HISTORY OF STRUCTURAL EUROCODES

The idea to develop models for an international set of Codes for structural design for the different materials used in construction and applicable to all kinds of structures was born in 1974 based on an agreement between several technical-scientific organisations.

In May 1990 the European Committee for Standardization (CEN) created a new Technical Committee, CEN/TC 250 "Structural Eurocodes". This Committee was given the mandate to elaborate Codes of Practice within the following scope:

"Standardization of structural design rules for building and civil engineering works taking into account the relationship between design rules and the assumptions to be made for materials, execution and control."

In the first step, the individual Codes and their relevant parts are published as European prestandards (ENV). After a test period, their transposition into EN standards is planned. Final publication will depend to a great extent on CEN internal methods of proceeding.

EUROCODE PROGRAMME

The following structural Eurocodes, each generally consisting of a number of parts, will be released as ENs between 2000 and 2004. All exist at present as ENVs:

ENV 1990	Basis of Design
ENV 1991	Eurocode 1: Actions on structures
ENV 1992	Eurocode 2: Design of concrete structures
ENV 1993	Eurocode 3 : Design of steel structures
ENV 1994	Eurocode 4 : Design of composite steel and concrete structures
ENV 1995	Eurocode 5 : Design of timber structures
ENV 1996	Eurocode 6 : Design of masonry structures
ENV 1997	Eurocode 7 : Geotechnical design
ENV 1998	Eurocode 8 : Design of structures for earthquake resistance
ENV 1999	Eurocode 9 : Design of aluminium structures

Co-existence between Eurocodes & National Codes

After a Eurocode becomes an EN, under CEN rules there will be a period of co-existence, with the appropriate National Code (possibly five years) following which the National Code will cease to be maintained.

FUNDAMENTAL REQUIREMENTS OF STRUCTURAL EUROCODES

The common basic rules of structural design on the one hand:

follow the requirements for public safety and serviceability of structures based on the principle of risk on terms of reliability conditions.

They also require that as far as economic aspects are concerned, construction works are fit for their intended use and represent - adequate durability under normal maintenance conditions – an economically reasonable working life – further the structure should also be designed so that it will not sustain damage disproportionate to the original cause.

On the other hand, they follow

- the necessary liberty of the designers
- the efforts for innovation made by the construction industry

INFORMATION & EDUCATION ON THE STRUCTURAL EUROCODES

Evidence suggests that the use of the ENV Eurocodes by the design professions in Malta is almost non-existent. Awareness could be enhanced by:

- Greater publicity on:
  - ✓ The importance of Eurocodes and their supporting standards for the design and construction of structures in Malta
  - ✓ The objectives, use and timetable of implementation of the Eurocodes;
  - ✓ Information papers describing the emerging documents.
- A web site would also be a very useful method of communication
- The BICC and the Chamber of Architects & Civil engineers intend to provide:
  - ✓ Information t members, the publication of user guides, worked examples, CPD courses on the Eurocodes.

Encouraging universities to teach design based on the Eurocodes

- Universities should be encouraging the teaching of design to the Eurocodes.

FORMAT OF THE STRUCTURAL EUROCODES

- The format of the Eurocodes is different from other codes in that all clauses are designated either as Principles or Rules of Application.
- Principles are those fundamental bases of structural performance which must be achieved.
- Rules of Application are recommended methods of achieving those Principles Where alternative design rules from the Rules of Application are used, it must be shown that the alternative rules accord with the Principles and provide the equivalent reliability that would be achieved for the structure using the Eurocode. Thus a more flexible approach is adopted.
- Currently the ENV Eurocodes may be used for design purposes, in conjunction with the National Application Document (NAD) applicable to the Member State where the designed structures are to be located. NADs provide essential information.

RULES FOR APPLICATION: INDICATIVE VALUES

The Eurocodes contain a considerable number of parameters for which only indicative values are given. Each country may specify its own values for these parameters which are indicated by being enclosed by a box (|______|). The appropriate values which are at least equivalent with regard to the resistance, serviceability and durability achieved with present Eurocodes, are set out in the National Application Document (NAD). The NAD also includes a number of amendments to the rules in EC2 where, in the experimental stage of using EC2, it was felt that the EC2 rules either did not apply, or were incomplete. Two such areas are the design for fire resistance and the provision of ties, where the NAD states that the rules in BS 8110 should apply.

INFORMATION ON EUROCODE 2

Eurocode 2 is for the design of buildings and civil engineering works in plain, reinforced and prestressed concrete. It is concerned with the essential requirements for resistance, serviceability and durability of concrete structures.

The work on EC2 started in 1979 and was originally based on the CEB/FIP Model Code 1978. A first important step was the publication of a first draft for EC2 in 1984, issued in form of a Technical Report. EC2 was issued in form of a European Pre-Standard ENV at the end of 1991.

The due date for EN status appears to be 2002/03 for Common rules for buildings, whilst structural fire design extends to 2012. Part of EC 2 should become mandatory by 2008.

CONTENTS LIST OF EC 2 – part 1

UNUSUAL DEFINITIONS

BS 8110 differ from EC2 in that they contain a considerable amount of material which those drafting EC2 would have considered to belong more properly in a manual. E.g. bending moment coefficients for beams and slabs, design charts, etc.

One area where the EC2 terminology differs is its use of the word ‘actions’. This is a logical term used to describe all the things that can act on a structure. The definition states that it includes ‘direct actions’ (loads) and ‘ indirect actions’ (imposed deformations).

Self weight and dead loads are permanent actions normally represented by a unique value.

Superimposed loads are variable actions having different values depending on combination value ψ, rare load combination $\psi_{o,}$ frequent value ψ_1 , and quasi-permanent value $\psi_{2,}$ found in EC1.

An accidental action normally has a unique value.

LOADING CODES FOR THE USE OF EC2 WITH THE UK NAD

- BS 648 : 1964 Schedule of weights of building materials
- BS 6399 Loading for buildings
- BS 6399: Part 1: 1984 Code of practice for dead and imposed loads
- BS 6399: Part 3: 1988 Code of practice for imposed roof loads
- CP 3 Code of basic data for the design of buildings
- CP 3: Chapter V Loading
- CP 3: Chapter V: Part 2: 1972 Wind loads

The wind loading should be taken as 90% of the value obtained from CP3: Chapter V: Part 2: 1972

Table 1 - Partial Safety factors for actions in building structures for persistent and transient design solutions

Load combination	Permanent (γ_G)		Variable (γ_Q)		Wind
	Favourable effect	Unfavourable effect	Favourable effect	Unfavourable effect	
Permanent + variable	1.0	1.35	-	1.5	-
Permanent + wind	1.0	1.35	-	-	1.5
Permanent + variable + wind	1.0	1.35	-	1.35	1.35

Variable loads considered simultaneously are treated as primary & secondary loads. As both loads are not at their full value. This is considered by applying the factor ψ_o to the secondary load.

Table 2 - Characteristic values of imposed loads on floors in buildings and Ψ values

Loaded areas	UDL (kN/M^2)	Conc. Load (kN)	Ψ_o	Ψ_1	Ψ_2
Domestic	2.0	2.0	0.7	0.5	0.3
Offices	3.0	2.0	0.7	0.5	0.3
Assembly With fixed seats	4.0 5.0	4.0 4.0	0.7 0.7	0.7 0.7	0.6 0.6
Storage	5.0	7.0	1.0	0.9	0.8
Wind			0.6	0.5	0.0

Table 3 - Design value of actions for use in combination of actions

Design Situation	Permanent actions G_d	Single variable actions Q_d		Accidental actions or seismic actions A_d
		Dominant	Others	
Persistent and transient	$\gamma_G G_k$ $(\gamma_P P_k)$	$\gamma_{Q1} Q_{K1}$	$\gamma_{o1} \psi_{o1} Q_{k1}$	
Accidental	$\gamma_{GA} G_K$ $(\gamma_{PA} P_k)$	$\Psi_{11} Q_{K1}$	$\Psi_{21} Q_{1d}$	$\gamma_A A_k$ or A_d
Seismic	G_k		$\Psi_{21} Q_{1d}$	$\gamma_1 A_{Ed}$
Serviceability	G_k (P_k)	$\Psi_{21} Q_{k1}$	$\Psi_{21} Q_{k1}$	

(quasi permanent) where γ_1 is the importance factor (see EC8) and P_k is the prestressing action

For loading from several storeys, a reduction factor is used, given by :

$$\alpha_n = \frac{2+(n-2)\,\psi_o}{n}$$

PROBABILISTIC MODEL CODE

www.iabse.ethz.ch/lc/jcss.html

Most present day building codes are based on the Limit State Approach and the Partial Factor Method. However, as the full probabilistic design method may be considered as more rational and consistent than the partial factor design, there is a tendency to use probabilistic methods not only as a background for codes but also directly in the assessment of special or important structures, existing as well as under design. In Eurocode EN 1990 Basis of Design (Draft July 2000), the option of full probabilistic design is mentioned as an alternative.

Table 4 :EXAMPLES OF RELIABILITY DIFFERENTIATION ACCORDING TO LIFE AND ECONOMIC AND SOCIAL LOSS RISKS

Degree of reliability	Potential risk to life, risk of economic and social losses	Examples of buildings and civil engineering works
Extremely high	Very high	Nuclear power reactors, major dams and barriers, strategic defence structures
> normal	High	Significant bridges, grandstands, public buildings where consequences of failure are high
Normal	Medium	Residential and office buildings, public buildings where consequences of failure are medium
< normal	Low	Agricultural buildings where people do not normally enter, greenhouses, lightning poles

EC1 differentiates structures in relation to risk to life, and risk of economic and social losses, as in Table 1.

It is suggested that such a classification may be used to select appropriate degrees of reliability, according to such consequences.

Table 5 : DESIGN WORKING LIFE EXAMPLES

Design working life	Examples
1-5 years	Temporary structures
25 years	Replacement structural parts e.g. handrails, small canopies, protective features (slats, caps, etc.)
50 years	Buildings, footbridges and other common structures
100 years	Monumental buildings and other special or important structures
120 years	Highway and rail bridges

PROBABILITY OF BUILDING COLLAPSE

Hazard Consequences of building structures and civil engineering works

- Injury or less of life due to structural collapse
- Reconstruction Costs
- Loss of Economic activity

Complete certainty is statistically impossible and a probability of building collapsing is postulated low enough to be acceptable, with a 1:10,000 CHANCE (10^{-4}), on which the present Load factors are based.

Table 6 – Safety requirements in the Ultimate Limit Sate specified as the formal yearly probability of failure P_f and the corresponding reliability index β by the Nordic Committee (NKB)

Failure consequences (Safety class)	Failure type 1, Ductile failure with remaining capacity	**Failure type II, Ductile failure without remaining capacity**	Failure type III, Brittle failure
Less Serious (Low safety class)	$P_f \leq 10^{-3}$; $\beta \geq 3.09$	$P_f \leq 10^{-4}$; $\beta \geq 3.71$	$P_f \leq 10^{-5}$; $\beta \geq 4.26$
Serious (Normal safety class)	$P_f \leq 10^{-4}$; $\beta \geq 3.71$	$P_f \leq 10^{-5}$; $\beta \geq 4.26$	$P_f \leq 10^{-6}$; $\beta \geq 4.75$
Very serious (High safety class)	$P_f \leq 10^{-5}$; $\beta \geq 4.26$	$P_f \leq 10^{-6}$; $\beta \geq 4.75$	$P_f \leq 10^{-7}$; $\beta \geq 5.20$

To be noted that the Very high Safety Class listed in table 1 is not included in above table. The consequences are here regarded as extreme & a full cost-benefit analysis is recommended. The conclusion might be that the structure should not be built at all.