EU-Russia Regulatory Dialogue: Construction Sector Subgroup

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TC250 Structural Eurocodes

Basic Principles of the Eurocodes and their implementation

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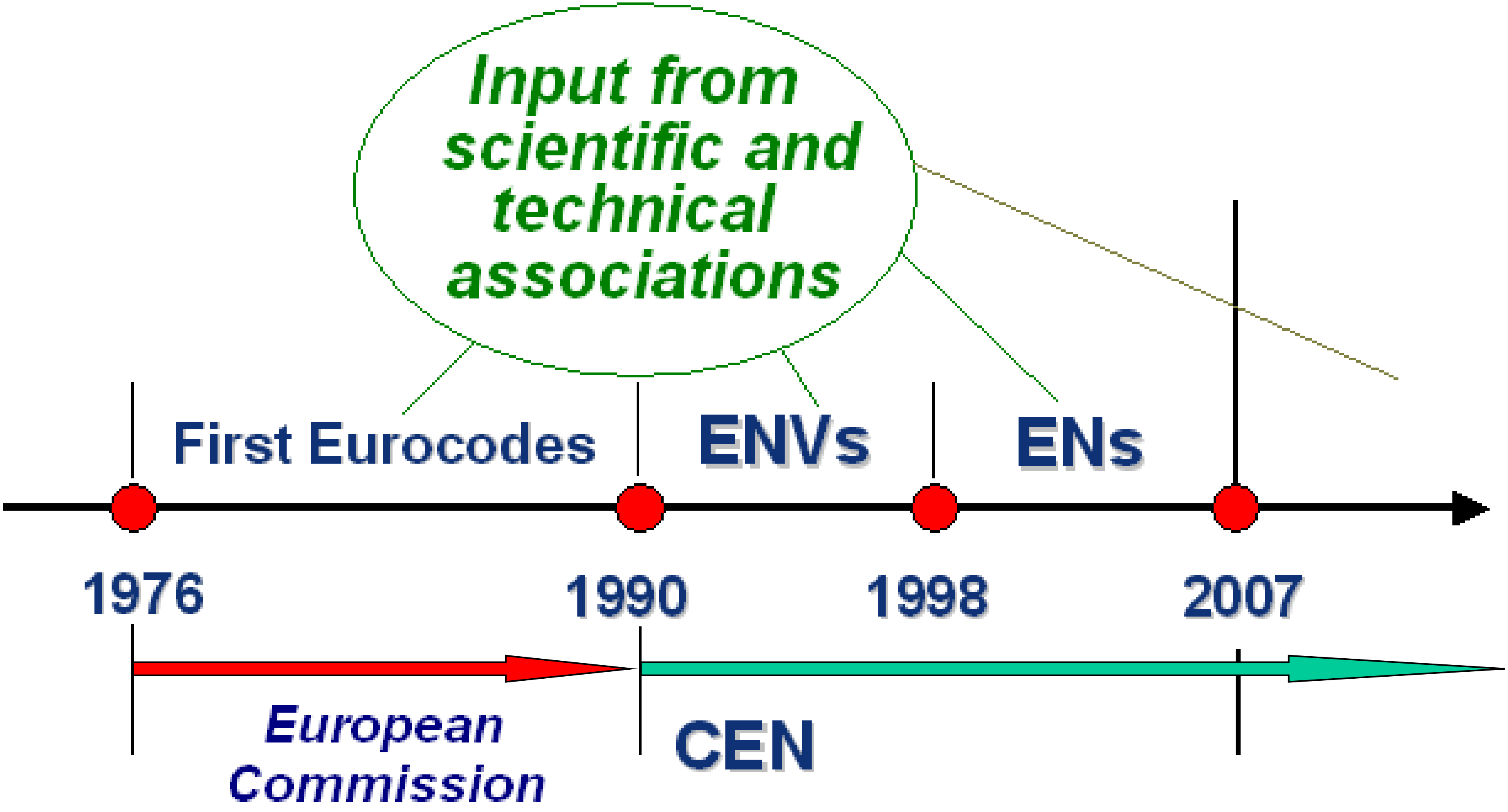
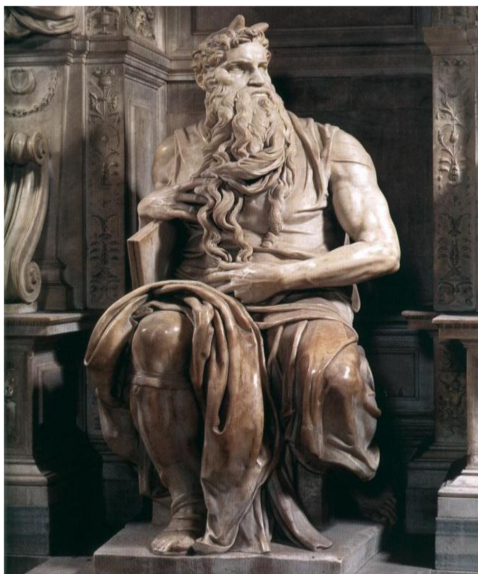


Development of the present generation of Eurocodes

THE EUROCODE FAMILY



EN 1990 Basis of Structural design

EN 1990 : BASIS OF STRUCTURAL DESIGN: CONTENTS

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BASIC PRINCIPLES

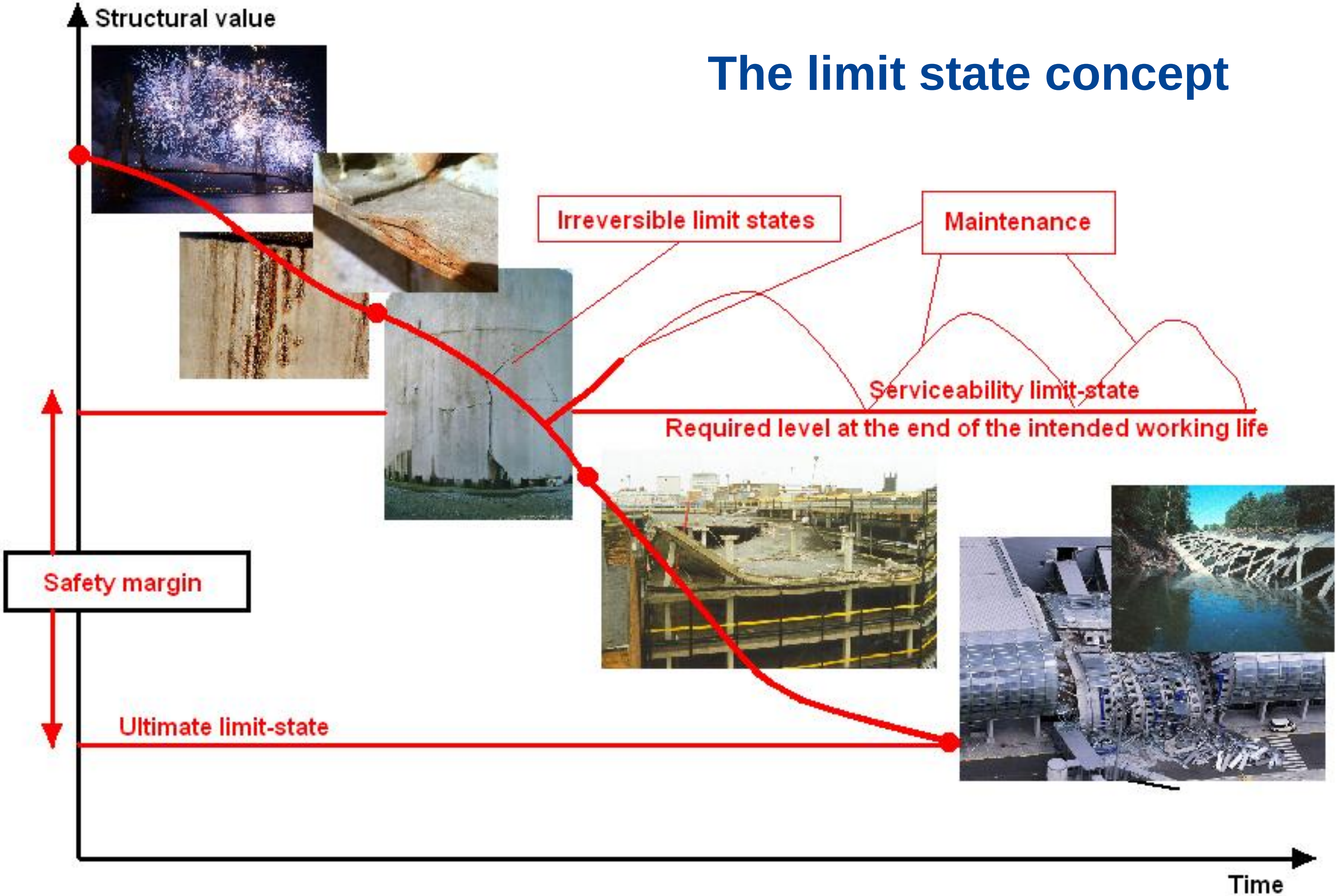
All Eurocodes are based on the

– limit state concept

used in conjunction with the

– partial factor method

The limit state concept



All Eurocodes are based on the following principles and requirements

- Safety
- Serviceability
- Durability
- Robustness

of structures

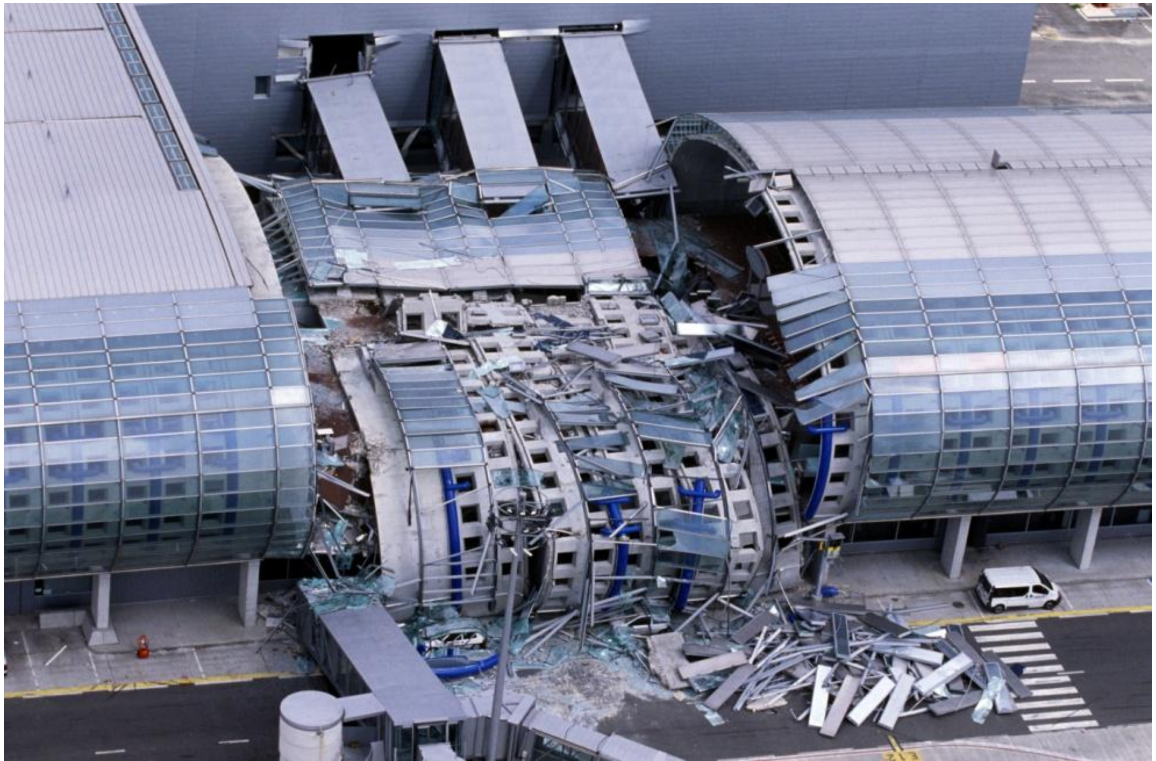
THE REQUIREMENTS

- Fundamental requirements (safety - including fire resistance - ; serviceability; durability; robustness)
- Reliability differentiation
- Design working life
- Durability
- Quality Assurance

The fundamental requirements in EN 1990 for the reliability of construction works include :

Structural safety: A structure shall be designed and executed in such a way that it will, during its intended life with appropriate degrees of reliability,

and in an economic way sustain all actions likely to occur during execution and use. Safety of people, the structure and contents.



Serviceability

A structure shall be designed and executed in such a way that it will, during its intended life with appropriate degrees of reliability and in an economic way

remain fit for the use for which it is required.

Functioning, comfort and appearance of the structure

Robustness

A structure shall be designed and executed in such a way that it will not be damaged by events such as

- **Explosions**
- **Impact and**
- **Consequences of human errors**

to an extent disproportionate to the original cause

Note: The events to be taken into account are those agreed for an individual project with the client and the relevant authority

THE REQUIREMENTS

- Fundamental requirements (safety; serviceability; durability, robustness and fire)
- Reliability differentiation
- Design working life
- Durability
- Quality Assurance

EN 1990 : BASIS OF STRUCTURAL DESIGN

Reliability differentiation

An appropriate degree of reliability for the majority of structures is obtained by design and execution according to Eurocodes 1 to 9, with appropriate quality assurance measures

EN 1990 provides guidance for obtaining different levels of reliability in Annex B (see later)

THE REQUIREMENTS

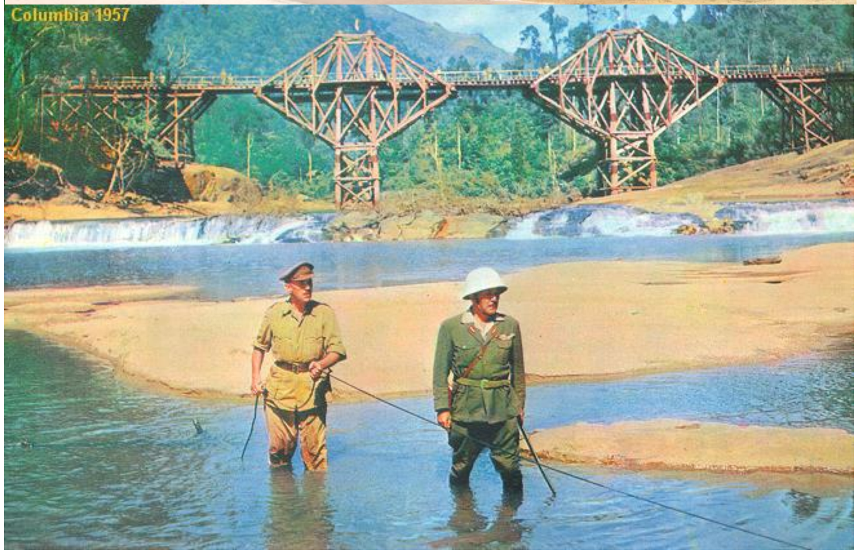
- **Fundamental requirements (safety; serviceability; durability; robustness)**
- **Reliability differentiation**
- **Design working life**
- **Durability**
- **Quality Assurance**

The fundamental requirements for design working life states :

The design working life is the assumed period for which a structure is to be used for its intended purpose with anticipated maintenance but without major repair being necessary

a design working life of

- **50 years for buildings**
- **100 to 120 years for bridges**



The concept of design working life is useful for:

- **The selection of design actions (e.g. wind, earthquake)**
- **Consideration of material property deterioration (e.g. fatigue, creep)**
- **Life cycle costing**
- **Evolution of maintenance strategies**

THE REQUIREMENTS

- Fundamental requirements (safety; serviceability; durability; robustness)
- Reliability differentiation
- Design working life
- Durability
- Quality Assurance

Durability

It is an assumption in design that the durability of a structure or part of it in its environment is such that it remains fit for use during the design working life given appropriate maintenance

The structure should be designed in such a way that deterioration should not impair the durability and performance of the structure having due regard to the anticipated level of maintenance

Durability

Interrelated factors to be considered:

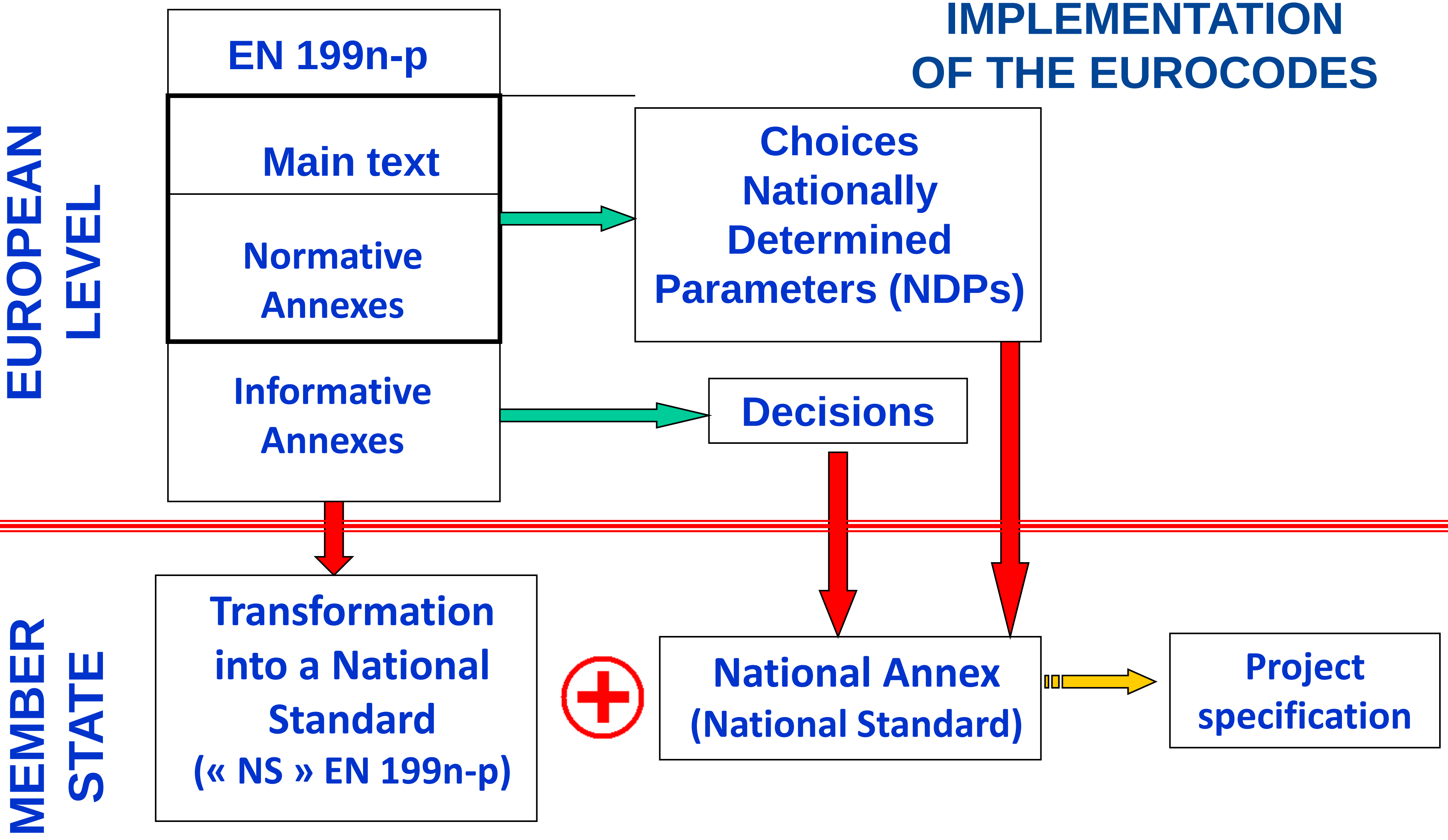
- The intended and future use of the structure
- The required performance criteria
- The expected environmental influences
- The composition, properties and performance of materials
- The choice of structural system

Durability

Interrelated factors to be considered (cont)

- The shape of members and structural detailing
- The quality of workmanship and level of control
- The particular protective measures
- The maintenance during the intended life

IMPLEMENTATION OF THE EUROCODES



ESSENTIAL REQUIREMENTS

SAFETY in CASE of FIRE

Concerning the construction work :

Load Bearing Capacity ... for a Specific Period of Time

The Generation and Spread of Fire and Smoke are limited

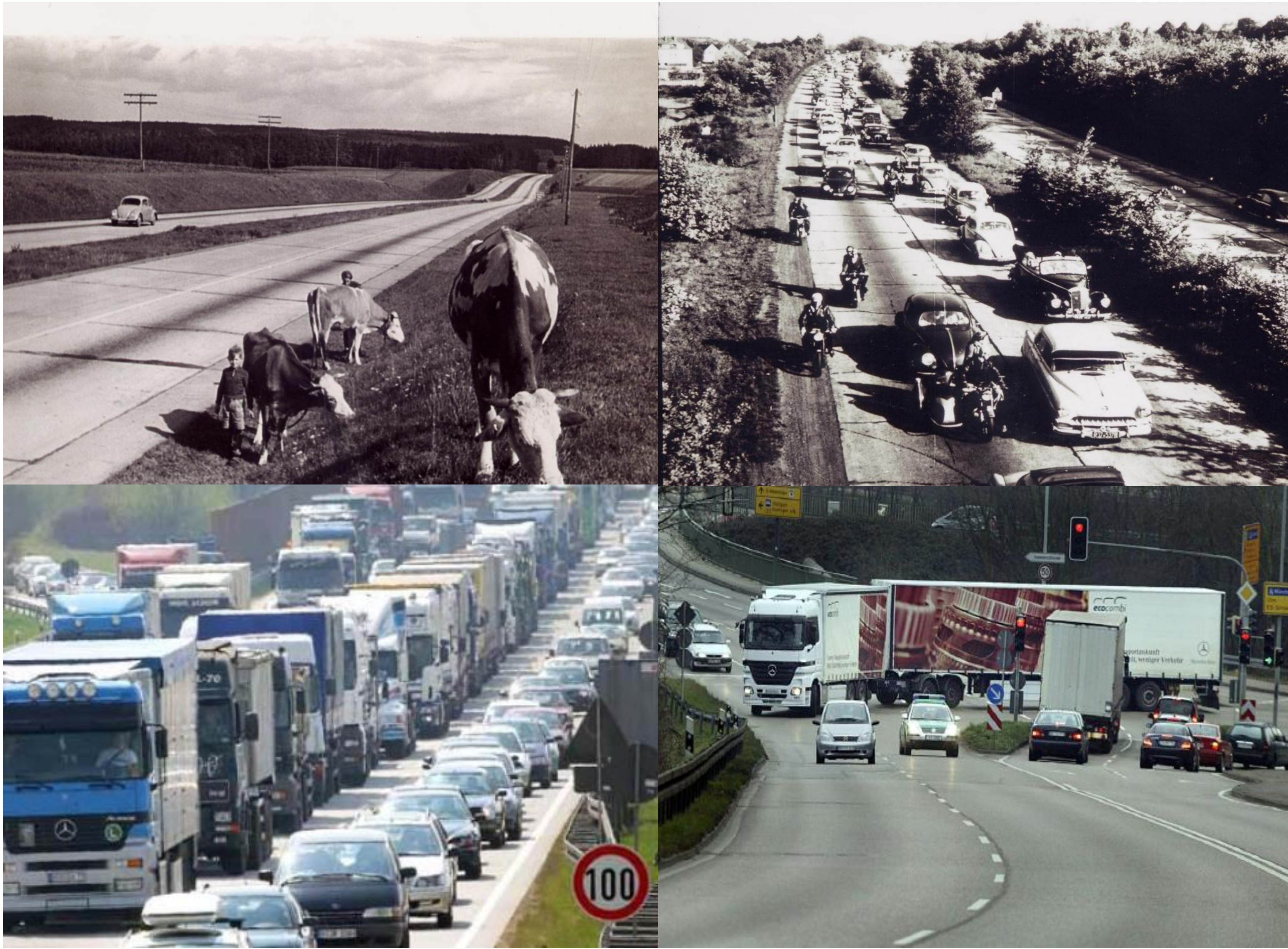
The Spread of Fire to Neighbouring Construction is limited

The Occupants can leave the Works or be rescued

The Safety of Rescue Teams is taken into Consideration

AP / Mike Meadows

EN 1991-2 - Traffic loads on bridges



EN 1990 Annex B (informative)

Management of Structural Reliability for Construction Works

B1 Scope and field of application

(1) This annex provides additional guidance to 2.2 (Reliability management) and to appropriate clauses in EN 1991 to EN 1999.

(2) The approach given in this Annex recommends the following procedures for the management of structural reliability for construction works (with regard to ULSs, excluding fatigue) :

a) In relation to 2.2(5)b, classes are introduced and are based on the assumed consequences of failure and the exposure of the construction works to hazard. A procedure for allowing moderate differentiation in the partial factors for actions and resistances corresponding to the classes is given in B3.

b) In relation to 2.2(5)c and 2.2(5)d, a procedure for allowing differentiation between various types of construction works in the requirements for quality levels of the design and execution process are given in B4 and B5.

NOTE Those quality management and control measures in design, detailing and execution which are given in B4 and B5 aim to eliminate failures due to gross errors, and ensure the resistances assumed in the design.

c) The procedure has been formulated in such a way so as to produce a framework to allow different reliability levels to be used, if desired.

B2 Symbols

In this annex the following symbols apply:

K_{FI} Factor applicable to actions for reliability differentiation

β Reliability Index

B3 Reliability differentiation

B3.1 Consequences classes

For the purpose of reliability differentiation, consequences classes (CC) may be established by considering the consequences of failure or malfunction of the structure as given in Table B1.

Table B.1 – Table B1 - Definition of consequences classes

Consequences Class	Description	Examples of buildings and civil engineering works
CC3	High consequence for loss of human life, *or* economic, social or environmental consequences very great	Grandstands, public buildings where consequences of failure are high (e.g. a concert hall)
CC2	Medium consequence for loss of human life, economic, social or environmental consequences considerable	Residential and office buildings, public buildings where consequences of failure are medium (e.g. an office building)
CC1	Low consequence for loss of human life, *and* economic, social or environmental consequences small or negligible	Agricultural buildings where people do not normally enter (e.g. storage buildings), greenhouses

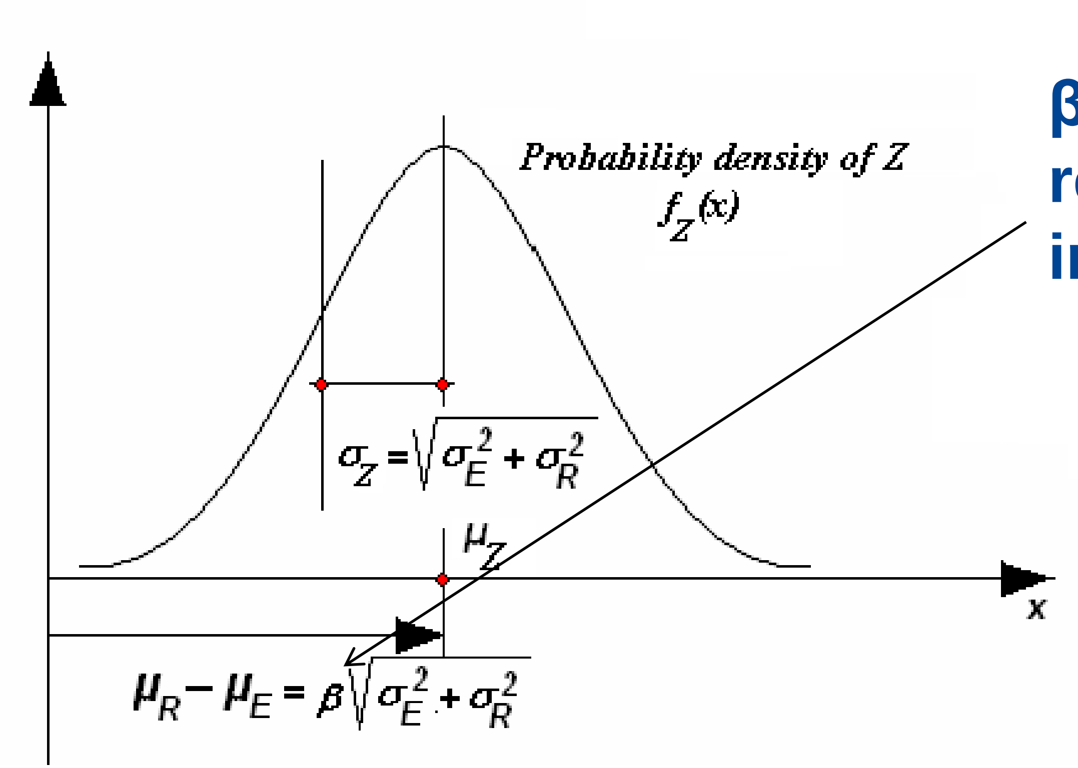
(2) The criterion for classification of consequences is the importance, in terms of consequences of failure, of the structure or structural member concerned. See B3.3

(3) Depending on the structural form and decisions made during design, particular members of the structure may be designated in the same, higher or lower consequences class than for the entire structure.

NOTE At the present time the requirements for reliability are related to the structural members of the construction works.

E	**Effect of actions (for example bending moment)**
R	**Resistance**
Z = R-E	**Safety margin**

E and R follow Normal laws characterized by their mean value and their standard deviation



β is the reliability index

B3.2 Differentiation by β values

(1) The reliability classes (RC) may be defined by the β reliability index concept.

(2) Three reliability classes RC1, RC2 and RC3 may be associated with the three consequences classes CC1, CC2 and CC3.

(3) Table B2 gives recommended minimum values for the reliability index associated with reliability classes (see also annex C).

NOTE A design using EN 1990 with the partial factors given in annex A1 and EN 1991 to EN 1999 is considered generally to lead to a structure with a β value greater than 3,8 for a 50 year reference period. Reliability classes for members of the structure above RC3 are not further considered in this Annex, since these structures each require individual consideration.

Table B2 - Recommended minimum values for reliability index β (ultimate limit states)

Reliability Class	Minimum values for β	
	1 year reference period	50 years reference period
RC3	5,2	4,3 (= 3,8 + 0,5)
RC2	4,7	3,8
RC1	4,2	3,3 (= 3,8 – 0,5)

B3.3 Differentiation by measures relating to the partial factors

(1) One way of achieving reliability differentiation is by distinguishing classes of γ_F factors to be used in fundamental combinations for persistent design situations. For example, for the same design supervision and execution inspection levels, a multiplication factor K_{FI}, see Table B3, may be applied to the partial factors.

NOTE In particular, for class RC3, other measures as described in this Annex are normally preferred to using K_{FI} factors. K_{FI} should be applied only to unfavourable actions.

(2) Reliability differentiation may also be applied through the partial factors on resistance γ_M. However, this is not normally used. An exception is in relation to fatigue verification (see EN 1993). See also B6.

Table B3 - K_{FI} factor for actions

K_{FI} factor for actions	Reliability class		
	RC1	RC2	RC3
K_{FI}	0,9	1,0	1,1

(3) Accompanying measures, for example the level of quality control for the design and execution of the structure, may be associated to the classes of γ_F. In this Annex, a three level system for control during design and execution has been adopted. Design supervision levels and inspection levels associated with the reliability classes are suggested.

(4) There can be cases (*e.g.* lighting poles, masts, etc.) where, for reasons of economy, the structure might be in RC1, but be subjected to higher corresponding design supervision and inspection levels.

B4 Design supervision differentiation

(1) Design supervision differentiation consists of various organisational quality control measures which can be used together. For example, the definition of design supervision level (B4(2)) may be used together with other measures such as classification of designers and checking authorities (B4(3)).

(2) Three possible design supervision levels (DSL) are shown in Table B4. The design supervision levels may be linked to the reliability class selected or chosen according to the importance of the structure and in accordance with National requirements or the design brief, and implemented through appropriate quality management measures. See 2.5.

Table B4 - Design supervision levels (DSL)

Design Supervision Levels	Characteristics	Minimum recommended requirements for checking of calculations, drawings and specifications
DSL3 relating to RC3	Extended supervision	Third party checking : Checking performed by an organisation different from that which has prepared the design
DSL2 relating to RC2	Normal supervision	Checking by different persons than those originally responsible and in accordance with the procedure of the organisation.
DSL1 Relating to RC1	Normal supervision	Self-checking: Checking performed by the person who has prepared the design

(3) Design supervision differentiation may also include a classification of designers and/or design inspectors (checkers, controlling authorities, etc.), depending on their competence and experience, their internal organisation, for the relevant type of construction works being designed.

NOTE The type of construction works, the materials used and the structural forms can affect this classification.

(4) Alternatively, design supervision differentiation can consist of a more refined detailed assessment of the nature and magnitude of actions to be resisted by the structure, or of a system of design load management to actively or passively control (restrict) these actions.

B5 Inspection during execution

(1) Three inspection levels (IL) may be introduced as shown in Table B5. The inspection levels may be linked to the quality management classes selected and implemented through appropriate quality management measures. See 2.5. Further guidance is available in relevant execution standards referenced by EN 1992 to EN 1996 and EN 1999.

NOTE Inspection levels define the subjects to be covered by inspection of products and execution of works including the scope of inspection. The rules will thus vary from one structural material to another, and are to be given in the relevant execution standards.

Table B5 - Inspection levels (IL)

Inspection Levels	Characteristics	Requirements
IL3 Relating to RC3	Extended inspection	Third party inspection
IL2 Relating to RC2	Normal inspection	Inspection in accordance with the procedures of the organisation
IL1 Relating to RC1	Normal inspection	Self inspection

B6 Partial factors for resistance properties

(1) A partial factor for a material or product property or a member resistance may be reduced if an inspection class higher than that required according to Table B5 and/or more severe requirements are used.

NOTE For verifying efficiency by testing see section 5 and Annex D.

NOTE Rules for various materials may be given or referenced in EN 1992 to EN 1999.

NOTE Such a reduction, which allows for example for model uncertainties and dimensional variation, is not a reliability differentiation measure : it is only a compensating measure in order to keep the reliability level dependent on the efficiency of the control measures.

European Commission

Thank you for your attention