Asociación Caminos

# II Jornada sobre

# EUROCODIGOS 2G

## Novedades en el Eurocódigo 1 – Acciones sobre las estructuras

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Madrid, 4 Diciembre 2025

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# 1. General overview of the evolution of EN 1991

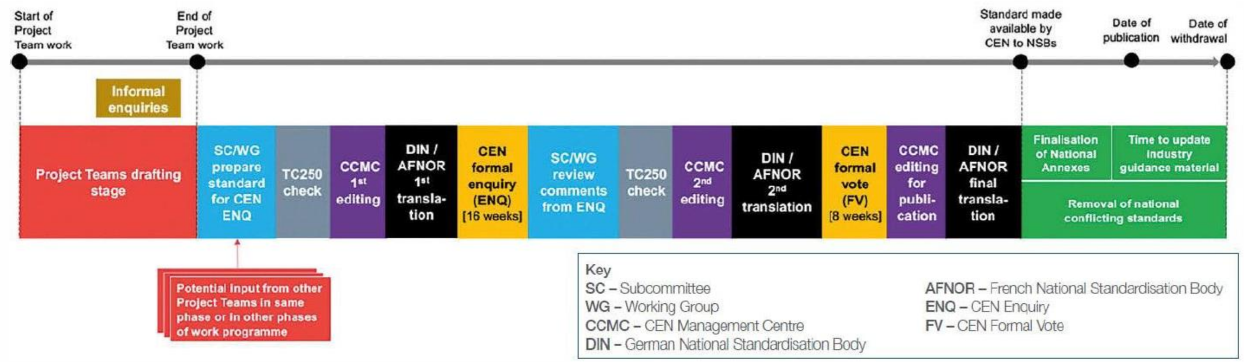


**FIGURE 1 — Eurocode development process**

# 2. General overview of the evolution of EN 1991 parts

| | | Date of Formal Vote | | | | num pags |
|---|---|---|---|---|---|---|
| EN 1991-1-1 | Peso específicos, pesos propios y sobrecargas de uso en edificios | | oct-24 | | | 46 |
| EN 1991-1-2 | Acciones en estructuras expuestas a fuego | oct-23 | | | | 75 |
| EN 1991-1-3 | Cargas de nieve | | oct-24 | | | 41 |
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| EN 1991-1-5 | Acciones térmicas | | oct-24 | | | 37 |
| EN 1991-1-6 | Acciones durante la ejecución | | | oct-25 | | 33 |
| EN 1991-1-7 | Acciones accidentales | | | abr-25 | | 74 |
| EN 1991-1-8 | Acciones producidas por oleaje y corrientes en estructuras costeras | | | oct-25 | | 169 |
| EN 1991-1-9 | Acciones producidas por hielo amosférico | | oct-24 | | | 32 |
| EN 1991-2 | Cargas de tráfico en puentes | abr-23 | | | | 159 |
| EN 1991-3 | Acciones inducidas por grúas y maquinaria | | | oct-25 | | 53 |
| EN 1991-4 | Silos y depósitos | | | oct-25 | | 160 |
| | | | | | | 1170 |

# The Second Generation Eurocodes

Key changes and benefits through design examples

Online, 3-5 June 2025

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# EN 1991 “Eurocode 1: Actions on structures”

Nick Malakatas, Mungo Stacy, Francesco Ricciardelli

CEN/TC 250/SC Chairman

# Contents

1. General overview of the evolution of EN 1991
2. General overview of the evolution of EN 1991 parts

Eurocode 1

EN 1991-1 Eurocode 1 – Actions on structures – Part 1-1: Specific weight of materials, self-weight of construction works and imposed loads on buildings
EN 1991-2 Eurocode 1 – Actions on structures – Part 1-2: Actions on structures exposed to fire
EN 1991-3 Eurocode 1 – Actions on structures – Part 1-3: Snow loads
EN 1991-4 Eurocode 1 – Actions on structures – Part 1-4: Wind actions
EN 1991-5 Eurocode 1 – Actions on structures – Part 1-5: Thermal actions
EN 1991-6 Eurocode 1 – Actions on structures – Part 1-6: Actions during execution
EN 1991-7 Eurocode 1 – Actions on structures – Part 1-7: Accidental actions
EN 1991-8 Eurocode 1 – Actions on structures – Part 1-8: Actions from waves and currents on coastal structures
EN 1991-9 Eurocode 1 – Actions on structures – Part 1-9: Atmospheric icing
EN 1991-2 Eurocode 1 – Actions on structures – Part 2: Traffic loads on bridges and other civil engineering works
EN 1991-3 Eurocode 1 – Actions on structures – Part 3: Actions induced by cranes and machinery
EN 1991-4 Eurocode 1 – Actions on structures – Part 4: Silos and tanks

# Key changes to EN 1991

- Update of **titles**
- **Common structure** of the core content of practically all EN 1991 parts (design situations; classification of actions; representation of actions)
- Incorporation in EN 1991 of two **new parts** based on relevant ISO standards, namely :
  - EN 1991-1-8 on “Actions from waves and currents on coastal structures”
  - EN 1991-1-9 on “Atmospheric icing”
- Consistency with the relevant Annexes of EN 1990 enhanced

# Key changes to EN 1991-1-1

- Clarification/update of some definitions
- Provision of a single table of imposed loads on buildings for all categories of use
- Idem for horizontal loads on partition walls and parapets
- Updates on partitions treated as imposed loads
- Updates on reduction factors:
  - Modified formula for the reduction factor $\alpha_A = 0.5 + \frac{10}{A} \leq 1{,}0$
  - Modified formula for the reduction factor $\alpha_n = \min\left\{0.7 + \frac{0.6}{n} ; 1\right\}$

# New content included in the scope of EN 1991-1-1 and enhancement of the Ease of Use

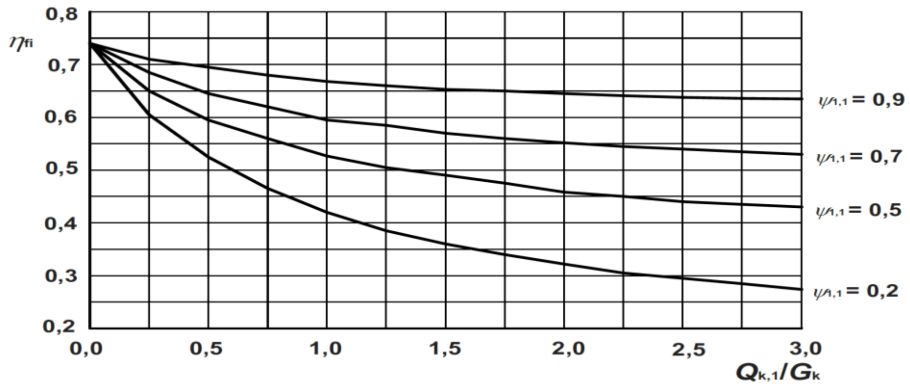
- Additional sub-category G2 of garages for vehicles with gross weight > 160 kN
- Additional class of helicopter HC3 for 60 kN < Q < 120 kN for category K roof
- Three subcategories S1, S2, S3 for stairs and landings and
- Inclusion of previously separated tables for various imposed loads on buildings in a single table integrating all categories and subcategories (but foreseen as NDP)
- Former Annex B (Vehicle barriers and parapets for car parks) removed

# Key changes to EN 1991-1-2

- Clarification/update of some definitions
- Scope clarified, in particular the non-coverage of:
  - the possible installation and maintenance of sprinkler systems;
  - conditions on occupancy of building or fire compartment;
  - the use of approved insulation and coating materials, including their maintenance
- Formulae and relevant diagrams are given as simplified rules for the determination of the reduction factor $\eta_{fi}$

$$E_{fi,d,t} = E_{fi,d} = \eta_{fi} \cdot E_d \qquad (6.1)$$

$$\eta_{fi} = \frac{G_k + \psi_{fi} Q_{k,1}}{\gamma_G G_k + \gamma_{Q,1} Q_{k,1}} \qquad (6.2)$$



# Key changes to EN 1991-1-2

- The **Annex E** on "**Fire load densities, Fire Growth Rates and Rate of Heat Releases**" has been revisited and led to the introduction of an updated and detailed <u>factor taking into account the different active fire fighting measures</u> (sprinkler, detection, automatic alarm transmission, firemen …) in the formula (E.1) for the evaluation of the design value of the fire load $q_{f,d}$ :

$$q_{f,d} = q_{f,k} \cdot m \cdot \delta_{q1} \cdot \delta_{q2} \cdot \delta_{\mathbf{n}} \cdot \delta_{q3} \qquad [MJ/m^2] \qquad (E.1)$$

**Table E.2 — Factors $\delta_{ni}$**

| Automatic Fire Suppression | | | | Automatic Fire Detection & Alarm | | | | Manual Fire Suppression | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Automatic Water Extinguishing System | Independent Water Supplies | | | Automatic Fire Detection & Alarm | | | Automatic Alarm Transmission To Fire Brigade | Fire Brigade | | Safe Access Route | | | Fire Fighting Device | | Smoke Exhaust System | |
| | 0 | 1 | 2 | By heat | By smoke | By heat & smoke | | Work FB | Off Site FB | Improved | Standard | Difficult | Present | Not present | Present | Not present |
| $\delta_{n1}$ | $\delta_{n2}$ | | | $\delta_{n3}$ | | | $\delta_{n4}$ | $\delta_{n5}$ | | $\delta_{n6}$ | | | $\delta_{n7}$ | | $\delta_{n8}$ | |
| 0,61 | 1 | 0,87 | 0,7 | 0,9 | 0,73 | 0,73 | 0,87 | 0,61 | 0,78/0,84 | 0,9 | 1 | 1,5 | 1 | 1,5 | 1 | 1,5 |

# Key changes to EN 1991-1-2 (new content)

- The scope of **Annex C** on the thermal action of a **localised fire** represented by a virtual solid flame as exposed in this annex has been clarified and substantially extended.
- In **Annex G** a model has been introduced for the evaluation of the virtual solid flame used in the determination of the "**configuration factor**" (expressing the diffusely radiated energy of heat transfer from one surface to another)
- A new **Annex H** (informative) on "**Thermal actions for structural fire loads of timber structures**" has been added, to be combined with the Annex A (informative) of EN 1995-1-2 on the "Design of timber structures exposed to physically based design fires"
- All Annexes remain informative

# Key changes to EN 1991-1-3 and new content

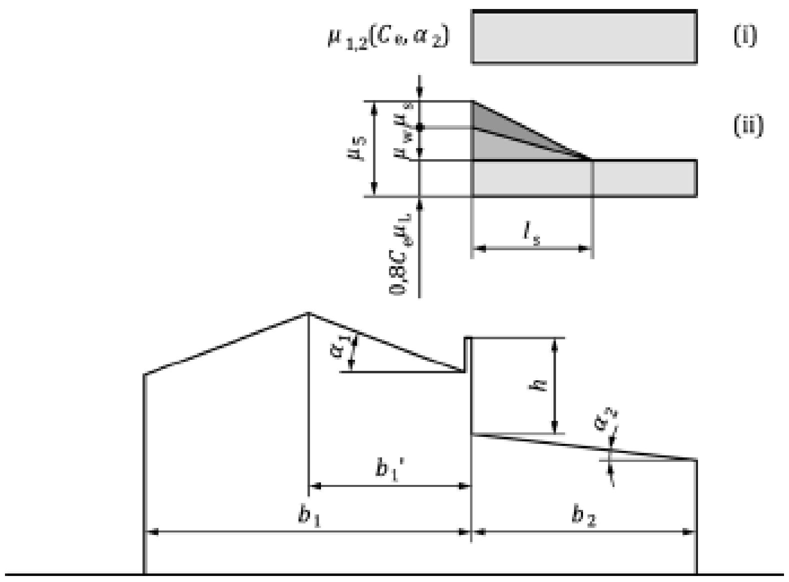
- Implementation of new models closer to the physics and based on state-of-the-art experimental data available for European climates, e.g. an updated model for the snow load on the roofs
- Consideration of snow load for additional types of roofs
- Implementation of updated and specific models for snow local effects
- As an example, the terms “**balanced**” and “**unbalanced**” are used in place of “undrifted” and “drifted”. (This terminology is also consistent with ISO 4355:2013 and with ASCE/SEI 7-16)
- The exposure coefficient **Ce** has been updated accordingly, in order to account for the increase of snow load in locally sheltered areas of the roof
- The snow coefficients have been revisited and a **new snow model** for **pitched (gabled) roofs** has been introduced
- For **flat roofs**, the influence of the roof dimensions is now taken into account, as well as the presence of rows of tilted (solar) panels

# Key changes to EN 1991-1-3 and new content

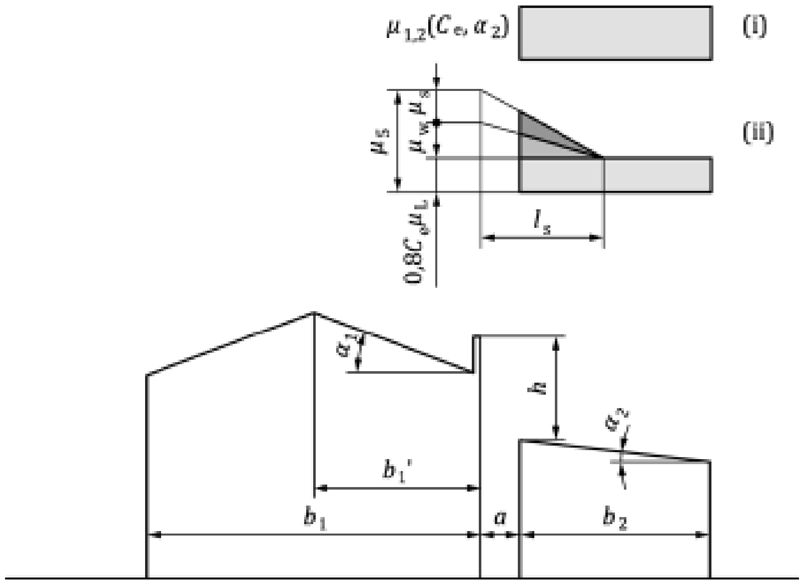
- For **cylindrical roofs** slightly updated model to account for variations in drifted snow load based on varying exposure coefficient.
- For **domes** a new snow load model is introduced, as a simplification of the relevant models of ISO 4355:2013 and with ASCE/SEI 7-16
- For **multi-span roofs** the model is revised to account for realistic snow load depths in the valley (not exceeding the ridge of the roof) and the effect of sliding in the valley
- Update to the snow load shape to account for the **drifting at obstructions** (snow load shape coefficient and drift length of obstructions are made dependent on the exposure coefficient)
- New snow load shape coefficients for **intersecting pitched roofs**

# Key changes to EN 1991-1-3 and new content

- **For roof abutting and close to taller construction works a new model for "unbalanced" snow load on the lower roof is introduced**, in order to correct inconsistencies detected in the current standard. The new model accounts for three different contributions: the load pertaining to the balanced condition (**$\mu_L$**), the sliding part from the upper roof (**$\mu_s$**) and the wind driven accumulated snow (**$\mu_w$**)



a) This load arrangement applies where $a = 0$ and $b_2 \geq l_s$



b) This load arrangement applies where $0 < a < l_s$

# Key changes to EN 1991-1-4 and new content

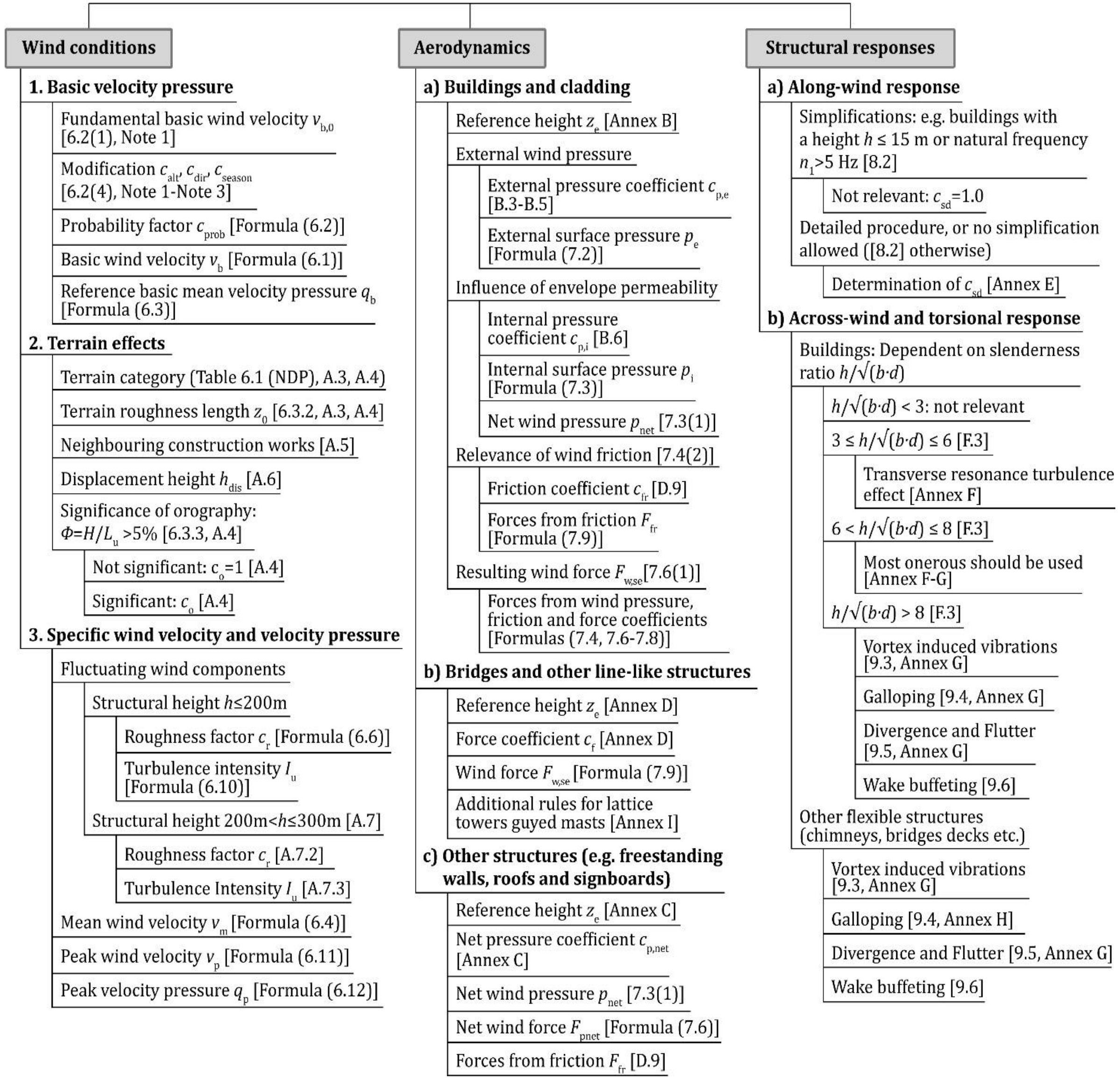
- **Extension of the field of application of the standard for guyed masts, other open lattice structures, chimneys and other slender structures up to 300 m high**
- Inclusion of an alternative wind model for slender structures with heights up to 300 $m$
- The two procedures defined in the current standard for determining the structural factor $c_{\mathrm{s}}c_{\mathrm{d}}$ (**along wing** dynamic response) have been unified in the informative Annex E, while the procedure for **across-wind** dynamic and aeroelastic response of **slender structures** is developed in the informative Annex G
- Treatment of the **across-wind and torsional actions** on susceptible buildings included in the informative Annex F
- Inclusion of the wind effects on **ice-accreted structures**
- Inclusion of wind actions on **silos and tanks**

# Key changes to EN 1991-1-4 and new content

- Many values of aerodynamic coefficients have been added for types of structures not considered in the current standard, to cover most of the current designs. Considering their large amount, they have been transferred into 3 new normative Annexes: B (**pressures on surfaces**), C (**net pressures coefficients and force coefficients for canopies**) and D (**force and friction coefficients**).
- A new Annex I (informative) on the response of **steel lattice towers and guyed masts** has been added (transferred from EN 1993-3-1).
- Guidance is given in three new informative Annexes J, K and L, respectively:
  - on the derivation of design parameters from **wind tunnel tests and numerical simulations (CFD)**
  - on the derivation of wind speeds **from measurements** at meteorological stations, and
  - on **probabilistic models** for wind actions.

# Key changes to EN 1991-1-4 and new content

## Figure 5.1 – Overview of the general design process and classification regarding the relevance of methods for individual design situations



# Key changes to EN 1991-1-5

- Some definitions and rules of application clarified and improved
- Guidance provided on how to determine the temperature components and temperature differences of different structural members within a structure
- For buildings a new presentation of temperatures - merging of tables for inner and outer temperatures
- New approach for the consideration of uncertainties related to the **initial bridge temperature $T_0$** of a structural member at the relevant stage of its restraint (completion) **and its range $\Delta T_0$** (see next slide); especially important for the design of bearings and joints
- For the evaluation of the **vertical components of temperature differences with non-linear effects on bridge decks** an improved presentation in the form of figures and tables has been provided, together with a couple of corrections of values

# Key changes to EN 1991-1-5

**Table 8.1 (NDP) — Maximum and minimum uniform bridge temperature $T_{N,max}$ and $T_{N,min}$**

| Bridge deck type | $T_{N,max}$ | $T_{N,min}$ |
|---|---|---|
| 1 | $T_{max} + 16$ | $T_{min} - 3$ |
| 2 | $T_{max} + 4$ | $T_{min} + 4$ |
| 3 | $T_{max} + 2$ | $T_{min} + 8$ |

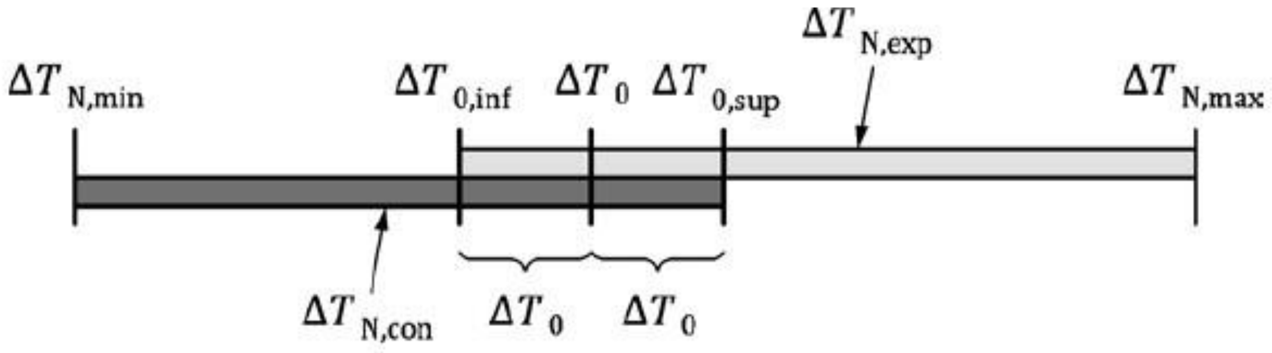



**Figure 8.1 — Characteristic value of the maximum contraction ($\Delta T_{N,con}$) and expansion ($\Delta T_{N,exp}$) range of the uniform bridge temperature component**

# Key changes to EN 1991-1-6 and new content

- Update and clarification of the scope and the assumptions
- Proper delimitation vis-à-vis the use of product standards relevant for auxiliary structures and equipment (e.g. falsework, temporary works equipment, scaffolds)
- Design of auxiliary structures clarified
- Improved description of the design situations and limited update of the classification and representation of actions
- Update of the guidance for the determination of the characteristic values of the climatic actions (new Table 6.1, former Table 3.1)
- Additional considerations on actions during execution (imperfections, lateral stability, dynamically applied actions)
- Former Annex B (Actions on structures during alteration, reconstruction or demolition) removed

# Key changes to EN 1991-1-6 and new content

**Table 6.1(NDP) — Guidance for the determination of the characteristic values of the climatic actions**

| Duration of the activities | Method for determining characteristic values |
|---|---|
| ≤ 5 days | The characteristic values are determined based on reliable meteorological data covering a period that extends over the entire planned maximum duration of the activity under analysis. |
| ≤ 1 year (but > 5 days) | The characteristic values are taken as specified in the applicable part of EN 1991 (i.e. based on an annual probability of exceedance of 0,02), accounting, when applicable, for seasonal variations by seasonal factors. |
| > 1 year | The characteristic values are taken as specified in the applicable part of EN 1991 (i.e. based on an annual probability of exceedance of 0,02), but neglecting seasonal factors. |

(2) Threshold values (or a range of values) of a specific climatic action may be used if specified by the relevant authority and agreed for a specific project by the relevant parties.

NOTE Providing a threshold value (or a range of values) of a climatic action can be relevant in cases where the decision to start or continue an execution activity is made dependent on checking whether values of that action meet the threshold value.

# Key changes to EN 1991-1-7 and new content

- Exclusion from the scope of actions from ship operations as berthing and mooring, as well as of actions due to high detonation explosions
- Limitation of the scope of Annex A to rules and actions for tying systems and key members
- Improvement of the compatibility with EN 1990 by transferring design strategies for robustness and related rules (to its Annex E related also to strategies for accidental design situations)
- Rearrangement of the categorization of consequence classes
- Clarifications for the impact from river, canal and seagoing vessels
- Addition of ship impact formulas for non-ice-classed vessels
- Clarification about internal explosions
- Addition of a new Annex E on actions from debris

# Content of  EN 1991-1-8 (new standard)

- There has not been so far an EN 1991-1-8, therefore any “changes” could only make sense if a comparison is made against ISO 21650:2007 upon which (as background) EN 1991-1-8 is based
- As compared with ISO 21650 the following key differences can be stated:
  - EN 1991-1-8 is intended to be a standard referring to actions (only) while ISO 21650 covers actions and modelling (actions effects) and also touches some resistance aspects of the design.
  - ISO 21650 is only briefly covering aspects of reliability, while partial factors and combinations of actions are missing. Achieving full consistency with EN 1990 and the Eurocodes framework in general is hardly feasible in view of some design provisions of ISO 21650, **especially in the case of (rubble) mound breakwaters (RMBW)**, for which after lengthy discussions it was decided to be excluded form the scope of this standard and **a relevant CEN TS to be drafted instead**

# Content of EN 1991-1-8 (new standard)

## Contents

# Content of  EN 1991-1-8 (new standard)

# Exclusions from the content of EN 1991-1-8

Actions addressed in EN 1991-1-8 do not cover:

- hydraulic resonance in sheltered areas or basins (phenomena also known as **harbour** resonance);
- translation waves, e.g. **tsunamis**;
- waves and currents induced by maritime operations, i.e. vessel wake, **berthing and mooring**;
- hydrodynamic actions induced by **earthquakes**;
- **ice-induced** pressures and forces;
- coastal structures where **flood risk** and/or erosion or sediment management is the dominant function.

# Content of  EN 1991-1-8 (new standard)

- As most significant items of the standard can be considered the following:
  - A comprehensive definition of design **“Environmental sea conditions”** (essentially water level, wave conditions, currents). Detailed guidance is provided in Annex A
  - The implementation of the **“Hydrodynamic Estimate Approach”” (HEA)**, which is defined as : “methodology to assess metocean parameters that relates to the consequence class of the structure and the local hydrodynamic conditions”
  - The implementation of **“Design Approaches” (DA)**

The purpose is that methods and requirements for the design can be outlined depending on the HEA-level, the DA-Level and the Consequence Classes (CC).

# Content of EN 1991-1-8 (new standard)

- **Design Approaches**:
  - **DA1** : Partial factor method
  - **DA2** : Reliability based design approach
  - **DA3** : Risk-informed decision-making design approach
  - **DA4** : Design assisted by physical testing

# Content of EN 1991-1-8 (new standard)

**Table 4.3 (NDP) — Design approach selection matrix**

| **HEA level** | **Low-to medium structure design/ response uncertainty** | **High structure design/ response uncertainty** |
|---|---|---|
| HEA1 | DA1 | DA1 with DA4[a] |
| HEA2 | DA1 or DA2 | DA1 or DA2, with DA4[a] |
| HEA3 | DA1 or DA2 or DA3 | DA1 or DA2 or DA3, with DA4[a] |

a DA4 can be omitted if the structure is CC1 or CC2, and if the lack of model testing is compensated by added safety through the design (for example an increase of the characteristic return period, or an increase in the quality monitoring at the design and construction stages). DA4 can be omitted if the hydrodynamic actions and related uncertainty on the actions are sufficiently far from being design governing, i.e. other actions dominate the design.

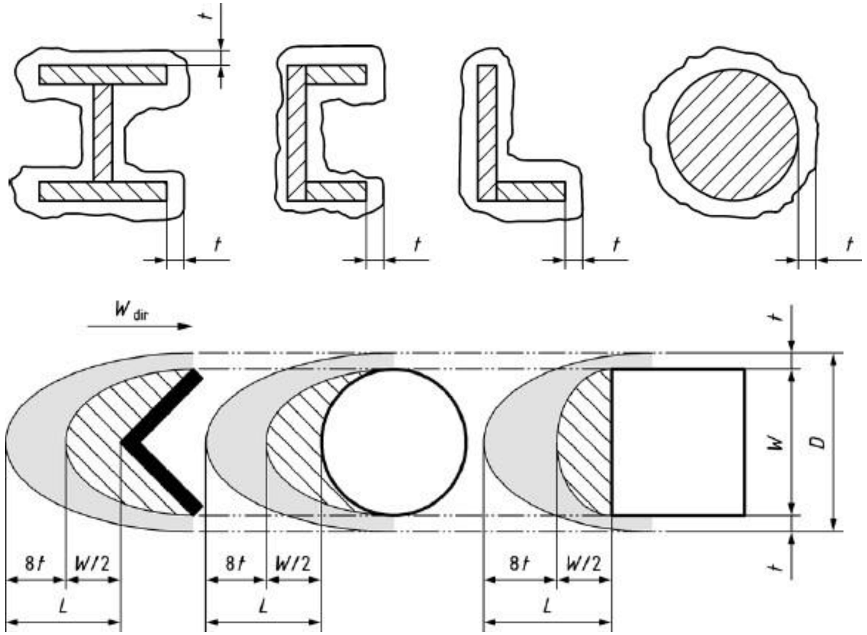
# Content of EN 1991-1-9 (new standard)

- There has not been so far an EN 1991-1-9, therefore any “changes” could only make sense, if a comparison is made against ISO 12494:2001 upon which (as background) EN 1991-1-9 is based
- Ice load is determined and classified according to **ice classes** (IC) for both **glaze** (ICG) and **rime** (ICR), because their characteristics differ. ICG should be determined for glaze deposits and ICR for rime deposits (see following slide)
- Combination with wind actions is considered
- New height factor is introduced for glaze ice
- Most information on how to measure and model atmospheric icing left open for the National Annexes
- In sum, EN 1991-1-9 is more compact than ISO 12494 and consistent with EN 1990 and the Eurocode style

# Content of EN 1991-1-9 (new standard)

- Ice thickness for ICGs **(glaze)**

| Ice classes ICG | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| Characteristic ice thickness *t* (mm) | 10 | 20 | 30 | 40 | 50 | * |
| * To be used for extreme ice accretions<br><br>NOTE The numbers represent the upper bound for the corresponding ICGs. | | | | | | |




- Ice masses for ICRs **(rime)**

| Ice classes for rime | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Characteristic Ice mass *m* (kg/m) | 0,5 | 0,9 | 1,6 | 2,8 | 5,0 | 8,9 | 16,0 | 28,0 | 50,0 | * |
| * To be used for extreme ice accretions<br><br>NOTE The numbers represent the upper bound for the corresponding ICRs | | | | | | | | | | |

# Key changes of EN 1991- 2 (and new content)

- **Extension of the scope and field of application (and associated change of title)** to include other civil engineering works (e.g. geotechnical works, but not buildings)
- Some changes for geotechnical items especially new wording (more accurate/ clear technical terms and definitions), mainly related to railway traffic loading
- Addressing the request of ERA (European Railway Agency, now European Union Agency for Railways) for the revision of some clauses in order to achieve consistency with TSI INF and relevant standards (e.g. EN 15528)
- Former Annexes F and G removed
- Update of Annex E (on limits of validity of Load Model HSLM)
- Adjustments in view of consistency with EN 1990-Annex A.2 and other Eurocodes bridge parts (following HG-B proposals)

# Key changes of EN 1991- 2 (and new content)

- **New subclauses 6.9 and 8.10 (Static load models for geotechnical structures – characteristic values), for road and railway traffic, respectively**
- Update of clauses related to the final CEN/TR 17231 for Track-Bridge interaction
- Including the bases of design for noise barriers at railway lines (transfer from EN 16727-2-2)
- Including of some new methods and materials (e.g. for footbridges and timber structures)
- Creating an updated clause 7 and a **new Annex G for footbridges** with additional special requirements related to EN 1990 Annex H, in particular on dynamic actions and pedestrian induced vibrations, based on state-of-the-art literature (guidelines and/or largely/commonly accepted methods and results); see next slide

# Key changes of EN 1991- 2 (and new content)

**Table G.1 — Traffic classes and harmonic load models**

| | | (G.4) | (G.5) | (G.6) |
|---|---|---|---|---|
| Traffic Class | Description | Pedestrian stream $P/m^2$ (A) | Pedestrian group $n_w$ (B) | Jogging group $n_j$ (C) |
| TC 1 | Very weak traffic | 0,1 | 1 | 0 |
| TC 2 | Weak traffic | 0,2 | 2 | 0 |
| TC 3 | Dense traffic | 0,5 | 4 | 1 |
| TC 4 | Very dense traffic | 1,0 | 8 | 2 |
| TC 5 | Exceptionally dense traffic | 1,5 | 16 | 4 |

$d$ = density [$P/m^2$ = pedestrians on loaded surface]
$n_w$ = number of pedestrians in a group
$n_j$ = number of joggers in a group

NOTE 1 As an example:
TC 2(A) = load model of pedestrian stream with pedestrian density of 0,2 × $P/m^2$
TC 4(B) = load model of group of 8 pedestrians
TC 3(C) = load model of a single jogger

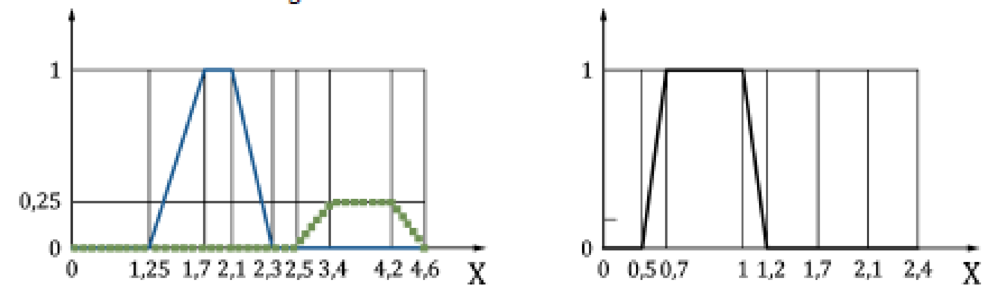
NOTE 2 Further guidance for the selection of design situations, depending on the usage and location of the bridge, is presented in EN 1990:2023, A.2.8.3 and Annex H.

For pedestrian stream load model minimum of 15 persons on the bridge deck should be assumed unless otherwise defined in the National Annex or for the individual project.

**Table G.2 — Parameters for load model of TC 1 to TC 5**

| $P_w$ N | | |
|---|---|---|
| Vertical | Longitudinal | Lateral |
| 280 | 140 | 35 |

Reduction coefficient $\psi_w$




Key
1. Harmonic
2. Harmonic
X frequency

Equivalent number $n'$ of pedestrians on the loaded surface $S$ for traffic classes TC1 to TC5:

TC 1 to TC 3 (density $d < 1,0\ P/m^2$):

$$n' = \frac{10,8\sqrt{\xi \cdot n}}{S}\ [1/m^2] \qquad (G.2)$$

TC 4 to TC 5 (density $d \geq 1,0\ P/m^2$):

$$n' = \frac{1,85\sqrt{n}}{S}\ [1/m^2] \qquad (G.3)$$

where

$\xi$ is the structural damping ratio;
$d$ is the density of pedestrians [$P/m^2$] (see Table G.1);
$n$ is the number of pedestrians on the loaded surface $S$ ($n = d \times S$);
$S$ is the area of loaded surface.

# Key changes of EN 1991- 3 (and new content)

- Clarification in the scope that the content concerns the structures supporting **bridge, gantry and wall cranes travelling on fixed runways** and **fixed machines** that cause a harmonic dynamic loading on fixed supporting structures
  - Setting of some additional principles and requirements on actions transferred from cranes or machines at the interface with their supporting structures
  - Update of the definitions, together with Annex A.5 of EN 1990, based on ISO 4306-1, especially on crane-related terms
- Improvement of the multiple crane operation
- Addition and clarification for the handling of in-service wind
- Removal of the former normative Annexes A (practically covered now by the Annex A.5 of EN 1990) and B (practically covered now by 6.9 and new Annex A)

# Key changes of EN 1991- 3 (and new content)

- More user-friendly guidance on actions from cranes travelling on fixed runways for two important standard cases:
  - **Main case** of application: Use of the technical data file for cranes designed according to a relevant European crane product standard
  - **Minor case** of application for existing older cranes: User-friendly guidance on how to determine the crane-induced actions, if no technical data file is available (new Annex B)
- Improved and updated classification of typical bridge and gantry cranes for the **fatigue design** of their supporting structure that is now consistent with the relevant crane product standard EN 15011 (new Annex A)
- Addition of guidance on the calculation of **actions from travelling wall cranes** as this information has been missing up to now (new Annex C).

# Key changes of EN 1991- 4 (and new content)

- A clear differentiation between silos with very different requirements is provided by classifying them according to action assessment, construction complexity, consequences of failure and stored bulk solid behavior
- A user-friendly structure with simple routes throughout the document and easy access to loads in silos designed for symmetrical conditions
- **Load modifying factors** have been introduced to address specific situations and materials of different Flow Group ending up with characteristic loads
- A **band load** has been introduced to cover the effective transition loads (fixed for Mass Flow and free for Mixed Flow)
- Improvement of the consistency with EN1990 Annex A4
- A new section added on **silos with inverted cone**
- Additional rules have been added on **rectangular silos with flexible walls**

# Key changes of EN 1991- 4 (and new content)

- New clauses have been added on **pressures in asymmetrical conical hoppers (mass flow)** and on **overpressure factors under mixed flow**, as well as on **thermal differential causing pressures** in different geometries
- A clear distinction is made between:
  - symmetrical loads on vertical silos (**S**ilo **F**undamental **L**oad **C**ases - **SFLC**), in the case of <u>symmetrical filling and discharge loads for silos of various slenderness and retaining silos, silo hoppers and bottoms</u> (in Sections 7 and 9); and
  - (**S**ilo **S**pecial **L**oad **C**ases - **SSLC**), in the case of <u>vertical walls, hoppers and silo bases with unsymmetrical pressures and high slenderness, large eccentricities of filling loads for squat or intermediate slender silos or pipe flow</u> and several other special cases (in Sections 8 and 10)
- The scope of **tank loads** has been extended to cover air and gas pressures

# Key changes of EN 1991- 4 (and new content)

## Table 5.2 — Eccentricity limits for all silos

| Silo Special Load Case depending on the eccentricity | Slender and very slender silos | Intermediate slenderness silos | Squat silos |
|---|---|---|---|
| Small filling eccentricity (SFLC rules) | $e_f < 0,30 d_c$ | $e_f < 0,20 d_c$ | $e_f < 0,20 d_c$ |
| Large filling eccentricity (SSLC Proxy load rules) | $e_f \geq 0,30 d_c$ (see 5.5.5) | $e_f \geq 0,20 d_c$ (see 5.5.6) | $e_f \geq 0,20 d_c$ (see 5.5.6) |
| Small discharge eccentricity (SFLC rules) | $e_e < 0,15 d_c$ | $e_e < 0,20 d_c$ | $e_e < 0,30 d_c$ |
| Moderate discharge eccentricity (SSLC Proxy load rules) | $0,15 d_c \leq e_e < 0,25 d_c$ (see 5.5.7) | $0,20 d_c \leq e_e < 0,30 d_c$ (see 5.5.8) | $0,30 d_c \leq e_e < 0,40 d_c$ (see 5.5.8) |
| Large discharge eccentricity (SSLC Pipe flow rules) | $e_e \geq 0,25 d_c$ (see 5.5.9) | $e_e \geq 0,30 d_c$ (see 5.5.9) | $e_e \geq 0,40 d_c$ (see 5.5.9) |

NOTE 1 Specific rules on the Silo Special Load Cases associated with large filling eccentricity and moderate and large discharge eccentricity are provided in 5.5.5 to 5.5.9.

NOTE 2 A 'small' eccentricity is deemed to be close to axisymmetric and the Silo Fundamental Load Case applies.

NOTE 3 See Figure 5.6 for the eccentricities of filling $e_f$ and discharge $e_o$.

# Key changes of EN 1991- 4 (and new content)

- A **new Annex G with flow charts** aid the use of the standard has been added

The flow charts are set out in the following sequence:

m) Silo Fundamental Load Cases for vertical walls (SFLC W)

n) Silo Fundamental Load Cases for hoppers and silo bases (SFLC H)

o) Silo Special Load Cases for vertical walls 1 (SSLC W1)

p) Silo Special Load Cases for vertical walls 2 (SSLC W2)

q) Silo Special Load Cases for vertical walls 3 (SSLC W3)

r) Silo Special Load Cases for hoppers and silo bases (SSLC H)

# Benefits of EN 1991 Second Generation

- Improvement and update of existing clause
- Extension of the scope(s) to cover additional items (specific conditions, design situations, types of structures etc.)
- Implementation of new parts
- Enhancement of the Ease of Use (easier navigation though the documents, most usual and classic cases covered in the main text, special cases dealt with in annexes)
- In most cases, decrase of the volume of the documents, as well as the number of retained NDPs

# Design examples

- Two separate presentations will follow with design examples (case studies), namely :

  - A steel building subjected to permanent actions, imposed loads, snow loads and wind actions

  - Wind actions on a medium to high rise building (including comparison with the current version of EN 1991-1-4)

# Copyright

# Thank you!

**Nick Malakatas**

Chairman of CEN/TC 250/SC 1