seconda generazione dell'Eurocodice 8: considerazioni generali

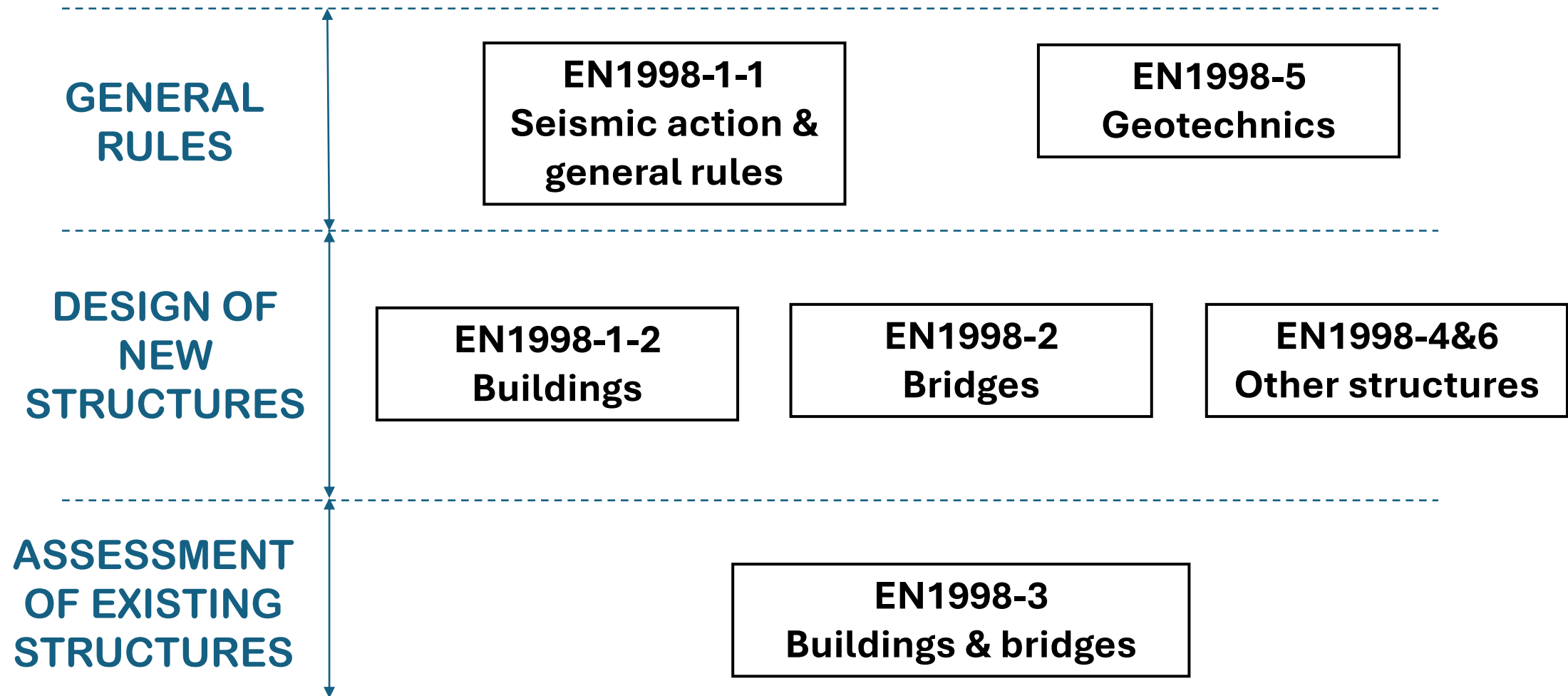
Iunio Iervolino

(Contributi: P. Bish, L. Callisto, P. Franchin, P. Labbè, S. Lagomarsino, G. Mucciaccia, R. Nascimbene, R. Paolucci)

Where are we?



Structure of EN 1998: three levels



New scope

- Verification of Operational (OP) limit state
- Development of the displacement-based approach and verification rules
- Structures equipped with antiseismic devices
- Soil structure interaction
- Ancillary elements and floor response spectra
- Flat slab systems (buildings)
- Infilled frames and claddings (buildings)
- Aluminium structures in part 1-2 (buildings)
- Bridges in part 3 (existing structures)
- Timber structures in part 2 (bridges) and part 3 (assessment of existing structures)

Nationally-determined parameters (NDPs)

	1st gen.	2 nd gen.
EC8-1 general /EC8-1-1	18	13
EC8-1 materials /EC8-1-2	39	18
EC8-2	29	5
EC8-3	8	8
EC8-4+6	10+7	3
EC8-5	4	8
TOTAL	115	55

Limit states and consequence classes

1st GENERATION

PARTS 1 & 2	PART 3
	NEAR COLLAPSE
NO COLLAPSE	SIGNIFICANT DAMAGE
DAMAGE LIMITATION	DAMAGE LIMITATION

PART 1	PART 2
I	I
II	II
III	III
IV	

2nd GENERATION

	Limit state
ULS	NEAR COLLAPSE (NC)
	SIGNIFICANT DAMAGE (SD)
SLS	DAMAGE LIMITATION (DL)
	OPERABILITY (OP)

Table A.1.1 (NDP) — Examples of buildings in different consequence classes

Consequence class	Description of consequence	Examples
CC4 ^a	Highest	Nuclear power plant, dams
CC3	High	Buildings or parts of buildings where a very large number of people could be affected by failure, e.g. grandstands, concert halls, high-rise buildings
CC2	Normal	Buildings or parts of buildings not covered by CC1 or CC3
CC1	Low	Buildings or part of buildings where very few people could be affected by failure, e.g. agricultural buildings, storage buildings
CC0 ^a	Lowest	Elements other than structural, see 3.1.1.7.

^a For provisions concerning CC0 and CC4, see 4.3.

- At least one ULS verification is mandatory
- Choice of SLS to be verified is up to the NA or the contract

Return periods and performance factors

Return periods in years

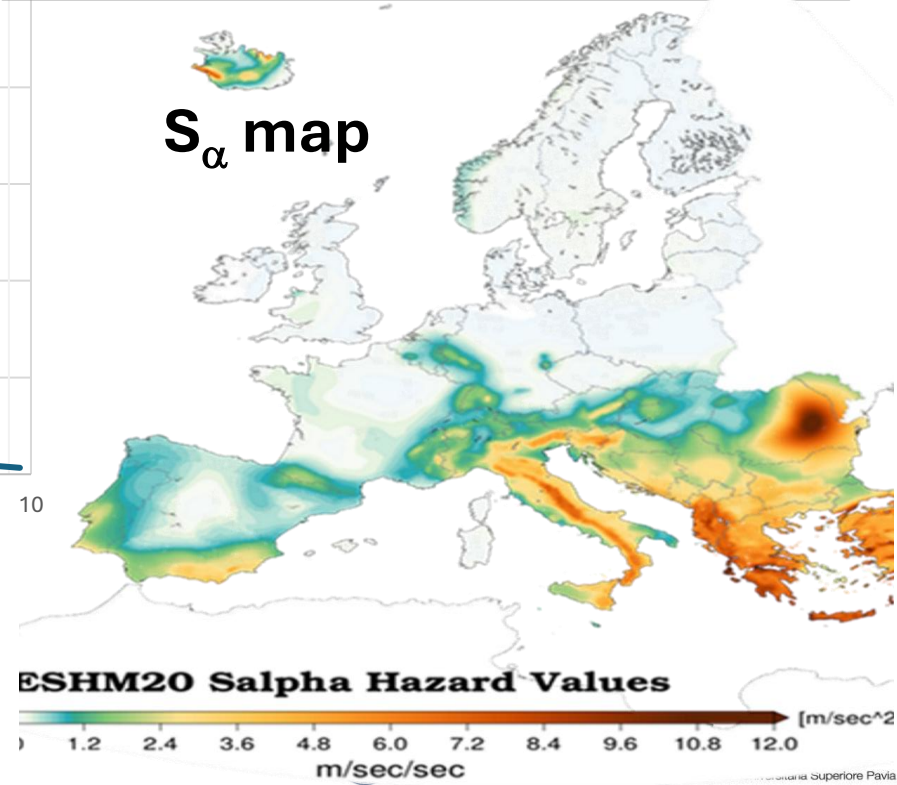
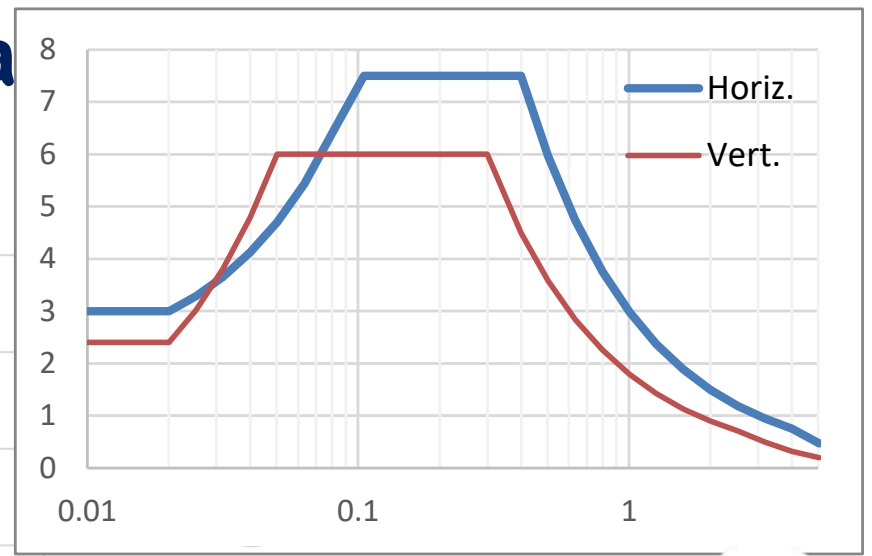
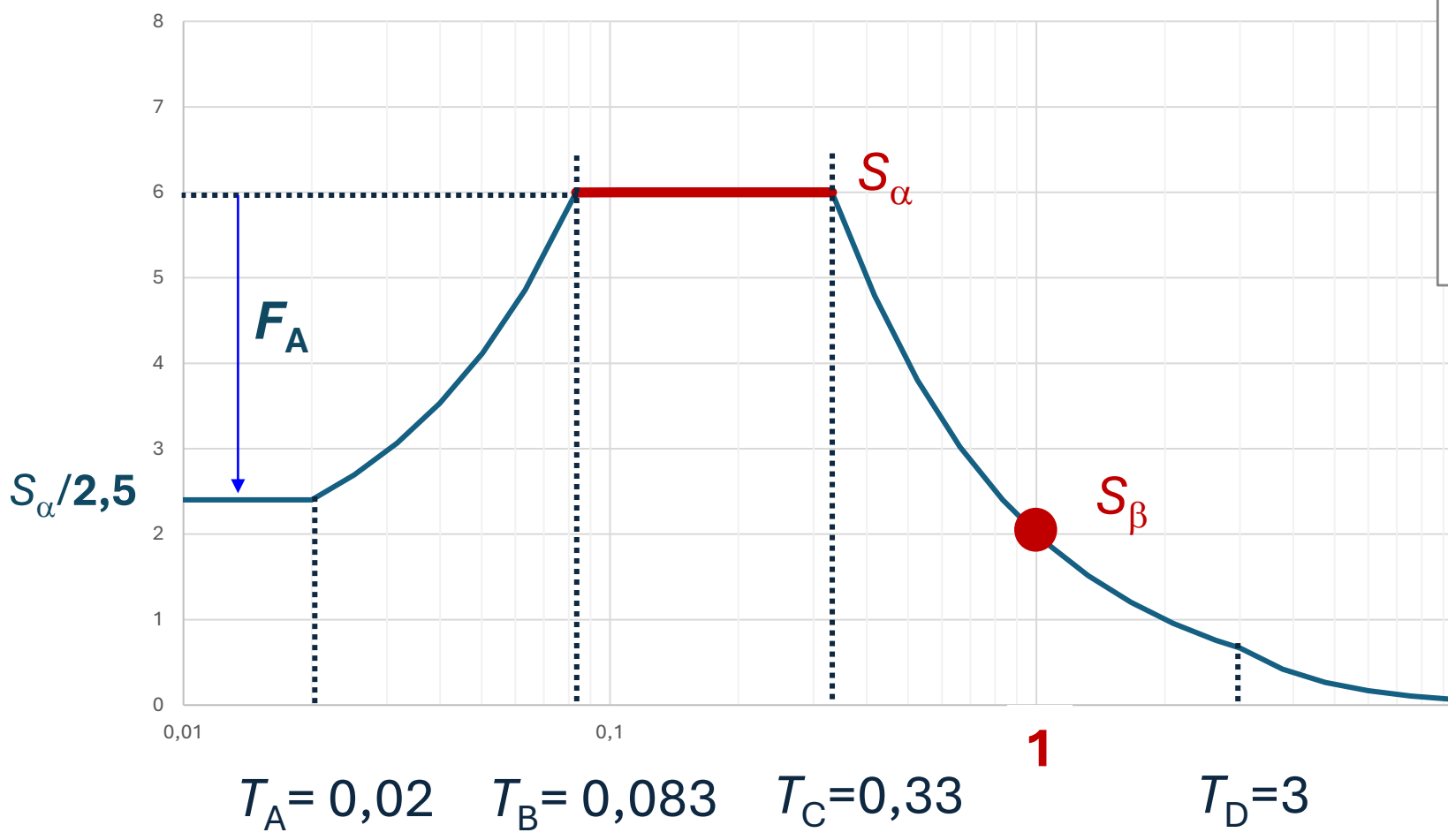
Limit state (LS)	Consequence class			
	CC1	CC2	CC3-a	CC3-b
NC	800	1600	2500	5000
SD	250	475	800	1600
DL	50	60	60	100

10% of exceedance in 50y

Performance factors

Limit state (LS)	Consequence class (IC)			
	CC1	CC2	CC3-a	CC3-b
NC	1,2	1,5	1,8	2,2
SD	0,8	1	1,2	1,5
DL	0,4	0,5	0,5	0,6

Response spectra



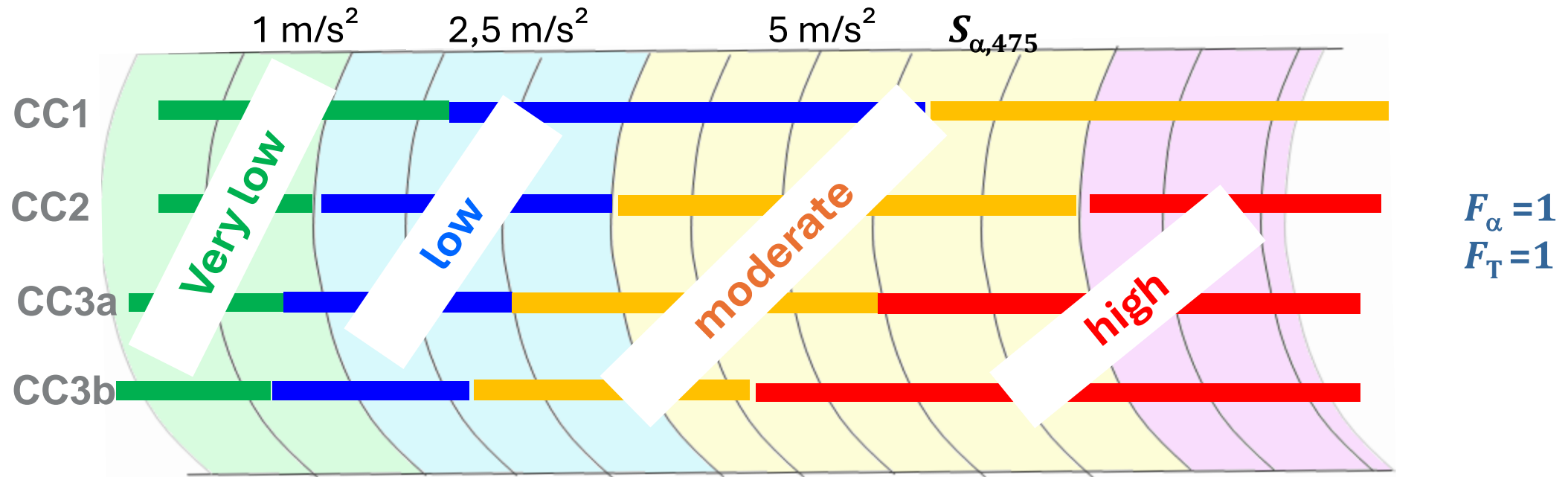
Seismic action index and ductility classes (1/2)

CC / site / topography / hazard

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

Range of seismic action index	Seismic action class
$S_{\delta} < 1,30 \text{ m/s}^2$	Very low
$1,30 \text{ m/s}^2 \leq S_{\delta} < 3,25 \text{ m/s}^2$	Low
$3,25 \text{ m/s}^2 \leq S_{\delta} < 6,50 \text{ m/s}^2$	Moderate
$S_{\delta} \geq 6,50 \text{ m/s}^2$	High

Seismic action index and ductility classes (2/2)



Linear elastic design, force approach ($q = 1$)

DC1

Overstrength capacity ($q = 1,5$)

DC2

Overstrength capacity, local deformation capacity and local energy dissipation capacity

DC3

Ability of the structure to form a global plastic mechanism at SD limit state

Site categories and site amplification (1/2)

Table B.1 Simplified description of site categories.

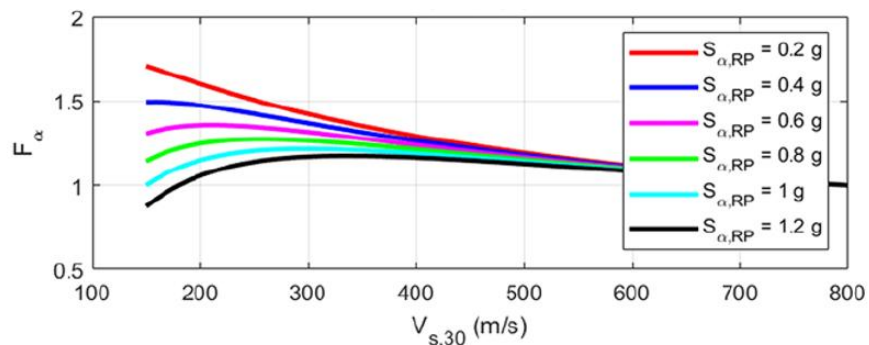
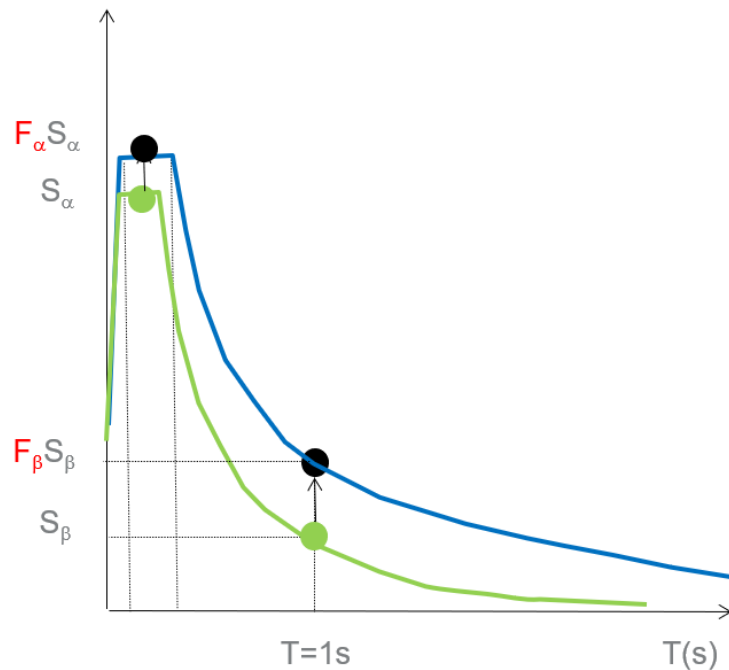
Site category	
A	Rock or other rock-like geological material, including very shallow layers of very dense, dense or medium-dense sand, gravels, very stiff or stiff clay.
B	Deposits consisting prevalently of very dense sand, gravel, or very stiff clay, with representative values of the geotechnical parameters in the range defined in Table A.2 for stiff ground.
C	Intermediate depth deposits consisting prevalently of dense or medium-dense sand, gravel or stiff clay, with representative values of the geotechnical parameters in the range defined in Table A.2 for medium ground.
D	Intermediate depth deposits consisting prevalently of loose-to-medium cohesionless soil, or of soft-to-firm cohesive soil, with representative values of the geotechnical parameters in the range defined in Table A.2 for soft ground.
E	Shallow soil deposits consisting of prevailing alluvium layers, underlain by rock-like materials as described for site category A. Representative values of the geotechnical parameters are in the range defined in Table A.2 for medium or soft ground.
F	Deep deposits consisting of prevailing alluvium layers, with representative values of the geotechnical parameters in the range defined in Table A.2 for medium or soft ground.

- (1) A simplified identification of site categories may be obtained from the combined use of Table B.1 and Table B.2.
 (2) If site category is identified based on (1), **default values in Table 5.4 should be used.**

Table B.2 Correspondence between ground class and geotechnical parameters

Test	Parameter	Ground class			
		stiff	medium stiffness	soft	
SPT	N_{60} (SPT, ER = 60%) [blows/30cm]	> 60	30-60	15-30	
CPT	q_c - sands (MPa)	> 30	15-30	5-15	
	q_c - clays (MPa)	> 6	3-6	1,5-3	
FVT or lab tests	c_u (kPa)	> 300	150-300	50-150	
PMt	E_m (MPa)	25-100	8-25	4-8	
	p_{lim} (MPa)	Sand	2,0-5,0	1,2-2,0	0,4-1,2
		Clay	>1,2	0,7-1,2	0,3-0,7

Site categories and site amplification (2/2)



short-period site amplification factor

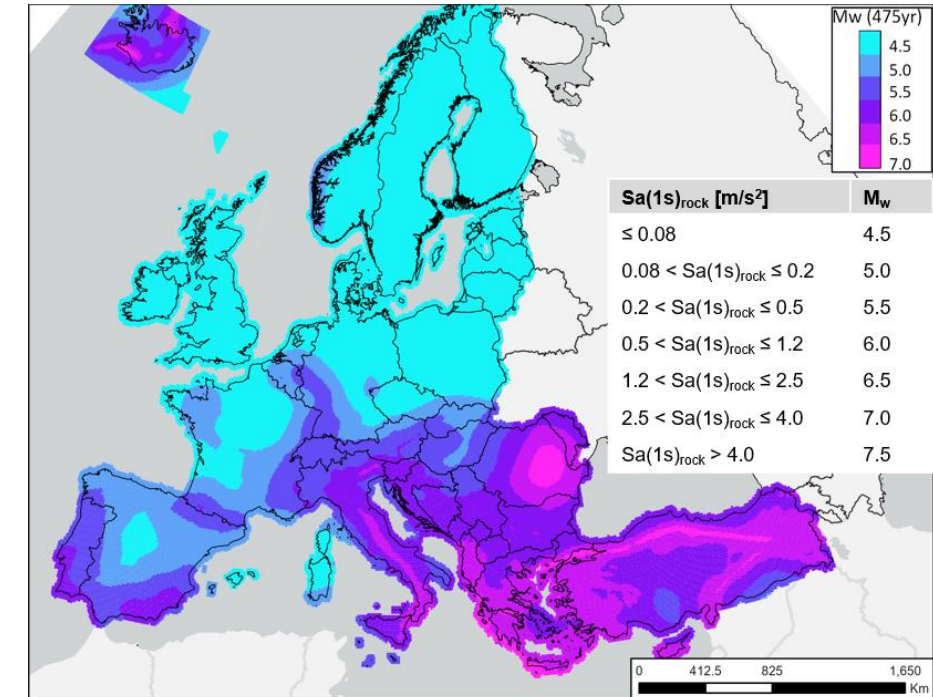
intermediate-period site amplification factor

Site category	F_α		F_β	
	H_{800} and $V_{s,H}$ available	Default value	H_{800} and $V_{s,H}$ available	Default value
A	1,0	1,0	1,0	1,0
B	$\left(\frac{V_{s,H}}{800}\right)^{-0,40r_\alpha}$	$1,3 * (1 - 0,1 * S_{\alpha,RP}/g)$	$\left(\frac{V_{s,H}}{800}\right)^{-0,70r_\beta}$	$1,6 * (1 - 0,2 * S_{\beta,RP}/g)$
C		$1,6 * (1 - 0,2 * S_{\alpha,RP}/g)$		$2,3 * (1 - 0,3 * S_{\beta,RP}/g)$
D		$1,8 * (1 - 0,4 * S_{\alpha,RP}/g)$		$3,2 * (1 - S_{\beta,RP}/g)$
E	$\left(\frac{V_{s,H}}{800}\right)^{-0,40r_\alpha} \frac{H}{30} \left(4 - \frac{H}{10}\right)$	$2,2 * (1 - 0,5 * S_{\alpha,RP}/g)$	$\left(\frac{V_{s,H}}{800}\right)^{-0,70r_\beta} \frac{H}{30}$	$3,2 * (1 - S_{\beta,RP}/g)$
F	$0,90 \cdot \left(\frac{V_{s,H}}{800}\right)^{-0,40r_\alpha}$	$1,7 * (1 - 0,4 * S_{\alpha,RP}/g)$	$1,25 \cdot \left(\frac{V_{s,H}}{800}\right)^{-0,70r_\beta}$	$4,0 * (1 - S_{\beta,RP}/g)$
$r_\alpha = 1 - \frac{S_{\alpha,RP}/g}{V_{s,H}/150}$; $r_\beta = 1 - \frac{S_{\beta,RP}/g}{V_{s,H}/150}$				

factors to account for non-linear site effects

Magnitude and duration

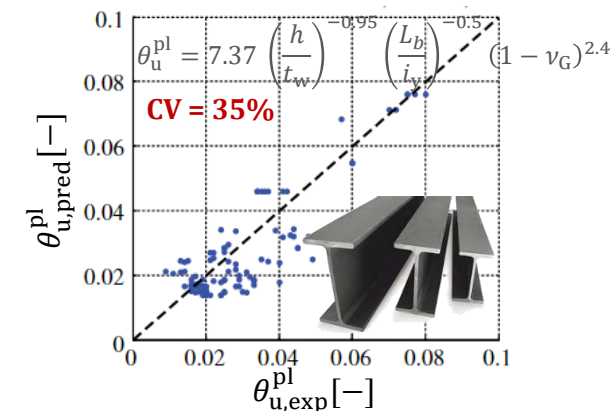
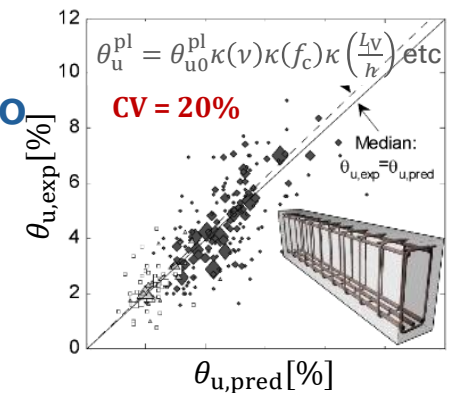
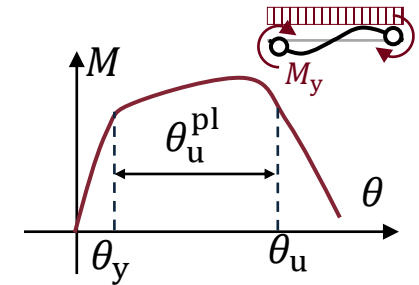
Range of $S_{\beta,RP}$ (m/s^2)	M_w	D_R (s)		
		Site category A	Site cat. B and C	Other site categories
$\leq 0,08$	4,5	0,5	0,6	0,75
$0,08 < S_{\beta,RP} \leq 0,2$	5,0	1,0	1,2	1,5
$0,2 < S_{\beta,RP} \leq 0,5$	5,5	2,0	2,4	3,0
$0,5 < S_{\beta,RP} \leq 1,2$	6,0	4,0	4,8	6,0
$1,2 < S_{\beta,RP} \leq 2,5$	6,5	8,0	9,6	12
$2,5 < S_{\beta,RP} \leq 4,0$	7,0	16	19	24
$S_{\beta,RP} > 4,0$	7,5	32	38	48



Values of epicentral distances less than about 20 km are implicitly assumed.

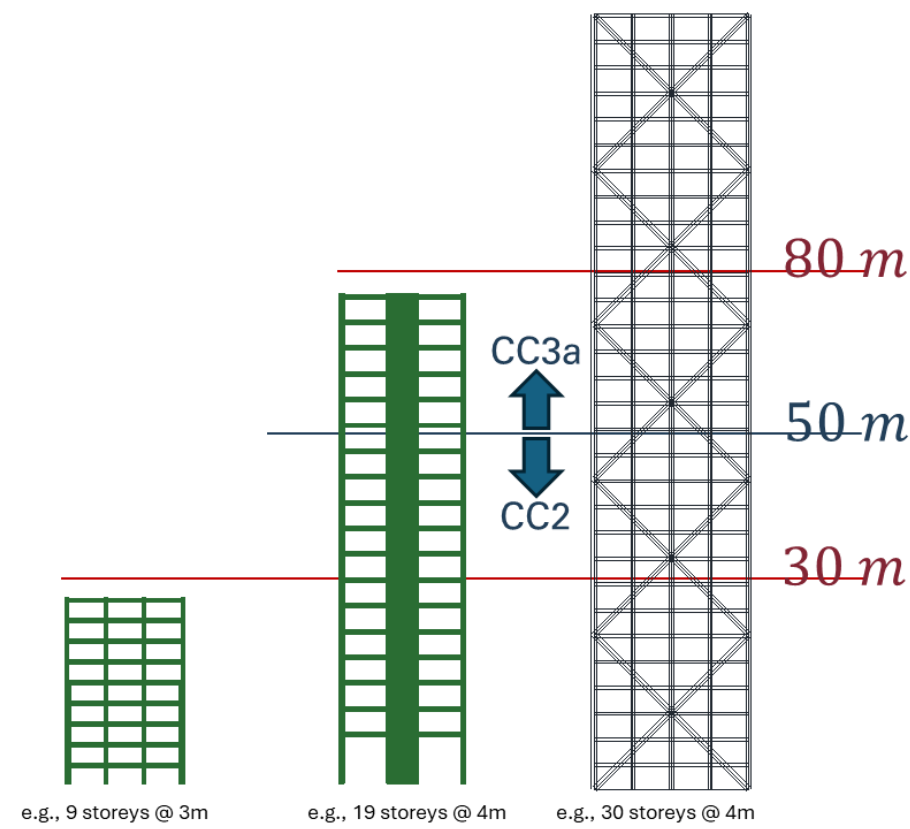
Buildings (1/2)

- Rationalization of the Force Based Approach;
- Increased transparency: behavior factor with explicit the contributions to the reduction of forces and makes; more consistent values of q between construction materials; hardening independent of the overstrength factor;
- New ductility classes differentiated not only in the construction details but also in the design aspects: DC3 = CDA of NTC; DC2 \neq CD" of NTC: no hierarchy control at the nodes, only IDR control; DC1 = NTC non-dissipative structures;
- Axial force consistent with shear on beams in capacity design;
- Complete development of the Displacement Based Approach: Nonlinear analysis and checks in ductility and strength (brittle; deformability and strength models for nonlinear analysis and verification in the main text;
- Partial factors for each reliability-based resistant mechanism;
- Action return period related to target reliability;
- Target reliability consistent with the reliability implied by the FBA.



Buildings (2/2)

- The DBA is an innovative tool that allows true performance design;
- While in the USA or China "normal" buildings and tall buildings are covered by the code or by ad-hoc guidelines (e.g. TBI), with the new EN1998 both can be done;
- Introduced damping reduction with height for buildings over 30 m;
- Buildings over 50 m in height are in CC3a;
- Mandatory nonlinear analysis in step with SSI for buildings over 80;
- Part 1-1 contains guidance for selecting recordings (also allowed conditional spectrum);
- Part 5 contains all the necessary guidance for SSI.



FBA	Lateral force method	✓	✗	✗
	Response spectrum analysis	✓ with q	✓	✗
DBA	Nonlinear static analysis	✓	✓	✗
	Response history analysis	✓	✓	✓ with SSI
Damping		$\xi = 5\%$	$\xi(H) \leq 5\%$	14

Cruz, Miranda. 2021. "Damping Ratios of the First Mode for the Seismic Analysis of Buildings."

Existing buildings (2/2)

- Structures = Buildings + Bridges (new specific chapter);
- Materials: CA, Steel, Masonry, but now also Wood;
- In particular, the chapters on metal structures, masonry and wood are completely new or rewritten;
- No longer one KL (LC) but three, distinct KLG, KLD and KLM to recognize the non-uniformity of information in the different categories;
- No longer just one KL but different KLs in different parts of the structure;
- Knowing everything about the upper floors of a building that develops a weak ground floor is not useful;
- Possibility of concentrating the cognitive activities downstream of a preliminary analysis (codified, Annex A);
- NC verification (SLC) by means of displacement -based approach (pushover);
- Partial factors dependent on the dominant KL (every resistive mechanism has one);
- Force-based approach allowed with limitations, low q values and fractions of the resistances determined by the tests taking into account the statistical uncertainty of estimation;
- Deformability and strength models consistent with those of new structures in Part 1-1.

Design criteria

Protection of the fastener

Protection of the attached element

	Type A	Type B
Capacity design		
Elastic design		
Fastener elongation		

Seismic action class	Connection	Design option	Ductility class of structure	
			DC1	DC2 & DC3
Low	Type A and Type B	OP1 or OP2	SPR1	SPR2
		OP3	SPR2	SPR2
Moderate or high	Type A	OP2	SPR2	SPR2
		OP3	SPR2	SPR2
	Type B	OP1	SPR1	-
		OP2	SPR1	SPR2
		OP3	SPR2	SPR2

Design options (Annex G EC8-1 and EC2-4)

The design of fastenings should satisfy either option OP1, or OP2, or OP3, as defined in a) to c), in the seismic design situation:

a) OP1: design assuming elastic behaviour of the structure and fastening.

b) OP2: design with action effects in the fastenings allowing the connected members to exploit their maximum strength according to Capacity Design Rules given.

c) OP3: design with requirements on the ductility of the fasteners.

In design to OP1 or OP2, fasteners should not be accounted for energy dissipation in the global structural analysis or in the analysis of ancillary elements.

In design to OP3, fasteners may be accounted for energy dissipation in the global structural analysis or in the analysis of ancillary elements; in that case, a non-linear response history analysis should be performed, based on data provided by cyclic tests.

In design to OP3, the tension capacity of the steel components of the fastening should be smaller than the tension capacity related to concrete failure modes.

Qualification and testing protocols

Protection of the fastener

Type A (structural)

Load cycling

Within 'elastic' range

Crack cycling

May be not relevant

Type B (ancillary)

Load cycling

Within 'elastic' range

Crack cycling

Up to crack at yielding

Protection of the attached element

Load cycling

Over yielding

Crack cycling

May be more relevant

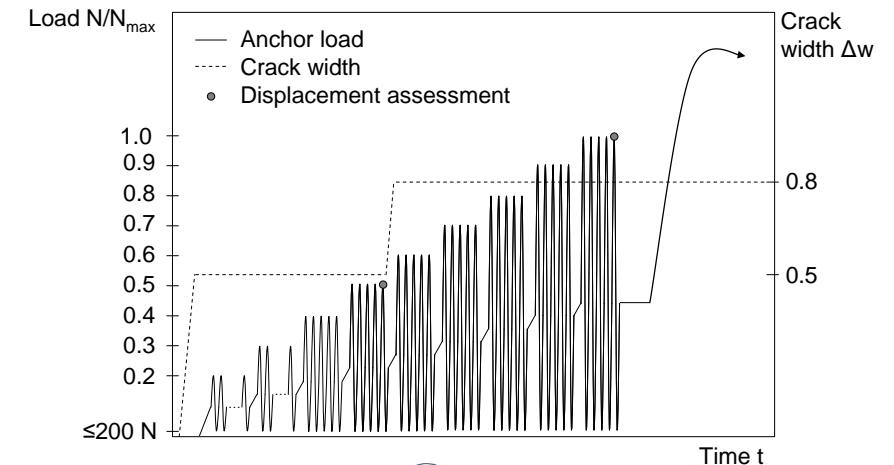
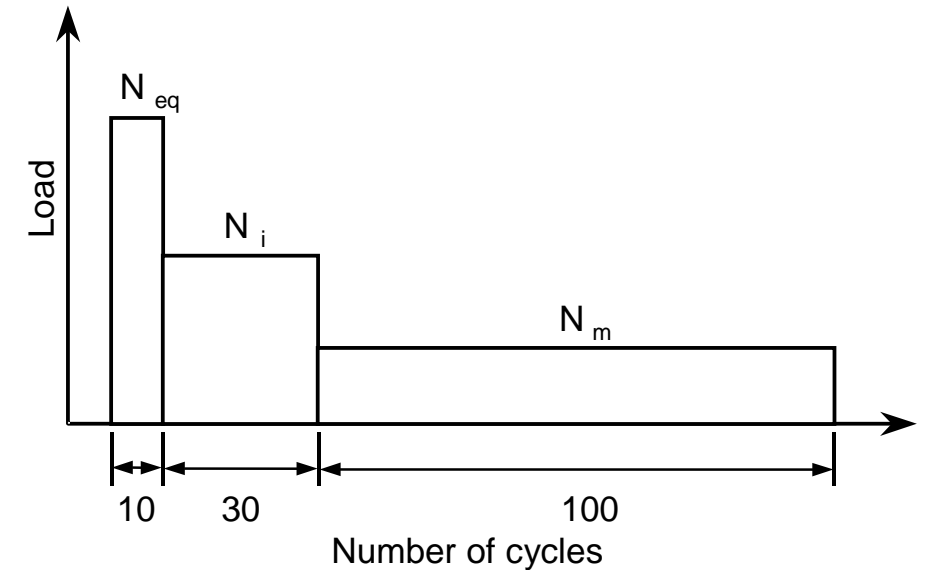
Load cycling

Over yielding

Crack cycling

Up to crack at yielding

Load level	N_{eq}	N_i	N_m
Number of cycles	10	30	100



Elephant foot buckling



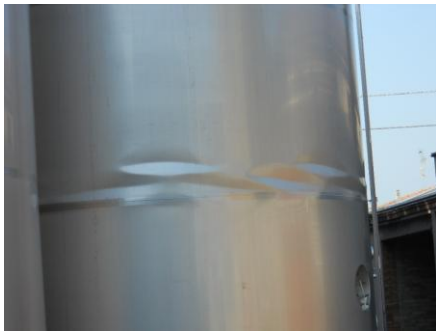
Damage at the base



Silos collapse



Diamond buckling



New EN 1998-4

- Completely new;
- consistent with EC0, EC1, EC2, EC3, and EC8;
- specific chapter for silos and leg-supported silos;
- overcoming the issue of flexible tanks vs. rigid tanks;
- spherical tanks, horizontal and truncated-conical tanks;
- new formulation for elevated tanks;
- addition of insulation systems and specific rules for non-structural elements (anchors, pipelines, etc.).

EC8-2G

Il nuovo standard europeo per la progettazione sismica



La seconda generazione dell' Eurocodice 8

5 giugno 2025

AGENDA

9.30-9.40	Introduzione alla giornata R. Pinho, Eucentre M. Dolce, ReLUIS G.M. Calvi, IUSS Pavia A. Penna, Università degli Studi di Pavia
9.40-9.50	L'aggiornamento degli Eurocodici e il ruolo della Commissione UNI-CIS R. Landolfo, Università degli Studi di Napoli Federico II
9.50-10.00	La seconda generazione dell'Eurocodice 8 I. Iervolino, Università degli Studi di Napoli Federico II e IUSS Pavia
Sessione 1 Azioni sismiche di progetto	
10.00-10.30	EN1998-1-1. Spettri elastici di progetto ed effetti di sito R. Paolucci, Politecnico di Milano
10.30-10.45	EN1998-1-1. Pericolosità sismica di progetto I. Iervolino, Università degli Studi di Napoli Federico II e IUSS Pavia
Sessione 2 Analisi e progettazione strutturale	
10.45-11.15	EN1998-1-1. Sicurezza, approcci alle forze e agli spostamenti, classi di duttilità P. Franchin, Sapienza Università di Roma
Sessione 3 Geotecnica	
11.15-11.45	EN1998-5. Fondazioni e opere di sostegno L. Callisto, Sapienza Università di Roma
Sessione 4 Materiali e tipologie costruttive	
11.45-12.15	EN1998-1-2. Strutture in calcestruzzo armato, sistemi di ancoraggio P. Riva, Università degli Studi di Bergamo
12.15-12.45	EN1998-1-2. Strutture metalliche e composte acciaio-CLS R. Landolfo, Università degli Studi di Napoli Federico II
12.45-13.30	<i>Pausa</i>
13.30-14.00	EN1998-1-2. Strutture in muratura, tamponature ed elementi costruttivi non strutturali G. Magenes, Università degli Studi di Pavia
14.00-14.30	EN1998-1-2. Strutture in legno M. Fragiocomo, Università degli Studi di L'Aquila
14.30-14.45	EN1998-2. Ponti P. Franchin, Sapienza Università di Roma
14.45-15.00	EN1998-4. Silos e serbatoi R. Nascimbene, IUSS Pavia
Sessione 5 Strutture esistenti	
15.00-15.30	EN1998-3. Conoscenza delle costruzioni e approcci dipendenti dal materiale S. Lagomarsino, Università degli Studi di Genova
Sessione 6 Dispositivi antisismici	
15.30-16.00	EN1998-1-2, EN1998-1-101. Strutture dotate di sistemi di isolamento/dissipazione e prestazioni dei dispositivi antisismici A. Pavese, Università degli Studi di Pavia



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