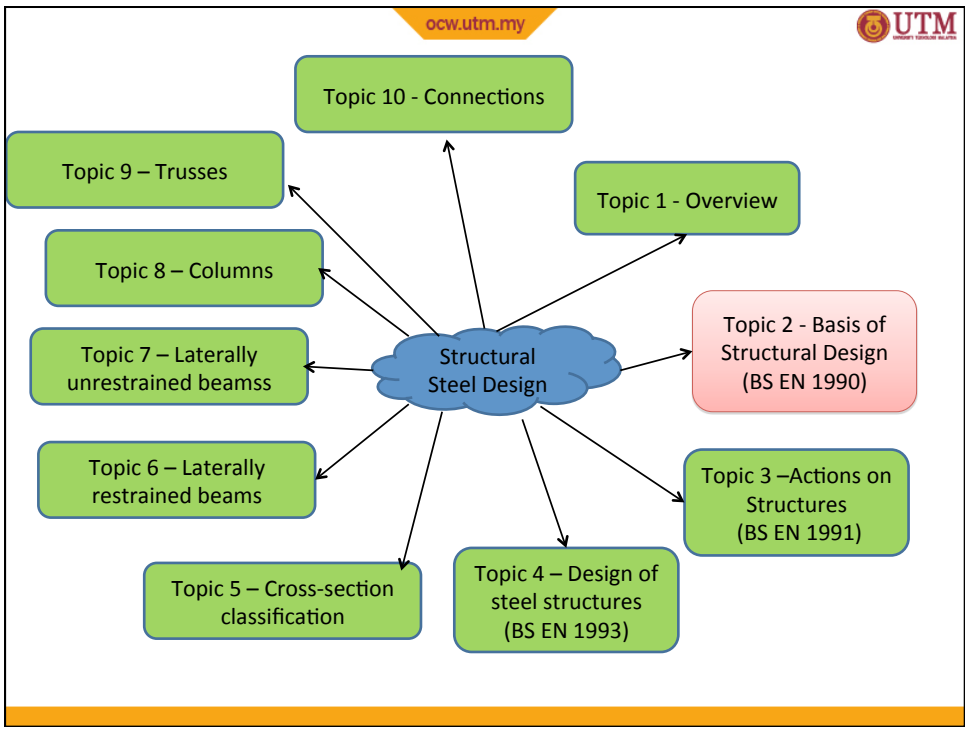
UTM OPENCOURSEWARE

Structural Steel and Timber Design SAB3233

Topic 2
Basis of Structural Design (BS EN 1990)

Prof Dr Shahrin Mohammad



Introduction to Eurocodes

WHAT IS EUROCODE ?

- A set of harmonized technical rules for the design of construction works developed for EU countries
- Started in 1974, originated in 1957 at the Treaty of Rome through EEC Euro Act 1986 tackle the legal issued to the process of harmonization
- The objective of the program was the elimination of technical obstacles to trade and the harmonization of technical specifications.
- for steel first drafted in 1984 pre-standard in 1992 - ENV 1993 Design of steel structures
- 2005 produce the EN version

3

In Europe;

- Shifting to Eurocodes is mandatory
- After publication of final version (EN version), 2 years is allocated for calibration- development of annex and NDP
- Followed by 3 years coexistent before total withdraw of 'conflicting standards'
- EC 3 to be fully enforced in 2010

- Initiative taken early 2000 - 'UTM raised the issue to IEM'
- IEM appointed as SWO
- a national code of practice for design in structural steel technical committee was set up

4

Why adopt Eurocode ?

- No more updates for BS 5950
- Local engineers be able to compete globally
- Unless we are able to develop more superior design code
  - Resources – expertise and funding
  - Limited research
- EC 3 fulfill ISO standards
- Opportunity to develop and utilise local values in National Annex
- Follow development in the UK, as local engineers are familiar with British system

5

The benefits?

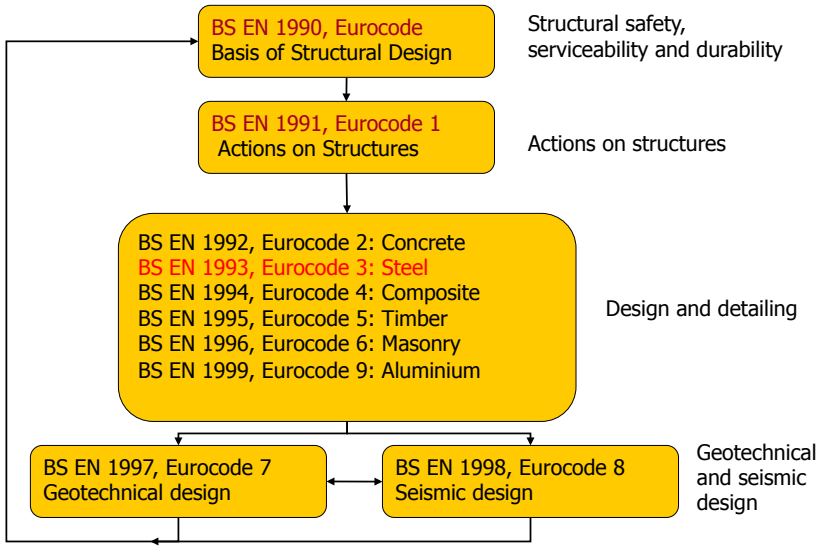
1.The new Eurocodes are claimed to be the most technically advanced codes in the world.
2.EC 3 should result in more economic structures than BS 5950
3.The Eurocodes are logical and organised to avoid repetition
4.EC 3 is less restrictive and more extensive than BS 5950
5.Use of the Eurocodes will provide more opportunity for designers to work throughout Europe
6.Europe all public works must allow the Eurocodes to be used for structural design
7.National Annex – opportunity to use local values in design known as NDP. Values determined based on local level of safety requirement
8.Unified approach in structural steel design

6

UTM OPENCOURSEWARE

Structural Eurocodes - an overview

Structural Eurocodes- an overview



8

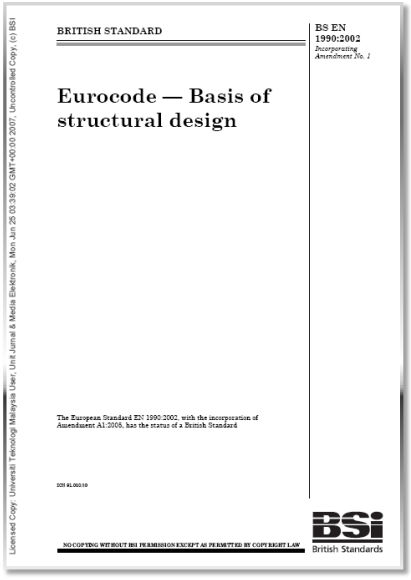
UTM OPENCOURSEWARE

Basis of structural design (BS EN 1990:2002) or EC-0

Structural Eurocodes- an overview

BS EN 1990:2002

There is no equivalent British Standard for *Basis of structural design and* the corresponding information has traditionally been replicated in each of the material codes.

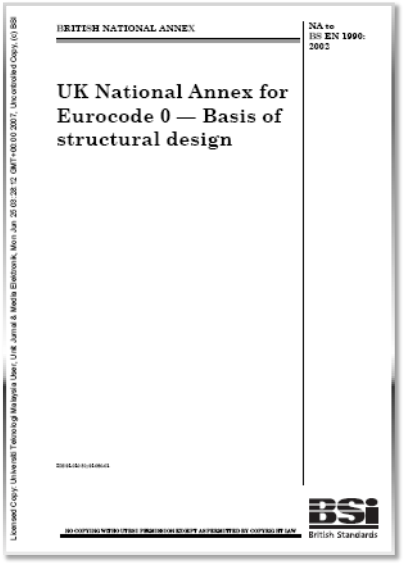

BRITISH STANDARD

BS EN 1990:2002
Incorporating Amendment No. 1

Eurocode — Basis of structural design

The European Standard EN 1990:2002, with the incorporation of Amendment A1:2005, has the status of a British Standard

BSi British Standards



- **Descriptives**
- **Terms, definitions, symbols**

11

Content of EN 1990

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

Annex A1: Application for buildings
Annex A2: Application for bridges
Annex B: Management of structural reliability for construction works
Annex C: Basis for partial factor design and reliability analysis
Annex D: Design assisted by testi

12

SCOPE OF BS EN 1990:2002

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

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

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

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.

13

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 during execution of the work, i.e. in design offices, factories, plants, and on site;
- 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.

14

Distinction between Principles and Application Rules

(1) Depending on the character of the individual clauses, distinction is made in EN 1990 between Principles and Application Rules.

(2) The Principles comprise :
- general statements and definitions for which there is no alternative
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The Principles are identified by the letter P following the paragraph number.

(4) The Application Rules are generally recognised rules which comply with the Principles and satisfy their requirements.

(5) It is permissible to use alternative design rules different from the Application Rules given in EN 1990 for works, provided that it is shown that the alternative rules accord with the relevant Principles and are at least equivalent with regard to the structural safety, serviceability and durability which would be expected when using the Eurocodes.

15

Section 1 Definitions of terms and symbols

Annex	...	"Appendix"
• Normative	...	"Design rules"
• Informative	...	"Principles"
Structural System	...	"Load-bearing elements of a building"
Actions	...	"Loadings of all types"
• Characteristic	...	"Representative value F_k
• Design	...	"Factored loads"
• Combination	...	"Factored loads in combination
Effects	...	"Internal forces caused by actions"
Resistance	...	"Structure: ability to withstand an effect
Strength	...	" .. of a material"
• Characteristic	...	"Nominal value"
• Design	...	"Divided by 'factor' "

16

National Application Documents (National Annexes)

Contain Partial Safety Factors to comply with national authorities' requirements.

Shown as "boxed" [ ] values in Standards.

Eurocode Notation

Unified system of notation, using subscripts separated by commas

Common Notation	
G	Permanent action
Q	Variable action
E	Effect of an action
R	Resistance
t	Time
θ	Temperature
γ	Partial safety factor
ψ	Combination factor

Common Subscripts	
A	accidental situation
cr	critical
fi	fire design (even at 20°C)
d	design
θ	at temperature
k	characteristic
t	exposure time in fire
1, 2 ..	ranking order

For example … $R_{fi,d,t}$ **… is *d*esign *R*esistance to *fi*re rules at *t*ime t**

Section 1

Definitions of terms and symbols

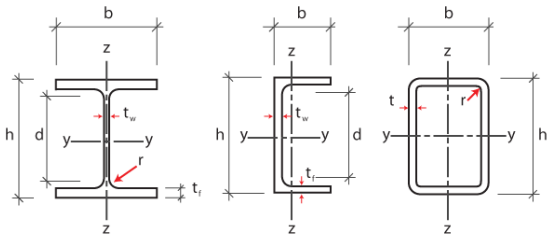
Action	Applied Load
Permanent	Dead Load
Variable	Live or Wind Load
Accidental	Impact or fire

EC	BS 5950
Effect	Internal Forces (moment, shear ..)
Resistance	Strength , Capacity (moment capacity, shear capacity)
Verification	Check
Execution	Construction

19

Section 1

Definitions of terms and symbols



	EC	BS 5950
Major axis	y-y	x-x
Minor axis	z-z	y-y
Along the member	x-x	-
Elastic modulus	W_{el}	Z
Plastic modulus	W_{pl}	S
Yield strength	f_y	P_y
	3,456	3.456

20

Section 2 Requirements

2.1 Basic requirements

(1) P 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 economical way
- sustain all actions and influences likely to occur during execution and use
- remain fit for the use for which it is required.

(2) P A structure shall be designed to have adequate :
- structural resistance,
- serviceability, and
- Durability

(3) P In the case of fire, the structural resistance shall be adequate for the required period of time.

21

Selected symbols for Eurocode

Symbol	Definition
G_k	Characteristic value of permanent action
Q_k	Characteristic value of single variable action
g_G	Partial factor for permanent action
g_Q	Partial factor for variable action
y_0	Factor for combination value of a variable action
y_1	Factor for frequent value of a variable action
y_2	Factor for quasi-permanent value of a variable action
x	Combination factor for permanent actions

22

2.3 Design working life

assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary

Table 2.1 - Indicative design working life

Design working life category	Indicative design working 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
5	100	Monumental building structures, bridges, and other civil engineering structures

(1) Structures or parts of structures that can be dismantled with a view to being re-used should not be considered as temporary.

23

2.4 Durability

(1) P The structure shall be designed such that deterioration over its design working life does not impair the performance of the structure below that intended, having due regard to its environment and the anticipated level of maintenance.

(2) In order to achieve an adequately durable structure, the following should be taken into account the:

- intended or foreseeable use of the structure ;
- required design criteria ;
- expected environmental conditions
- composition, properties and performance of the materials and products ;
- properties of the soil ;
- choice of the structural system ;
- shape of members and the structural detailing ;
- quality of workmanship, and the level of control ;
- particular protective measures ;
- intended maintenance during the design working life.

24

Section 3 Principles of limit states design

(1)P The relevant design situations shall be selected taking into account the circumstances under which the structure is required to fulfill its function.

(2)P Design situations shall be classified as follows :

- persistent design - conditions of normal use ;
- transient design - temporary conditions e.g. during execution or repair ;
- accidental design - exceptional conditions e.g. to fire, explosion, impact or localised failure ;
- seismic design – structure subjected to seismic events.

(3)P The selected design situations shall be sufficiently severe and varied so as to encompass all conditions that can reasonably be foreseen to occur during the execution and use of the structure

25

Section 3 Principles of limit states design

3.3 Ultimate limit states

(1) P The limit states that concern :

- the safety of people, and/or
- the safety of the structure

3.4 Serviceability limit states

(1) P The limit states that concern :

- the functioning of the structure or structural members under normal use ;
- the comfort of people ;
- the appearance of the construction works

26

Section 4 Basic variables

4.1 Actions and environmental influences

4.1.1 Classification of actions

(1)P Actions shall be classified by their variation in time as follows

- permanent actions *(G)*, e.g. self-weight of structures, fixed equipment and road surfacing, and indirect actions caused by shrinkage and uneven settlements
- variable actions *(Q)*, e.g. imposed loads on building floors, beams and roofs, wind actions or snow loads
- accidental actions *(A)*, e.g. explosions, or impact from vehicles.

4.1.3 Variable actions:

Characteristic (Q_k)

Combination

combination value ($y_0 Q_k$) of an action is intended to take account of the reduced probability of the simultaneous occurrence of two or more variable actions

Quasi-permanent

quasi-permanent value ($y_2 Qk$) may be exceeded for a considerable period of time; alternatively it may be considered as an average loading over time. It is used for the long-term affects at the SLS and also accidental and seismic ULS.

Frequent

frequent value ($y_1 Qk$) is such that it should be exceeded only for a short period of time and is used primarily for the serviceability limit states (SLS) and also the accidental
ultimate limit state (ULS)

Table A1.1 – EC 1990

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.			

Table NA.A1.1 — 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 ≤ 30 kN	0,7	0,7	0,6
Category G: traffic area, 30 kN < vehicle weight ≤ 160 kN	0,7	0,5	0,3
Category H: roofs[a]	0,7	0	0
Snow loads on buildings (see EN 1991-3)			
— for sites located at altitude H > 1 000 m a.s.l.	0,70	0,50	0,20
— for sites located at altitude H ≤1 000 m a.s.l.	0,50	0,20	0
Wind loads on buildings (see EN 1991-1-4)	0,5	0,2	0
Temperature (non-fire) in buildings (see EN 1991-1-5)	0,6	0,5	0
[a] See also EN 1991-1-1: Clause 3.3.2 (1)			

Section 5 Structural analysis and design assisted by testing

- Structural analysis
  - Modeling appropriate to limit states
  - Established engineering theory and to be verified if necessary
- Static actions, dynamic actions, fire design
- Design assisted by testing

Section 6 Verification by the partial factor method

- Design values (ULS, SLS)
- Inclusive of partial safety factors for actions, effect of actions, materials, resistance

31

Load Combinations (Ultimate)

Load factors

Combination factors for reduce probability of simultaneous actions

$$\sum_{j\geq 1} \gamma_{G,j} G_{k,j} + \gamma_{Q,1} Q_{k,1} + \sum_{j\geq 1} \gamma_{Q,j} \Psi_{0,j} Q_{k,j}$$

Permanent Load

Leading variable Load

Other variable load

EC	BS 5950
1.35DL + 1.5 LL	1.4DL + 1.6LL
1.35DL + 1.5 WL	1.4DL + 1.4WL
1.00DL + 1.5 WL	1.0DL + 1.4WL
1.35DL + 1.5 LL+0.75WL 1.35DL+1.05LL+1.5WL	1.2DL + 1.2LL+1.2WL

32

Load Combinations (Service)

Permanent Load

Combination factors for reduce probability of simultaneous actions

$$\sum_{j\geq 1} G_{k,j} + Q_{k,1} + \sum_{j\geq 1} \Psi_{0,j} Q_{k,j}$$

Leading variable Load

Other variable load

EC	BS 5950
DL + LL	DL + LL
DL + WL	DL + WL
DL + LL+0.5WL DL+LL+WL	DL + LL+WL

33

Thank You