EN 1990: Eurocode: Basis of Structural Design: The Key Head Eurocode

An Innovative Structural Safety Code Of Practice

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Visiting Professor, Imperial College, London

EN 1990 - SCOPE OF PRESENTATION

An overview of EN 1990, in particular

- **EN 1990 ’s objectives, scope and interaction with the other Eurocodes**
- **The requirements**
- **Design situations, limit states and actions**
- **The verification procedure and partial factors**

EUROCODES
Building the Future

Building the Future in the Euro-Mediterranean Area

EN 1990 – Eurocode :

Basis of Structural Design

Ratification by NSBs:
29-11-2001

Date of availability :
24-04-2002

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

ADOPTED EUROPEAN STANDARD NORME EUROPÉENNE ADOPTÉE ANGENOMMENE EUROPÄISCHE NORM	EN 1990:2002
Eurocode - Basis of structural design	
Date of ratification (dor): 2001-11-29	CEN/TC 250

Mandated
BC/CEN/97/38.1.2 M/265

2002-04-24
EN 1990 00007/75027

WI: 00250076

Sehr geehrte Mitglieder,

aufgrund des positiven Ergebnisses der formellen Abstimmung senden wir Ihnen den vom Technischen Büro des CEN ratifizierten Text der o.g. Europäischen Norm zwecks Übernahme als nationale Norm unter Ihrer Verantwortung.

Ihre Verpflichtungen als CEN-Mitglied in Bezug auf Europäische Normen sind in der CEN/CENELEC Geschäftsordnung Teil 2, Abschnitt 5.2.2 festgelegt.

Wir bitten Sie, uns jede Information hinsichtlich der Übernahme dieser Europäischen Norm in Ihrem Land entsprechend der o.g. Geschäftsordnung zu übersenden.

In Übereinstimmung mit den Entscheidungen des Verwaltungsrates bezüglich der Verbesserung der Transparenz und Verfügbarkeit von ENs darf der ratifizierte Text der ENs schon vor der Übernahme als nationale Normen verkauft werden.

Anbei senden wir Ihnen eine Anmerkung auf blauem Papier, die als Deckblatt für den ratifizierten Text während dieser Übergangszeit gebraucht werden soll.

Mit freundlichen Grüßen

Dear Members,

Further to the favourable result of the formal vote, please find enclosed the text of the above-mentioned European Standard, as ratified by the CEN Technical Board, in view of its implementation as national standard under your responsibility.

Your obligations as a CEN Member towards European Standards are laid down in the CEN/CENELEC Internal Regulations Part 2, subclause 5.2.2.

We kindly request you to send us all information concerning your action for the implementation of this European Standard in your country according to the above-mentioned regulations.

In accordance with the decisions of the Administrative Board of CEN aiming at an improvement of the transparency and availability of ENs, the ratified text of the ENs may be sold in anticipation of the national standards transposing those ENs.

We enclose for your convenience a notice printed on blue coloured paper which is to be used as a cover page for the ratified text during this interim period.

Yours faithfully,

G. HONGLER
Secretary General

Chers Membres,

Suite au résultat favorable du vote formel, nous vous prions de trouver ci-joint le texte définitif ratifié par le Bureau Technique du CEN de la Norme européenne ci-dessus mentionnée en vue de sa transposition comme norme nationale sous votre responsabilité.

Vos obligations comme Membre du CEN vis-à-vis des Normes européennes sont établies dans le Règlement Intérieur du CEN/CENELEC Partie 2, paragraphe 5.2.2.

Nous vous demandons de nous envoyer toute information concernant votre action pour la transposition de cette Norme européenne dans votre pays selon le règlement mentionné ci-dessus.

Selon les décisions du Conseil d'Administration du CEN pour améliorer la transparence et la disponibilité des EN, le texte ratifié des EN peut être vendu en anticipation des normes nationales transposant ces EN.

Nous joignons pour votre facilité un avertissement imprimé sur du papier bleu destiné à être utilisé comme page de garde du texte ratifié durant cette période transitoire.

Veuillez agréer, Chers Membres, l'expression de nos sentiments distingués.

Enclosures

[redacted]
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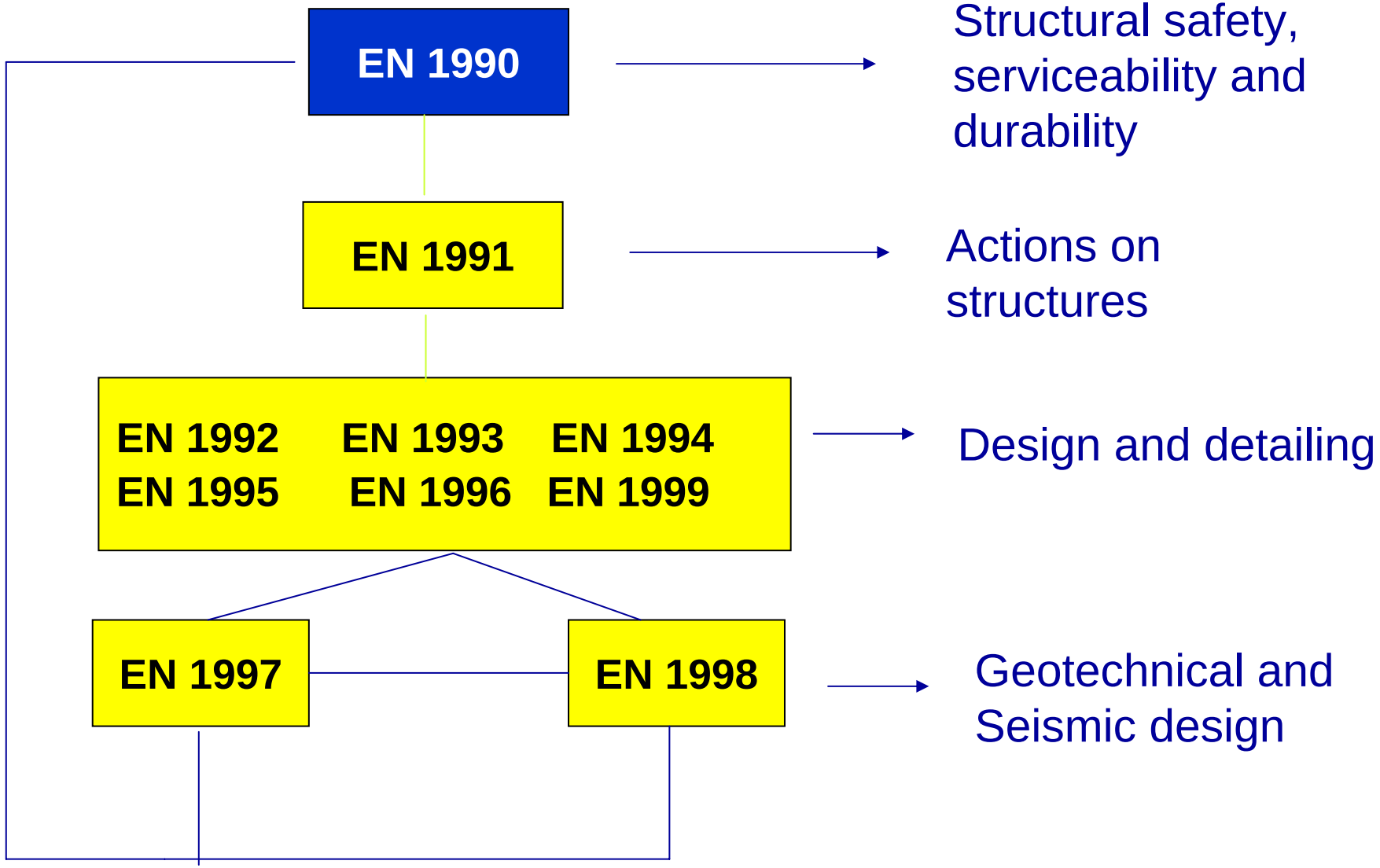
LINKS BETWEEN THE EUROCODES



EN 1990: EUROCODE: BASIS OF STRUCTURAL DESIGN

EN 1990 is the key Head Eurocode

➢ For the design of buildings and civil engineering works every Eurocode part from,

- EN 1991:Eurocode 1: Actions on Structures, and
- The design Eurocodes EN 1992 to EN 1999

has to be used together with EN 1990

➢ EN 1990 provides the material independent and safety related

- information required for the design of buildings, and
- civil engineering works

for the Eurocodes suite.

EN 1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN: CONTENTS

Foreword
Section 1 : General
Section 2 : Requirements
Section 3 : Principles of limit states
Section 4 : Basic variables
Section 5 : Structural analysis and design assisted by testing
Section 6 : Verification by the partial factor method

Annex A(n);(N) : Application for buildings (1); bridges (2)
Annex B (I) : Management of structural reliability for construction works
Annex C (I) : Basis for partial factor design and reliability analysis
Annex D (I) : Design assisted by testing

EN 1990: EUROCODE BASIS OF STRUCTURAL DESIGN

Objectives of EN 1990: Basis of Design

EN 1990 establishes principles and requirements for the

- **Safety**
- **Serviceability**
- **Durability**

of structures; and describes

- **The basis for their design and verification, and**
- **Gives guidelines for related aspects of structural reliability**

EN 1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

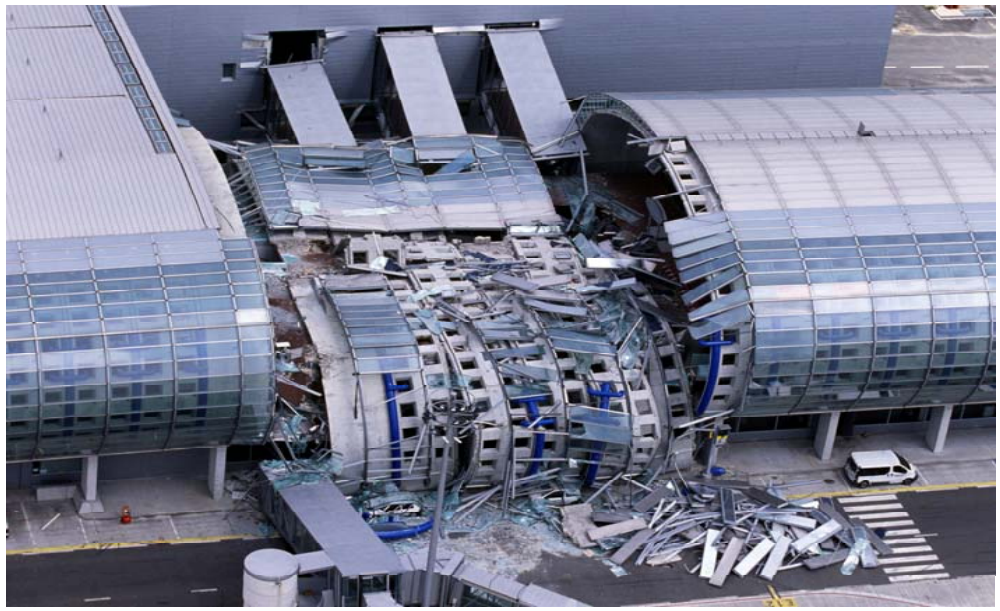
THE REQUIREMENTS

- **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 in EN 1990 for the reliability of construction works include :

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

Explosion at Ronan Point 1968

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"

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

EN 1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

THE REQUIREMENTS

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EN 1990: EUROCODE: BASIS OF STRUCTURAL DESIGN

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.**

EN 1990: 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, bridges, 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. for storage), greenhouses

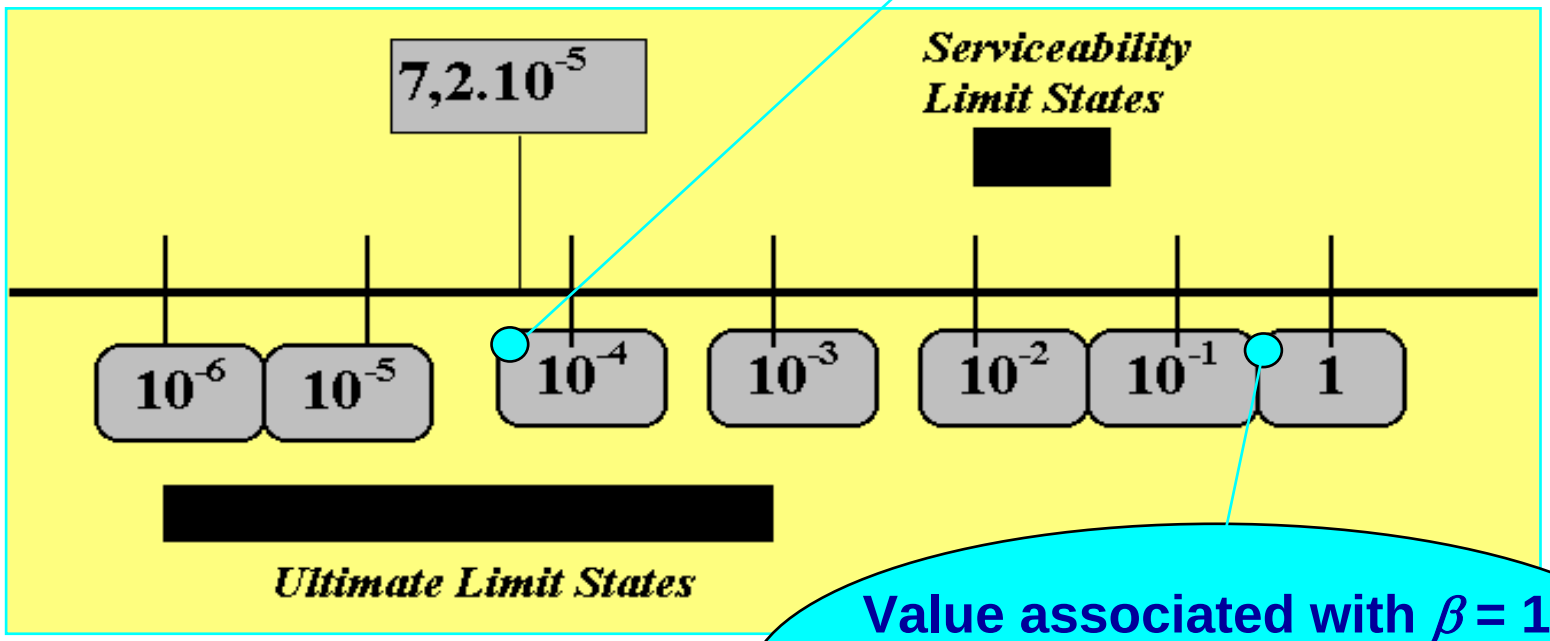
EN 1990: TOOLS FOR THE MANAGEMENT OF STRUCTURAL RELIABILITY

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 β (reliability index) values ; at this stage, this is a specialist activity;**
- **modification of partial factors ;**
- **design supervision differentiation ;**
- **inspection during execution**

EN 1990: PROBABILITIES OF FAILURE ASSOCIATED WITH LIMIT STATES

Value associated with β = 3,8 (ULS, 50 years reference period)



Value associated with β = 1,5 (SLS, 50 years reference period)

Accepted risks of death due to exposure to various hazards

Hazard	Risk (× 10^{-6} p.a.)[a]	Hazard	Risk (× 10^{-6} p.a.)[a]
Building hazards		*Occupations (UK)*	
Structural failure (*UK*)	0,14	Chemical and allied industries	85
Building fires (*Australia*)	4	Ship building and marine engineering	105
		Agriculture	110
		Construction industries	150
		Railways	180
		Coal mining	210
		Quarrying	295
		Mining (non-coal)	750
		Offshore oil and gas *(1967-1976)*	1650
		Deep sea fishing (*1959-1978)*	2800
Natural hazards (U.S)		*Sports (U.S)*	
Hurricanes (1901-1972)	0,4	Cave exploration *(1970-1978)*	45
Tornadoes (1953-1971)	0,4	Glider flying (*1970-1978)*	400
Lightning (1969)	0,5	Scuba diving *(1970-1978)*	420
Earthquakes (California)	2	Hang gliding *(1977-1979)*	1500
		Parachuting *(1978)*	1900
General accidents (U.S 1969)		*All causes (U.K. 1977)*	
Poisoning	20	Whole population	12000
Drowning	30	Woman aged 30	600
Fires and burns	40	Man aged 30	1000
Falls	90	Woman aged 60	10000
Road accidents	300	Man aged 60	20000

• [a] risk expressed as probability of death for typical exposed person per calendar year

[a] Risk expresssed as a probability of death for typical exposed person per calendar year

Accepted risks of death due to Structural Failure

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

THE REQUIREMENTS

- **Fundamental requirements (safety; serviceability; robustness and fire)**
- **Reliability differentiation**
- **Design working life**
- **Durability**
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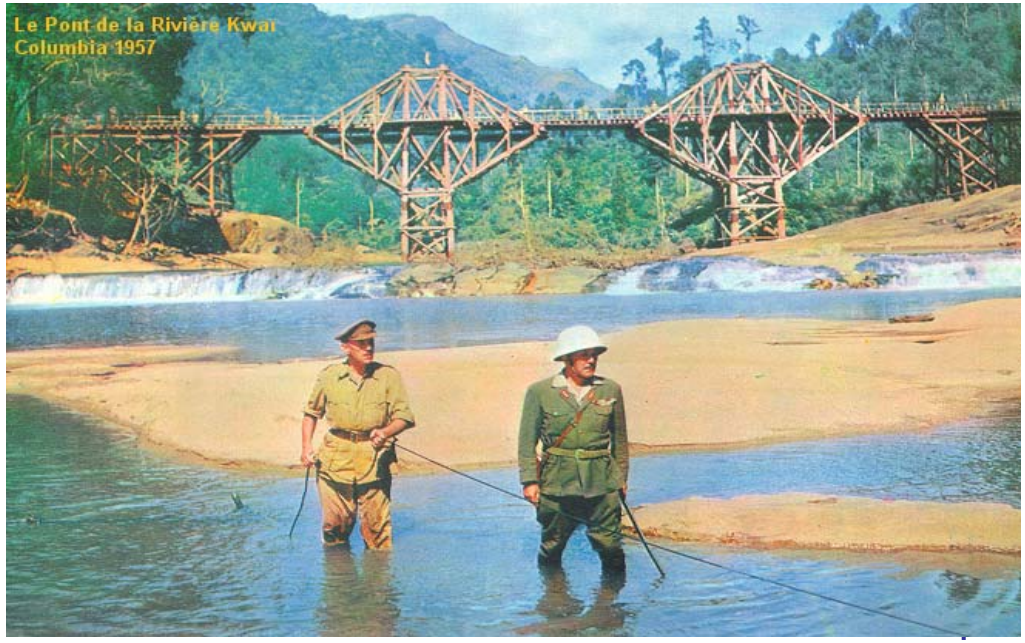
The fundamental requirements for design working life states :

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 years for bridges and**

is recommended in EN 1990.



EN 1990 – INDICATIVE DESIGN WORKING LIFE

Design working life category	design working Indicative life (years)	Examples
1	10	Temporary structures (1)
2	10 to 25	Replaceable structural parts, e.g. gantry girders, bearings
3	15 to 30	Agricultural and similar structures
4	50	Building structures and other common structures, not listed elsewhere in this table
5	100	Monumental building structures, highway and railway bridges, and other civil engineering structures
(1) Structures or parts of structures that can be dismantled with a view of being re-used should not be considered as temporary		

EN 1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

THE REQUIREMENTS

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ULTIMATE LIMIT-STATE :

- the safety of the structure
- the safety of people
- In special circumstances the protection of the contents

- loss of equilibrium of the structure or any part of it, considered as a rigid body

- failure by excessive deformation, transformation of the structure or any part of it into a mechanism, rupture, loss of stability of the structure or any part of it, including supports and foundations

- failure caused by fatigue or other time-dependent effects

SERVICEABILITY LIMIT-STATE

- Functioning of the structure or structural members under normal use,
- comfort of people
- appearance of construction works

EN 1990: EUROCODE: BASIS OF STRUCTURAL DESIGN

Design Situations

Design situations are classified in EN 1990 as follows:

- **persistent design situations, which refer to the conditions of normal use**
- **accidental design situations, which refer to exceptional conditions applicable to the structure or to its exposure, e.g. to fire, explosion, impact or the consequences of localised failure**
- **seismic design situations, which refer to conditions applicable to the structure when subjected to seismic events**
- **transient design situations which refer to temporary conditions applicable to the structure, e.g. during execution or repair**

EN 1990: Classification of Actions

- **Variation in time:** ***Permanent, Variable or Accidental***
- **Origin:** ***Direct or Indirect***
- **Spatial Variation:** ***Fixed or Free***
- **Nature and/or structural response:** ***Static or Dynamic***

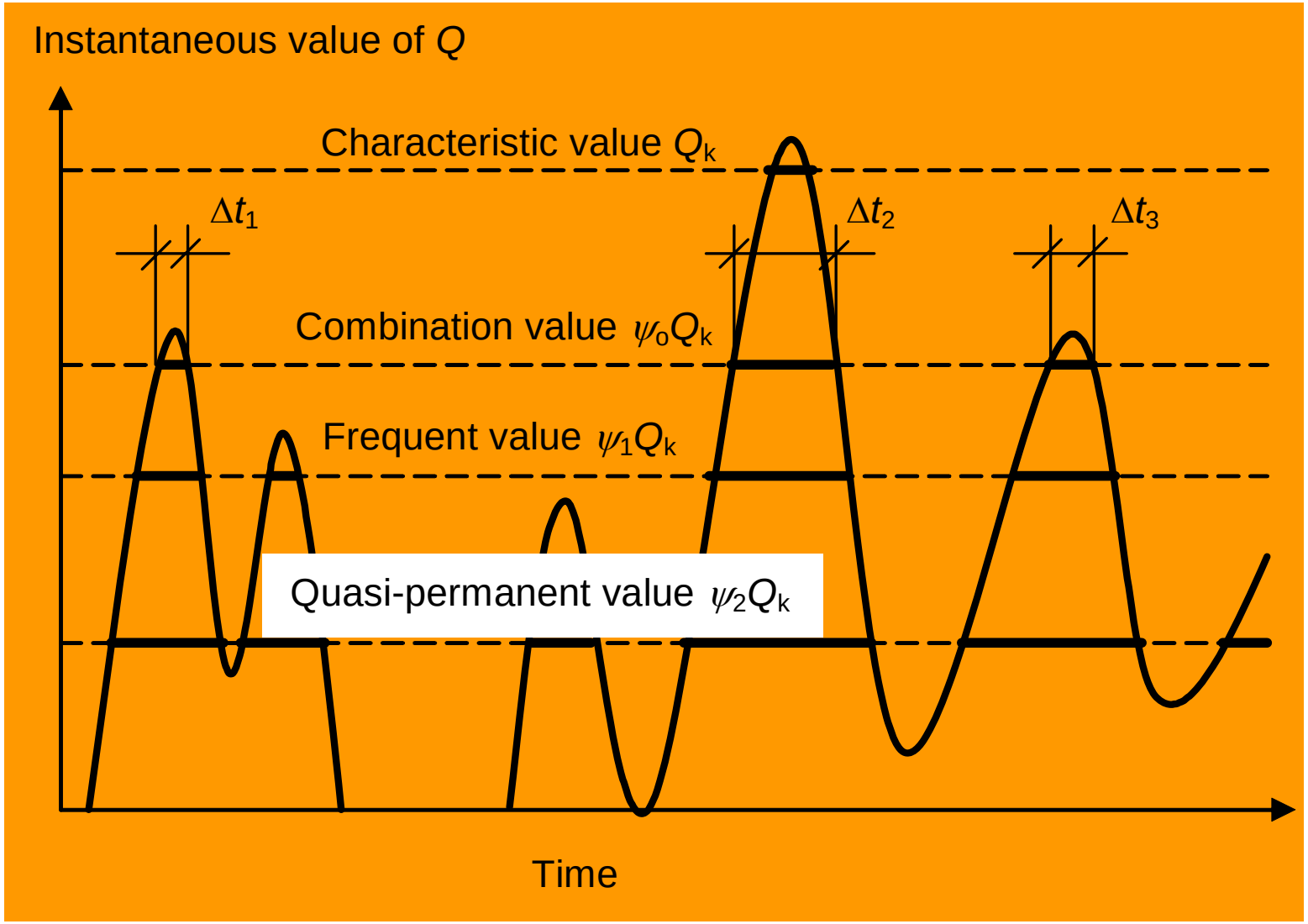
EN 1990: REDUCTION COEFFICIENTS (ψ) FOR ACTIONS

The reduction coefficients (ψ), are applied to the characteristic load values which are appropriate to cases where

- **Rare (ψ_0),**
- **Frequent (ψ_1), or**
- **Quasi-permanent (ψ_2).**

occurring events are being considered

EN 1990: VARIABLE ACTIONS – Representative Values



EN 1990: Recommended values of ψ factors for buildings

Action	ψ_0	ψ_1	ψ_2
Imposed loads in buildings, category (see EN 1991-1-1)			
Category A : domestic, residential areas	0,7	0,5	0,3
Category B : office areas	0,7	0,5	0,3
Category C : congregation areas	0,7	0,7	0,6
Category D : shopping areas	0,7	0,7	0,6
Category E : storage areas	1,0	0,9	0,8
Category F : traffic area, vehicle weight ≤ 30kN	0,7	0,7	0,6
Category G : traffic area, 30kN < vehicle weight ≤ 160kN	0,7	0,5	0,3
Category H : roofs	0	0	0
Snow loads on buildings (see EN 1991-1-3)*			
– Finland, Iceland, Norway, Sweden	0,70	0,50	0,20
– Remainder of CEN Member States, for sites located at altitude H > 1000 m a.s.l.	0,70	0,50	0,20
– Remainder of CEN Member States, for sites located at altitude H ≤ 1000 m a.s.l.	0,50	0,20	0
Wind loads on buildings (see EN 1991-1-4)	0,6	0,2	0
Temperature (non-fire) in buildings (see EN 1991-1-5)	0,6	0,5	0
NOTE The ψ values may be set by the National annex. * For countries not mentioned below, see relevant local conditions.			

EN1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

Verifications of static equilibrium and resistance

Individual verifications are performed

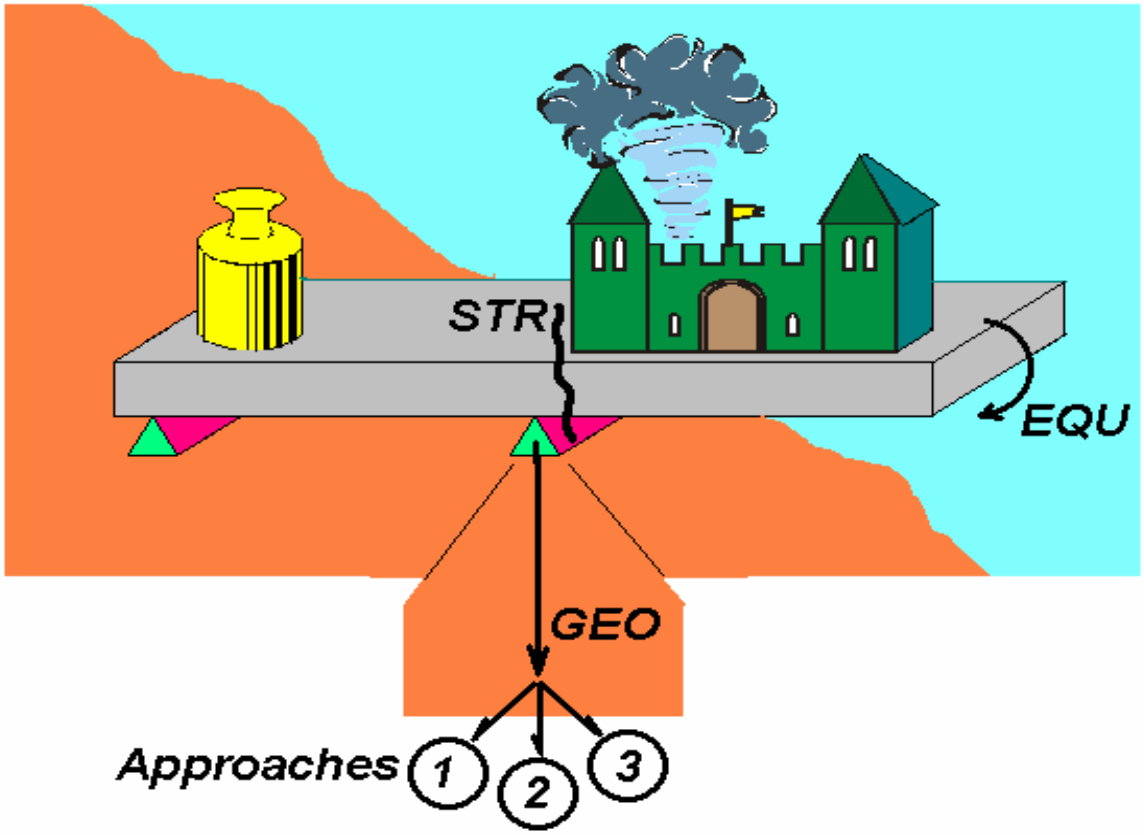
Ultimate limit states of static equilibrium (EQU) :

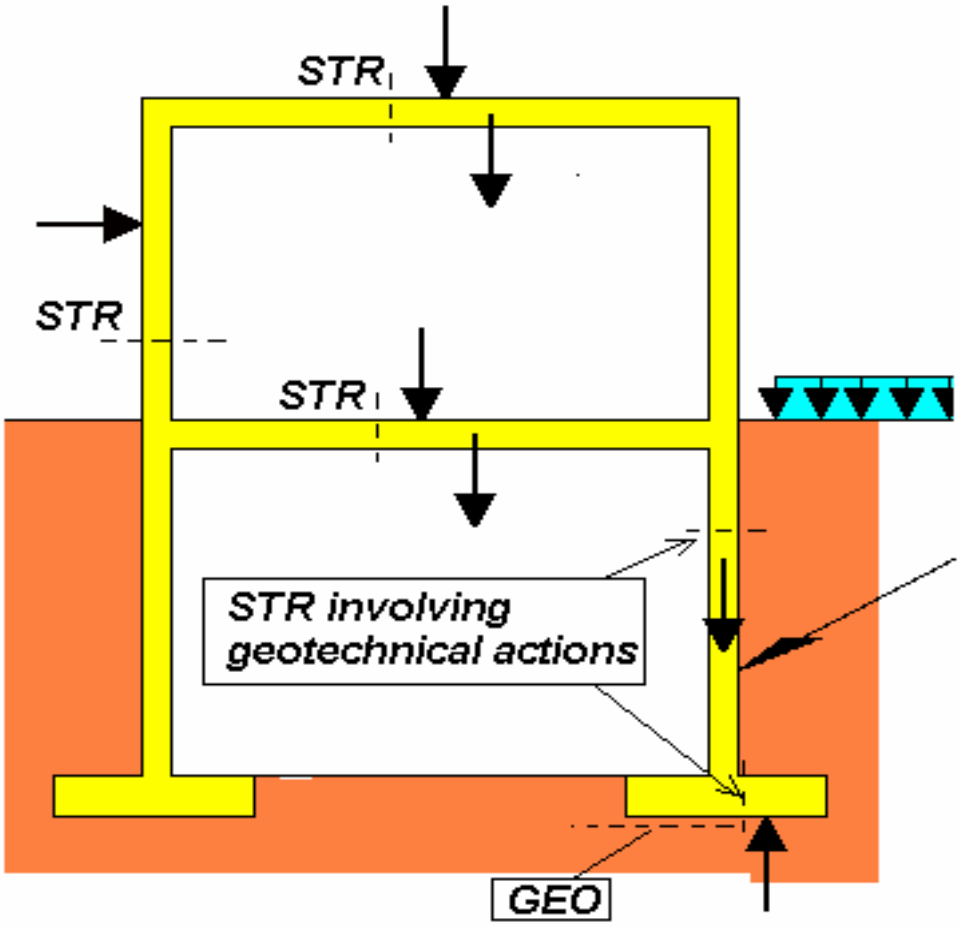
$$E_{d,dst} \leq E_{d,stb}$$

Ultimate limit states of resistance (STR/GEO) :

$$E_d \leq R_d$$

EN1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN





Ultimate limit states

EN1990 : EUROCODE: BASIS OF STRUCTURAL DESIGN

Ultimate limit states of STR/GEO - Fundamental combination for persistent and transient design situations

Expression (6.10)

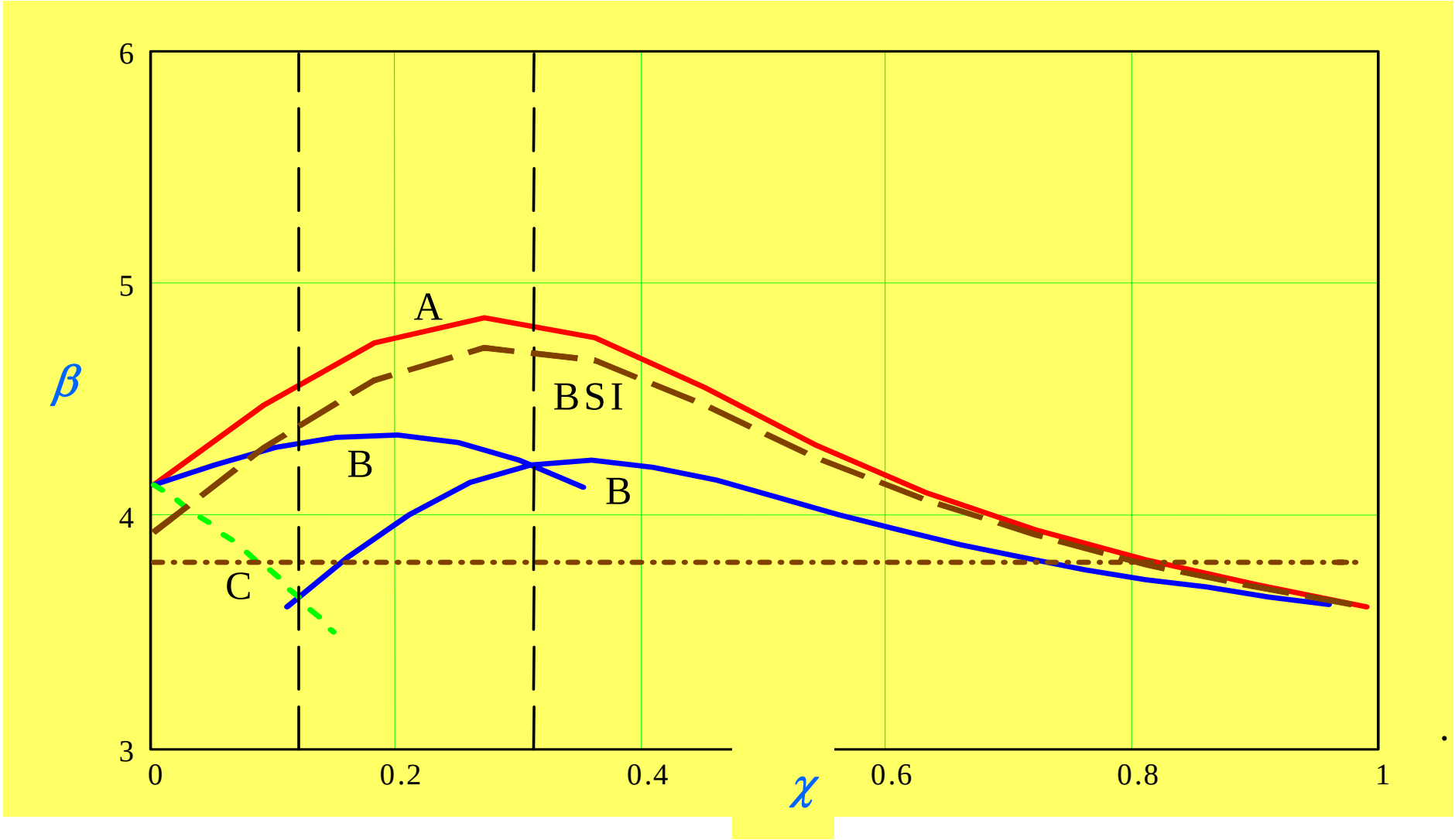
$$\sum_{j\geq 1} \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_P P \text{ "+" } \gamma_{Q,1} Q_{k,1} \text{ "+" } \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i}$$

Expressions (6.10a) and (6.10b)

$$\begin{cases} \sum_{j\geq 1} \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_P P \text{ "+" } \sum_{i\geq 1} \gamma_{Q,i} \psi_{0,i} Q_{k,i} \\ \sum_{j\geq 1} \xi_j \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_P P \text{ "+" } \gamma_{Q,1} Q_{k,1} \text{ "+" } \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i} \end{cases}$$

$$0{,}85 \leq \xi \leq 1{,}00$$

UK Calibration EN 1990 vs BSI (one variable action) for choice of Exp. 6.10 or 6.10a/6.10b in the UK National Annex to EN 1990



EN 1990: EUROCODE:BASIS OF STRUCTURAL DESIGN

Conclusions

EN 1990 is the key head code in the Eurocode suite setting out safety requirements for design of buildings and works and construction products for CE marking. EN 1990 encourages innovation and good design.

Not designed by EN 1990!

The Web Site and Information Service of the Institution of Civil Engineers in the UK: EUROCODES EXPERT www.eurocodes.co.uk

eurocodesnews

MARCH 2004
ISSUE 2

News letter of Eurocodes Expert, the construction industry's forum for users of the new structural Eurocodes

Erkki Liikanen, European commissioner for enterprise and the information society: 'The importance of the recommendation for European harmonisation in the construction industry cannot be underestimated.'

European Commission formally recommends Eurocodes

by Simon Foulstone, Editor

The European Commission has formally recommended the implementation of 58 structural Eurocodes as 'a suitable tool' for designing construction works, checking the mechanical resistance of components and checking the stability of structures.

Recommendation 4439 of 11 December 2003 says member states should recognise that construction works designed using Eurocodes will conform with the essential requirements of mechanical resistance and stability, safety in use and safety in case of fire.

Erkki Liikanen, European commissioner for enterprise and the information society, said: 'The importance of this recommendation for European harmonisation in the construction industry cannot be underestimated. Eurocodes are a state-of-the-art tool which will provide a better level of safety for our citizens. Member states should encourage their use as the standard for designing building and civil engineering works.'

Most significant document to date

According to chairman of the Eurocodes Expert advisory group Haig Gulvanessian: 'This is the most significant document ever published on adopting Eurocodes. It is the first time that the EC has given a strong recommendation to member states on adoption – all we had before were objectives. This recommendation tells the construction industry that the Eurocodes are here and we need to get ready.'

The Commission has warned member states that they should only diverge from recommended values in Eurocodes when 'geographical, geological or climatic conditions, or specific levels of protection which that necessary'. States diverging too far from recommended values, such that they result in 'unjustified hindrances to free trade,' will be told to change their nationally determined parameters.

Member states need to notify the Commission of the nationally determined parameters in force in their territory within two years of the date of which the each Eurocode part become available.

Application to construction products

To guarantee the free movement of structural construction products within the European Community, the Commission says that member states should make national provisions for the mechanical strength of such products to be assessed by the Eurocodes.

Member states are also encouraged to undertake research to ensure the latest research developments are transposed into Eurocodes. National research funding should be pooled – particularly with regard to earthquake and fire resistance – so that it can be used at community level.

Finally member states have been told to promote instruction in the use of the Eurocodes, especially in engineering schools and as part of continuous professional development courses for engineers and technicians.

The European Commission's core recommendations are printed in full on page 2 of this issue.

in this issue:

www.eurocodes.co.uk

THANK YOU VERY MUCH FOR YOUR KIND ATTENTION