EN 1990: Eurocode: Basis of Structural Design
The Key Head Eurocode
An Innovative Structural Safety Code Of Practice
EN 1990 – Sections 1 and 2

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SECTION 1 - GENERAL

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1.1 Scope

(1) EN 1990 establishes Principles and requirements for the safety, serviceability and durability of structures, describes the basis for their design and verification and gives guidelines for related aspects of structural reliability.

(2) EN 1990 is intended to be used in conjunction with EN 1991 to EN 1999 for the structural design of buildings and civil engineering works, including geotechnical aspects, structural fire design, situations involving earthquakes, execution and temporary structures.

NOTE For the design of special construction works (e.g. nuclear installations, dams, etc.), other provisions than those in EN 1990 to EN 1999 might be necessary.

(3) EN 1990 is applicable for the design of structures where other materials or other actions outside the scope of EN 1991 to EN 1999 are involved.

(4) EN 1990 is applicable for the structural appraisal of existing construction, in developing the design of repairs and alterations or in assessing changes of use.

NOTE Additional or amended provisions might be necessary where appropriate.
1.3 Assumptions

(1) Design which employs the Principles and Application Rules is deemed to meet the requirements provided the assumptions given in EN 1990 to EN 1999 are satisfied (see (2)).

(2) The general assumptions of EN 1990 are:

- the choice of the structural system and the design of the structure is made by appropriately qualified and experienced personnel;
- execution is carried out by personnel having the appropriate skill and experience;
- adequate supervision and quality control is provided in design offices and during execution of the work, i.e. factories, plants, and on site;
1.3 Assumptions (cont.)

- the construction materials and products are used as specified in EN 1990 or in EN 1991 to EN 1999 or in the relevant execution standards, or reference material or product specifications;
- the structure will be adequately maintained;
- the structure will be used in accordance with the design assumptions.

NOTE There may be cases when the above assumptions need to be supplemented.
1.4 Distinction between Principles and Application Rules

• The Principles (letter P) comprise:
  ➢ general statements and definitions for which there is no alternative, as well as
  ➢ requirements and analytical models for which no alternative is permitted unless specifically stated.

• It is permissible to use alternative design rules different from the application rules given in EN 1990, provided that it is shown that the alternative rules accord with the relevant principles and are at least equivalent with regard to resistance, serviceability and durability which would be achieved for the structure using Eurocodes.

NOTE If an alternative design rule is substituted for an application rule, the resulting design cannot be claimed to be wholly in accordance with EN 1990 although the design will remain in accordance with the Principles of EN 1990. When EN 1990 is used in respect of a property listed in an Annex Z of a product standard or an ETAG, the use of an alternative design rule may not be acceptable for CE marking.
1.5 Definitions

For the structural Eurocode suite, attention is drawn to the following key definitions, which may be different from current national practices:

- “Action” means a load, or an imposed deformation (e.g. temperature effects or settlement)
- “Effects of Actions” or “Action effects” are internal moments and forces, bending moments, shear forces and deformations caused by actions
- “Strength” is a mechanical property of a material, in units of stress
- “Resistance” is a mechanical property of a cross-section of a member, or a member or structure.
- “Execution” covers all activities carried out for the physical completion of the work including procurement, the inspection and documentation thereof. The term covers work on site; it may also signify the fabrication of components off site and their subsequent erection on site.
1.6 Symbols

Some Important Terms

Actions ($F$)
- Permanent Actions ($G$)
- Variable Actions ($Q$)
- Accidental Actions ($A$)
- Seismic Action ($A_e$)

Values of Actions

Representative Values of Actions
- Characteristic Value ($Q_k$)
- Combinations Value of a Variable Action ($\psi_0 Q_k$)
- Frequent Value of a Variable Action ($\psi_1 Q_k$)
- Quasi-permanent Value of a Variable Action ($\psi_2 Q_k$)
THE REQUIREMENTS

Fundamental requirements (safety; serviceability; robustness and fire)
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**
The fundamental requirements: 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.
EN 1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

Robustness - Limits of admissible damage

(A) is:

- 15% of the floor area or
- 100m² whichever is the smaller, in each of two adjacent storeys

(B) : Notional columns to be removed

a) is the plan
b) is the elevation

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Robustness of Buildings and Civil Engineering Works

Limiting potential damage from identified hazards

EN 1990 gives principles for limiting potential damage by a number of means including:

- avoiding, eliminating or reducing the hazards to which the structure can be subjected;
- selecting a structural form which has low sensitivity to the hazards considered;
- selecting a structural form and design that can survive adequately the accidental removal of an individual member or a limited part of the structure, or the occurrence of acceptable localised damage;
- avoiding as far as possible structural systems that can collapse without warning;
- tying the structural members together.

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Robustness: Acceptable extent of collapse in the event of a local failure in a large span building

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

**Fire:** “In the case of fire, the structural resistance shall be adequate for the required period of time”

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**GOETEBORG DISCO FIRE**

30.10.1998

Disco approved for 150 people with 2 stairwells serving as escape ways

⇒ **BUT DISCO WAS OVERCROWDED** and **FIRE OCCURRED WITH ONE STAIRWELL USED FOR STORAGE OF CHAIRS !!**

⇒ **INSUFFICIENT ESCAPE MEANS** & **NO SMOKE DETECTION**

⇒ ⇒ **63 YOUNG PEOPLE DIED**
THE REQUIREMENTS

Fundamental requirements (safety; serviceability; robustness and fire)
Reliability differentiation
Design working life
Durability
Quality Assurance
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.
Requirement: Reliability Differentiation

The choice of the levels of reliability for a particular structure should take account of the relevant factors, including:

- the possible cause and/or mode of attaining a limit state;
- the possible consequences of failure in terms of risk to life, injury, potential economical losses;
- public perception to failure;
- the expense and procedures necessary to reduce the risk of failure.
### Definition of Consequences Classes

<table>
<thead>
<tr>
<th>Consequences Class</th>
<th>Description</th>
<th>Examples of buildings and civil engineering works</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC3</td>
<td>High consequence for loss of human life, or economic, social or environmental consequences very great</td>
<td>Grandstands, bridges, public buildings where consequences of failure are high (e.g. a concert hall)</td>
</tr>
<tr>
<td>CC2</td>
<td>Medium consequence for loss of human life, economic, social or environmental consequences considerable</td>
<td>Residential and office buildings, public buildings where consequences of failure are medium (e.g. an office building)</td>
</tr>
<tr>
<td>CC1</td>
<td>Low consequence for loss of human life, and economic, social or environmental consequences small or negligible</td>
<td>Agricultural buildings where people do not normally enter (e.g. for storage), greenhouses</td>
</tr>
</tbody>
</table>
Probabilities Of Failure Associated With Limit States

Value associated with $\beta = 1.5$ (SLS, 50 years reference period)

Value associated with $\beta = 3.8$ (ULS, 50 years reference period)
Public perception does not accept fatalities and injuries due to structural failure (at home, at the work place, during recreational and other activities etc), for the design working life of a structure compared to fatalities arising from other hazards and events.
### EN 1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

**Accepted risks of death due to exposure to various hazards**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Risk ($\times 10^{-6}$ p.a.$^a$)</th>
<th>Hazard</th>
<th>Risk ($\times 10^{-6}$ p.a.$^a$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building hazards</strong></td>
<td></td>
<td><strong>Occupations (UK)</strong></td>
<td></td>
</tr>
<tr>
<td>Structural failure (UK)</td>
<td>0.14</td>
<td>Chemical and allied industries</td>
<td>85</td>
</tr>
<tr>
<td>Building fires (Australia)</td>
<td>0.4</td>
<td>Ship building and marine</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>engineering</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Agriculture</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction industries</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Railways</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coal mining</td>
<td>295</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarrying</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mining (non-coal)</td>
<td>1650</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Offshore oil and gas (1967-1976)</td>
<td>2800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep sea fishing (1959-1978)</td>
<td></td>
</tr>
<tr>
<td><strong>Natural hazards (U.S)</strong></td>
<td></td>
<td><strong>Sports (U.S)</strong></td>
<td></td>
</tr>
<tr>
<td>Hurricanes (1901-1972)</td>
<td>0.4</td>
<td>Cave exploration (1970-1978)</td>
<td>45</td>
</tr>
<tr>
<td>Tornadoes (1953-1971)</td>
<td>0.4</td>
<td>Glider flying (1970-1978)</td>
<td>400</td>
</tr>
<tr>
<td>Lightning (1969)</td>
<td>0.5</td>
<td>Scuba diving (1970-1978)</td>
<td>420</td>
</tr>
<tr>
<td>Earthquakes (California)</td>
<td>2</td>
<td>Hang gliding (1977-1979)</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parachuting (1978)</td>
<td>1900</td>
</tr>
<tr>
<td><strong>General accidents</strong></td>
<td></td>
<td><strong>All causes (U.K. 1977)</strong></td>
<td></td>
</tr>
<tr>
<td>(U.S 1969)</td>
<td></td>
<td>Whole population</td>
<td>12000</td>
</tr>
<tr>
<td>Poisoning</td>
<td>20</td>
<td>Woman aged 30</td>
<td>600</td>
</tr>
<tr>
<td>Drowning</td>
<td>30</td>
<td>Man aged 30</td>
<td>1000</td>
</tr>
<tr>
<td>Fires and burns</td>
<td>40</td>
<td>Woman aged 60</td>
<td>10000</td>
</tr>
<tr>
<td>Falls</td>
<td>90</td>
<td>Man aged 60</td>
<td>20000</td>
</tr>
<tr>
<td>Road accidents</td>
<td>300</td>
<td><strong>Risk expressed as probability of death for typical exposed person per calendar year</strong></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ Risk expressed as a probability of death for typical exposed person per calendar year

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EN 1990: Annex B: Tools for the management of structural reliability

Depending upon the consequences of failure, the main tools selected in EN1990 Annex B for the management of structural reliability of construction works are:

- differentiation by $\beta$ (reliability index) values; at this stage, this is a specialist activity;
- modification of partial factors;
- design supervision differentiation;
- inspection during execution
THE REQUIREMENTS

Fundamental requirements (safety; serviceability; robustness and fire)
Reliability differentiation
Design working life
Durability
Quality Assurance
The 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 years for bridges

is recommended in EN 1990.
<table>
<thead>
<tr>
<th>Design working life category</th>
<th>Design working Indicative life (years)</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>Temporary structures (1)</td>
</tr>
<tr>
<td>2</td>
<td>10 to 25</td>
<td>Replaceable structural parts, e.g. gantry girders, bearings</td>
</tr>
<tr>
<td>3</td>
<td>15 to 30</td>
<td>Agricultural and similar structures</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>Building structures and other common structures, not listed elsewhere in this table</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>Monumental building structures, highway and railway bridges, and other civil engineering structures</td>
</tr>
</tbody>
</table>

(1) Structures or parts of structures that can be dismantled with a view of being re-used should not be considered as temporary
Notion of design working life useful for

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

Fundamental requirements (safety; serviceability; robustness and fire)
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.

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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
THE REQUIREMENTS

Fundamental requirements (safety; serviceability; robustness and fire)
Reliability differentiation
Design working life
Durability
Quality Assurance
In order to provide a structure that corresponds to the requirements and to the assumptions made in the design, appropriate quality management measures should be in place. These measures comprise:

- definition of the reliability requirements,
- organisational measures, and
- controls at the stages of design, execution, use and maintenance.

EN ISO 9001:2000 is an acceptable basis for quality management measures, where relevant.
EN 1990: Selected Background Documents and further reading

1) ISO 2394: General principles on reliability for structures


Thank you for your attention