# Eurocode - Basis of structural design

# EN 1990 : Sections 3 & 4

COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG
EUROPEAN COMMITTEE FOR STANDARDIZATION

# EN 1990 : Section 3

## Principles of limit states design

# Requirements

**SAFETY**

**of people /of structure**

*resistance*

*stability*

**SERVICEABILITY**

*functions*

*comfort*

*appearance*

***DURABILITY***

*fatigue*

# Verification

**DESIGN SITUATIONS**

*persistent, transient, accidental, seismic*

**AGENTS**

*gravity, wind, solar radiation, earthquake…*

**ACTIONS**

*load, pressure, temperature, ground acceleration…*

**COMBINATIONS OF ACTIONS**

*actions likely to occur simultaneously*

**EFFECTS**

*force, moment, rotation, displacement*

# ULTIMATE LIMIT STATES

*rupture*

*collapse*

*loss of equilibrium*

*transformation into a mechanism*

*failure caused by fatigue*

# SERVICEABILITY LIMIT STATES

*deformations*

*vibrations*

*cracks*

*damages adversely affecting use*

# Design procedure

| REQUIREMENTS | |
|---|---|
| **SAFETY** | **SERVICEABILITY** |
| ***DURABILITY*** | |

DESIGN SITUATIONS

AGENTS

ACTIONS

COMBINATIONS OF ACTIONS

EFFECTS

| ULTIMATE LIMIT STATES | SERVICEABILITY LIMIT STATES |
|---|---|

# Limit state design

Structural and load models (physical or mathemetical) using design values for

- ***actions***
- ***material or product properties***
- ***geometrical data***

Load cases should be selected, identifying

- *load arrangements,*
- *possible deviations*
  *from assumed directions and positions of actions,*
- *sets of deformations and imperfections,*

that should be considered simultaneously

# Verifications at limit states

## ULTIMATE

- **Resistance :**

*effects of actions* $\boldsymbol{E_d \leq R_d}$ *resistance*

- **Static equilibrium :**

*destabilising actions* $\boldsymbol{E_{d,dst} \leq E_{d,st}}$ *stabilising actions*

## SERVICEABILITY

- **Criterion C :**

*design effect* $\boldsymbol{E_d \leq C_d}$ *design criterion*

# EN 1990 - Probabilistic methods

| CONSEQUENCES OF FAILURE | | | | STRUCTURAL RELIABILITY | | | |
|---|---|---|---|---|---|---|---|
| class | *Description* | | | class | Level III (full prob.) | Level II (FORM) | Level I (semi-prob.) |
| | *consequences for loss of human life* | | *economic, social or environmental consequences* | | failure probability $P_f$ | reliability index $\beta$ | multiplication factor $K_{FL}$ |
| CC3 | *high* | *or* | *very great* | RC3 | $10^{-7}$ | 5,20 | 1,1 |
| CC2 | *medium* | *and* | *considerable* | RC2 | $10^{-6}$ | 4,75 | 1,0 |
| CC1 | *low* | *and* | *small or negligible* | RC1 | $10^{-5}$ | 4,27 | 0,9 |

(1 year reference period)

# EN 1990 : Section 4

## Basic variables

# Actions and environment influences

# Actions and environment influences

## <u>CLASSIFICATIONS</u> :

- **permanent *G*** : *self-weight, shrinkage, settlements, prestressing* ***P*** *(imposed force/deformation),…*
- **variable *Q*** : *imposed loads, wind, snow, temperature,…*
- **accidenta**l ***A*** : *impacts, explosions, seismic actions…*

<u>NOTE</u> : *water* may be permanent or variable

*snow, wind, seismic actions* may be variable or accidental

- by **origin** : direct or indirect
- by **spatial variation** : fixed or free
- by **nature or structural response** : static or dynamic

# Representative values of actions

**Characteristic value** (main representative value) :

- mean value if variability small : $G_k$ , $P_m$
- upper or lower value if variability not small :
  - $G_{k,inf}$ (5 % fractile), $P_{k,inf}$
  - $G_{k,sup}$ (95 % fractile, i.e. probability of exceedence 5 %), $P_{k,sup}$
  - $Q_k$ (*climatic actions :* probability of exceedence 2 %/year)
  - $A_{Ek}$ (*seismic actions)*
- nominal value
- value specified for an individual project : $A_d$

# Other representative values of actions

**<u>Combination values</u>** $\Psi_0 Q_k$

- *for ultimate limit states of permanent and transient design situation*
- *for irreversible serviceability limit states*

**<u>Frequent values</u>** $\Psi_1 Q_k$ (e.g. during 1 % of the reference period)

- *for ultimate limit states of involving accidental actions*
- *for reversible serviceability limit states*

**<u>Quasi-permanent values</u>** $\Psi_2 Q_k$ (e.g during 50 % of the period)

- *for ultimate limit states involving accidental actions*
- *for reversible serviceability limit states*

# Material and product properties

Representative values from standardised tests :

- when a limit state verification is sensitive to variability :
  - **lower characteristic value** (5 % fractile)
    where a low value is unfavourable
  - **upper characteristic value** (95 % fractile,
    i.e. probability of exceedence 5 %)
    where a high value is unfavourable
- where statistical data are insufficient : **nominal values**
- **mean values** for structural stiffness and thermal expansion

Effects of repeated actions (fatigue) = reduction of resistance

# Geometrical data

Representative values :

- **characteristic values (**a prescribed fractile)
  where statistical distribution is sufficiently known
- directly **design values** (e.g. imperfections)

Tolerances for connected parts shall be mutually compatible

# Code of Hammurabi (1760 BC)

- *"If a builder build a house for some one, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death."* *(Art. 229)*

- *"If it ruin goods, he shall make compensation for all that has been ruined, and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means."* *(Art. 232)*

# Civil Code of Napoleon (1804)

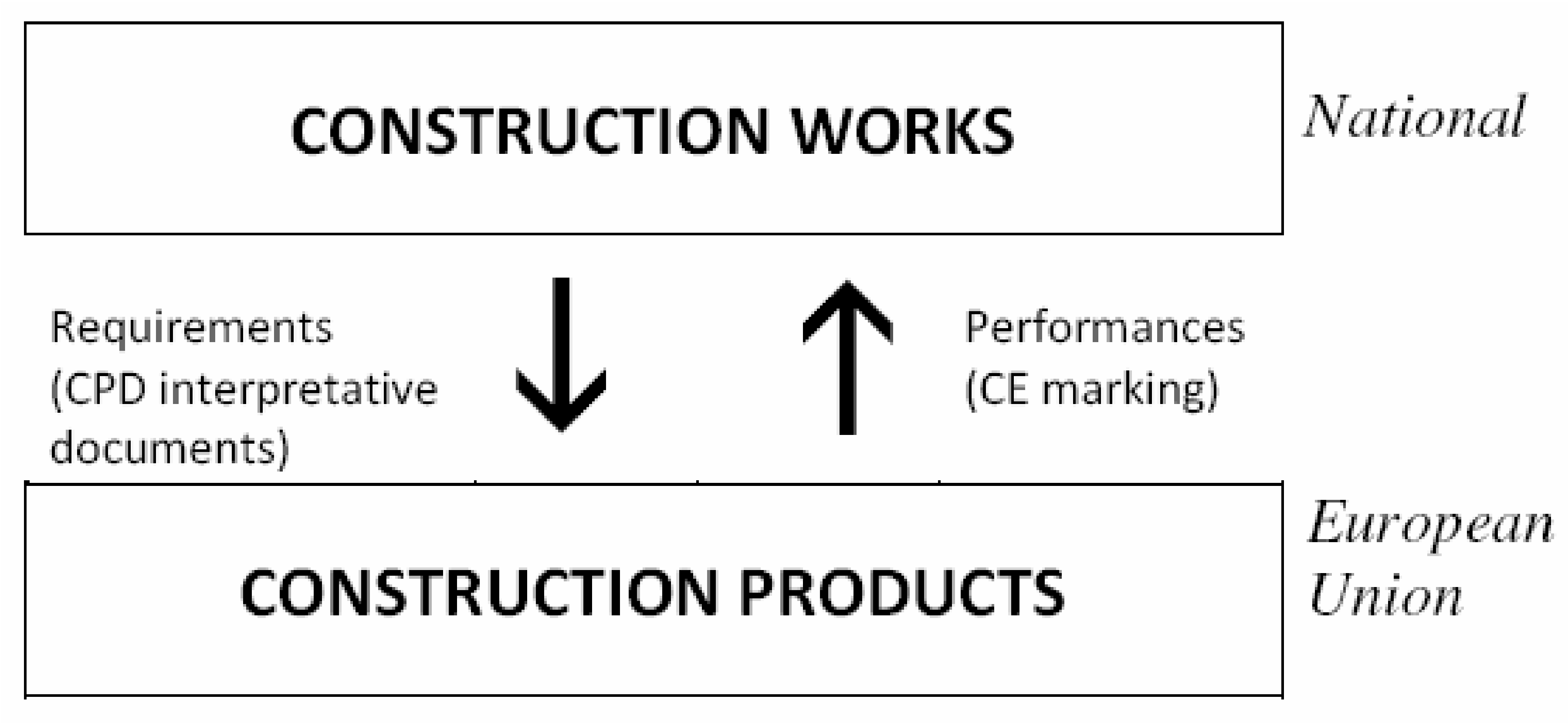
*"If the edifice, built at a set price,*
*perish in whole or in part*
*by defect in its construction,*
*even by defect in the foundation,*
*the architect and the contractor*
*are responsible therefor*
*for ten years."* *(Art. 1792)*

# Applicability of standards

## (calculation methods, e.g. Eurocodes)

| | | |
|---|---|---|
| *Source* | **CIVIL CODE** | **LAW** |
| *Technical requirements* | **JURISPRUDENCE of the COURTS** | **REGULATIONS** |
| *Application* | **a posteriori** | **a priori** |
| *Standards (e.g. Eurocodes)* | **Referenced good practice but not compulsory** | **Compulsory only if imposed by regulation** |

# Construction products directive



# Eurocodes : "a harmonised tool"

"***Beyond the defense of national positions,***"

like Jean MONNET wrote in his Memoirs,

"***something new and strong comes into living***

***within the team : it's the European spirit***

***which is the fruit of the work together***

***and, above all, of the need to come to***

***a common conclusion after the discussion.***"

# “the European spirit”

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*Merci de votre attention*