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Global Eurocodes Implementation

Dr Stephen Hicks

Overview of presentation

- Introduction to the Eurocodes
- Differences between the earlier National Standards and the Eurocodes
- Non-Contradictory Complementary Information (NCCI)
- Execution and Product Standards
- Eurocode transition tools and resources
- Future evolution of the Eurocodes

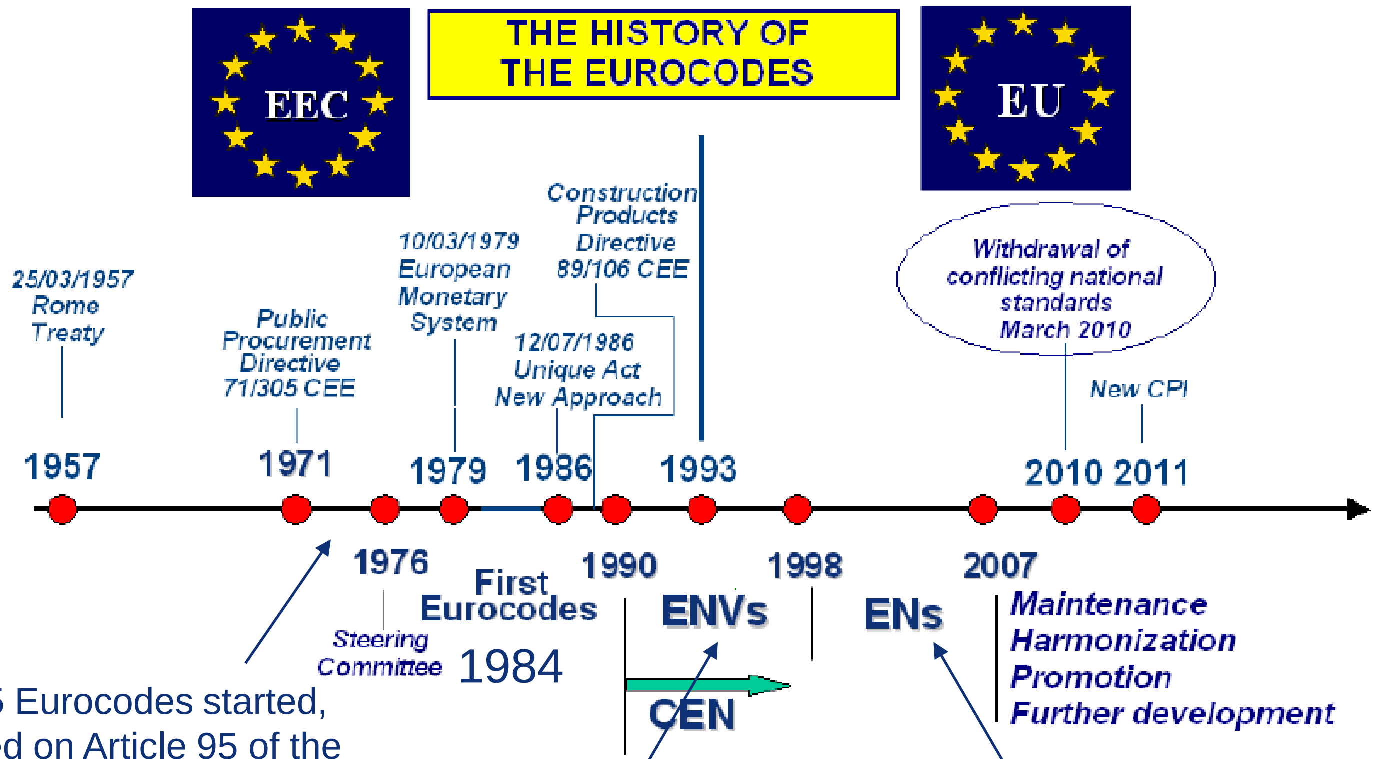
Introduction to the Eurocodes

Objective of the Eurocodes

- The Eurocodes started as a result of the decision of the European Economic Community, or 'Common Market' (later the European Union), to embark on an action programme in the field of construction based on Article 95 of the Treaty of Rome.

- The objective of the programme was: *the elimination of technical obstacles to trade and the harmonisation of technical specifications by means of technical rules which, in the first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them*

History of the Eurocodes



1975 Eurocodes started, based on Article 95 of the Treaty of Rome - Objective was the elimination of technical obstacles to trade and the harmonisation of technical specifications

ENV = European pre-Standard

EN = European Standard

What are the Eurocodes?

- The Eurocodes are a set of European Standards (EN) for the design of buildings and other civil engineering works and construction products including:
  - Geotechnical aspects
  - Structural fire design
  - Situations including earthquakes, execution and temporary structures
- The Eurocodes cover the basis of design, actions on structures, the principal construction materials, all major fields of structural engineering and a wide range of structural types and products.
- The verification procedure is based on the limit state concept used in conjunction with partial safety factors. The Eurocodes allow for design based on probabilistic methods as well as for design assisted by testing, and provide guidance for the use of these methods.

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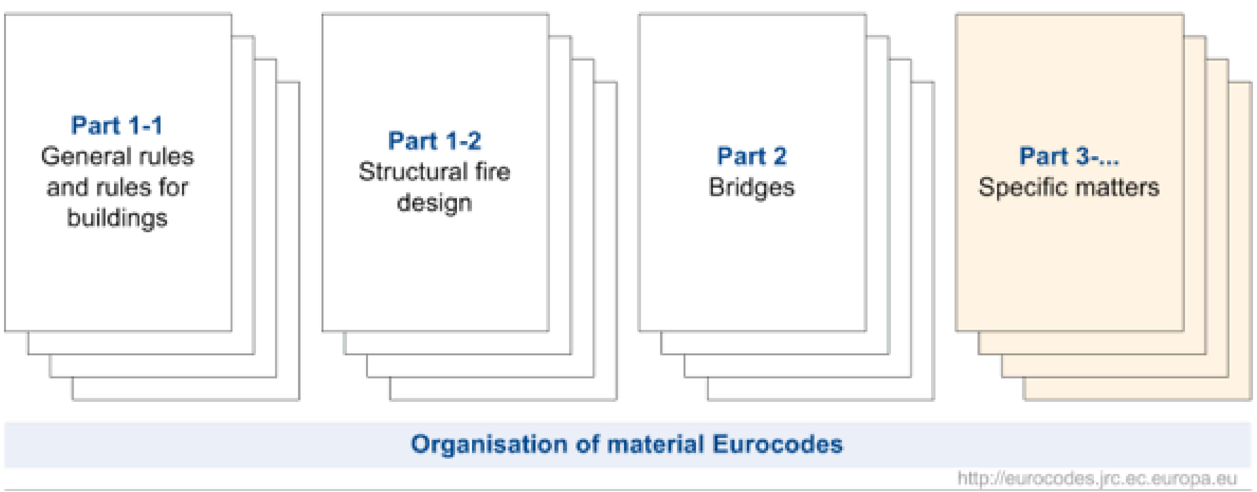
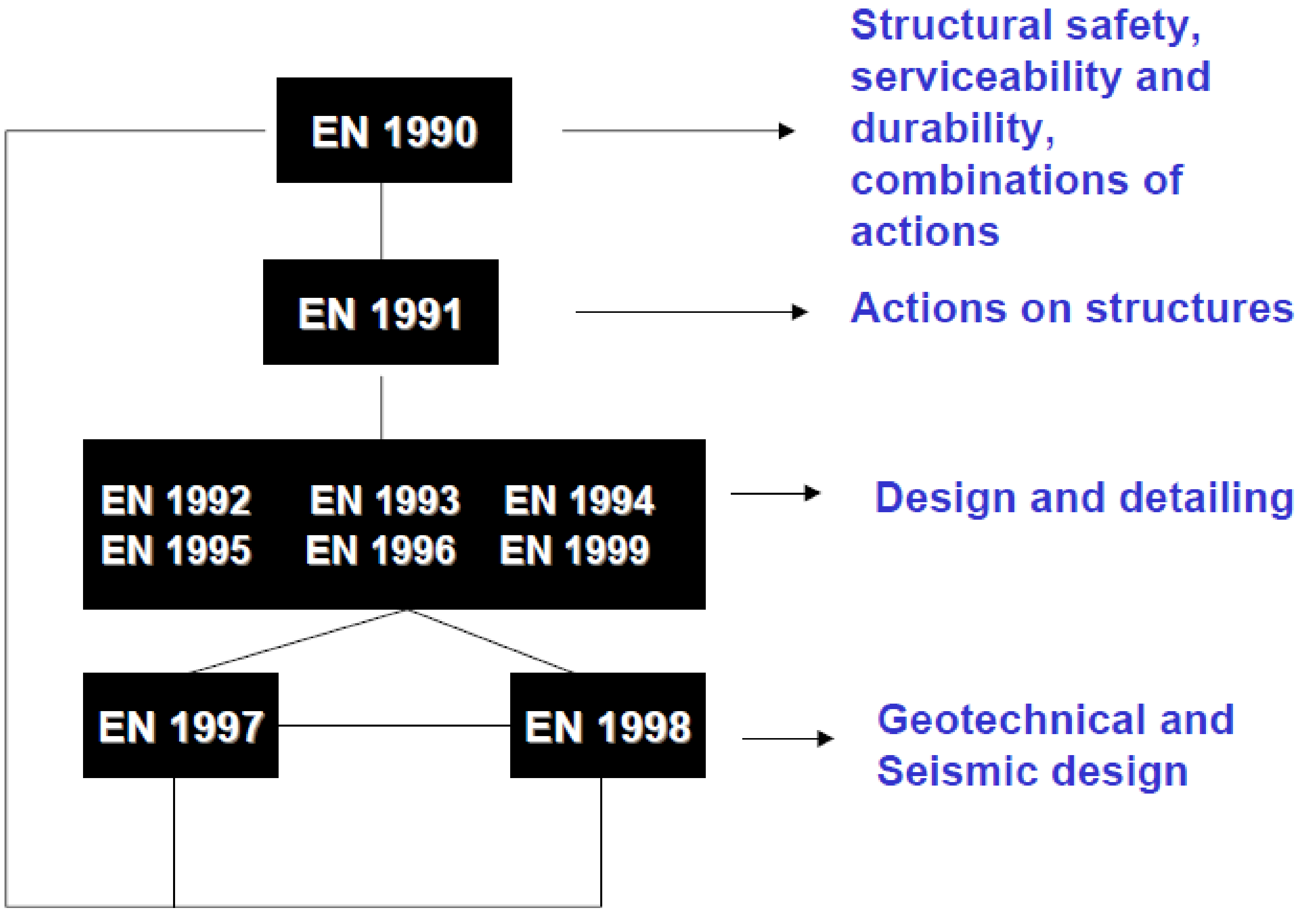
Key aspects of the Eurocodes

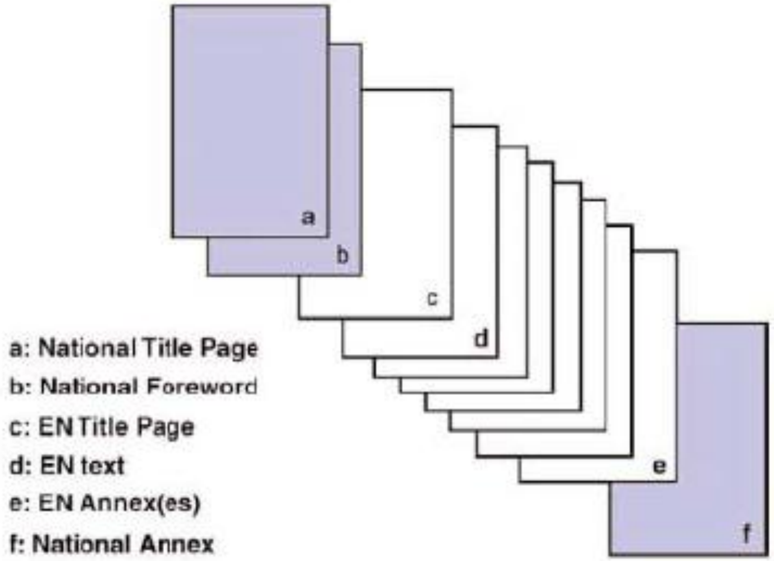
- To avoid ambiguity is no repetition of information, so values and properties are only given in one Eurocode (useful for maintenance, but potentially expensive to the user)
- The head standard EN 1990 applies to all types of structures and is material independent
- Each of the codes (except EN 1990) is divided into a number of Parts covering specific aspects of the subject.
- In total there are 58 EN Eurocode parts distributed in the 10 Eurocodes (EN 1990 – 1999).



Links between the structural Eurocodes



Structure of Eurocode published by National Standards body



a) National title page

b) National foreword
- Identifies which National Standards are replaced by the Eurocode.
- Identifies the Technical Committee of the National Standards Body (NSB) that participated in the preparation of the Eurocode and National Annex (NA).

c) EN title page

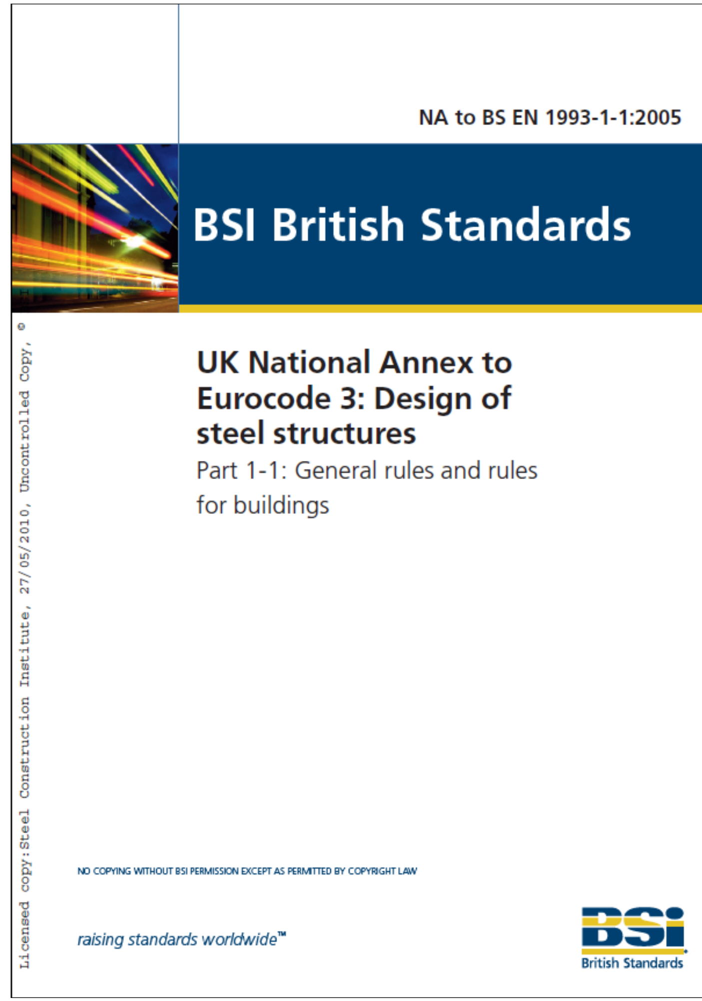
d) EN text
- The National Standards body implementing each Eurocode must publish, without alteration, the full text and its annexes as published by the European Committee for Standardization (CEN).
- The full text of each EN is issued initially by CEN in three languages (English translated into French and German)

e) EN Annex(es)
- Normative annexes are part of the requirements of the code.
- Informative annexes provide guidance that can be adopted, or not, on a country-by-country basis.

f) National Annexes

National Annex

- The National Annex (NA) is a special type of informative annex that contains the choices made by a particular country.
- The contents of a NA are:
  - Scope
    - List of clauses that were left open by the Eurocodes for national choice.
  - Nationally Determined Parameters (NDPs)
    - Values of partial safety factors and classes applicable to that country
    - Country specific data (e.g. snow map)
    - Values where only a symbol is given in the EN
  - Decisions on the status of informative annexes.
  - References to non-contradictory complementary information (NCCI).


NA to BS EN 1993-1-1:2005

BSI British Standards

UK National Annex to Eurocode 3: Design of steel structures

Part 1-1: General rules and rules for buildings

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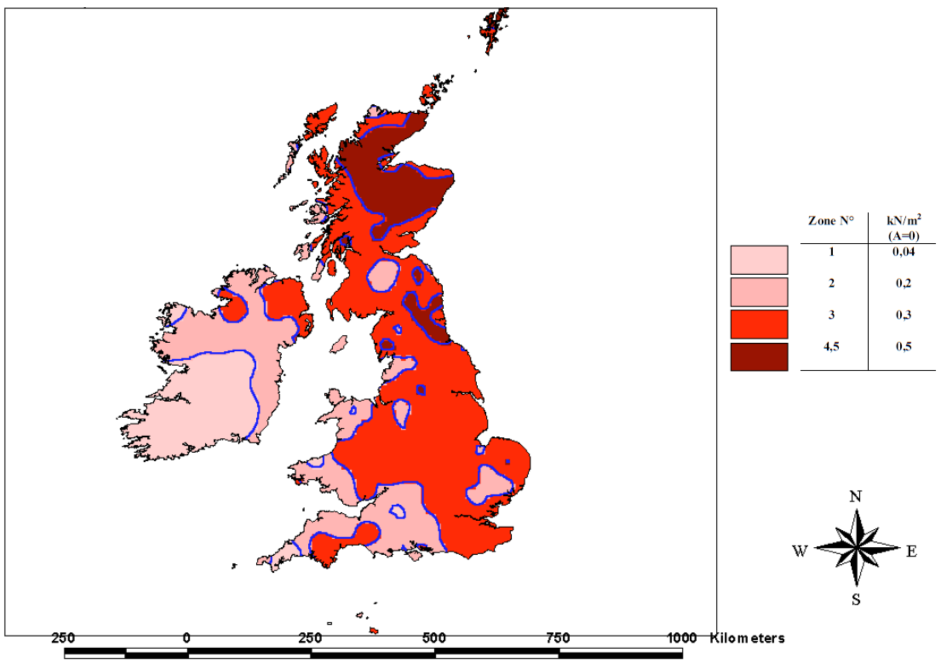
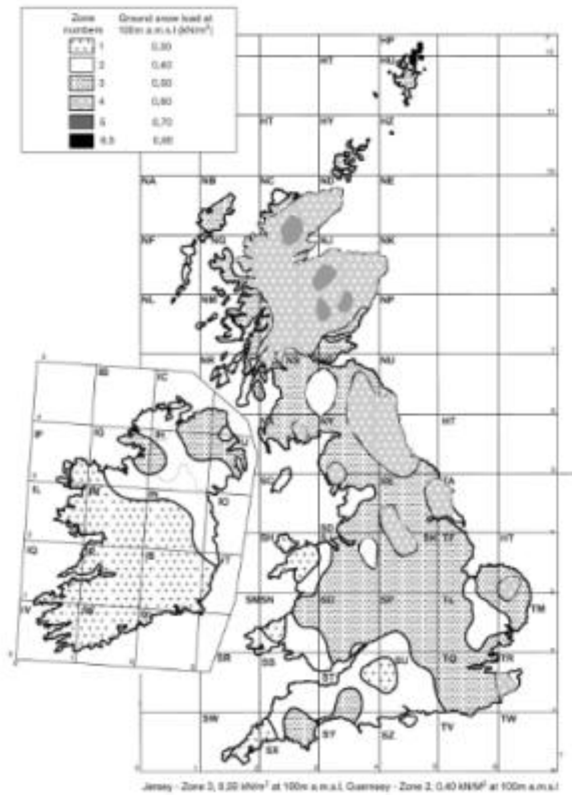
Characteristic ground snow load map NDP

BS EN 1991-1-3, Annex C

UK, Republic of Ireland: Snow Loads at sea level





UK NA for BS EN 1991-1-3

Differences between earlier National Standards and the Eurocodes

Format of the Eurocodes

- The clauses in the Eurocodes are divided into Principles and Application rules.
  - Principles are identified by (P) after the clause number and covers items for which no alternative is permitted (e.g. EN1993-1-1, 2.1.1(1)P The design of steel structures shall be in accordance with the general rules given in EN 1990).
  - Application rules are recommended methods of achieving the Principles but alternative rules may also be used.
- Part 1-1 of Eurocode intended to provide rules that are 'general' (i.e. they may be equally applied to bridges).
  - To differentiate between general rules and those specific to buildings:
    - the word 'buildings' is included within the heading before the appropriate rules are presented (e.g. EN 1994-1-1, 3.5 Profiled steel sheeting for composite slabs in *buildings*); or
    - the letter 'B' is used to indicate provisions specific to buildings (e.g. EN 1993-1-1, 2.1.3.2(1)P,*B*)
- There are two types of Annex in the Eurocodes.
  - Normative annexes are part of the requirements of the code.
  - Informative annexes provide guidance that can be adopted, or not, on a country-by-country basis (National decisions are identified in the National Annex).

Partial factor design format

- Ultimate limit states of resistance (STR/GEO):

  $E_d \leq R_d \ (E_k \gamma_F \leq R_k / \gamma_M)$

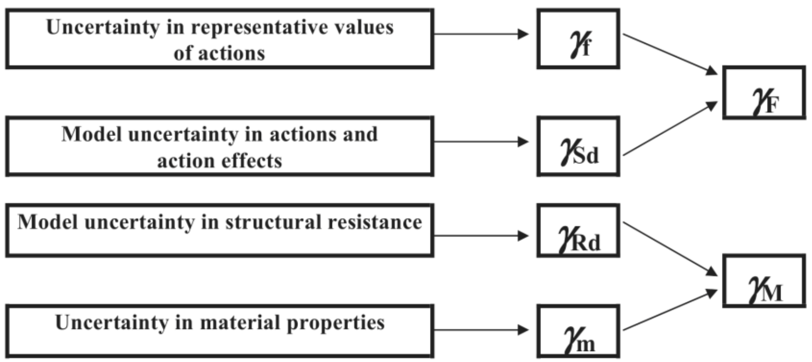
  - where E_d is the design value of the effects of actions and R_d is the design value of the resistance
- For resistance using Eurocode 3
  - for cross-sections that are not influenced by buckling at the ultimate limit state, the partial factor γ_{M0} should be applied to the characteristic values of the materials that are contained within the design equation, for example:

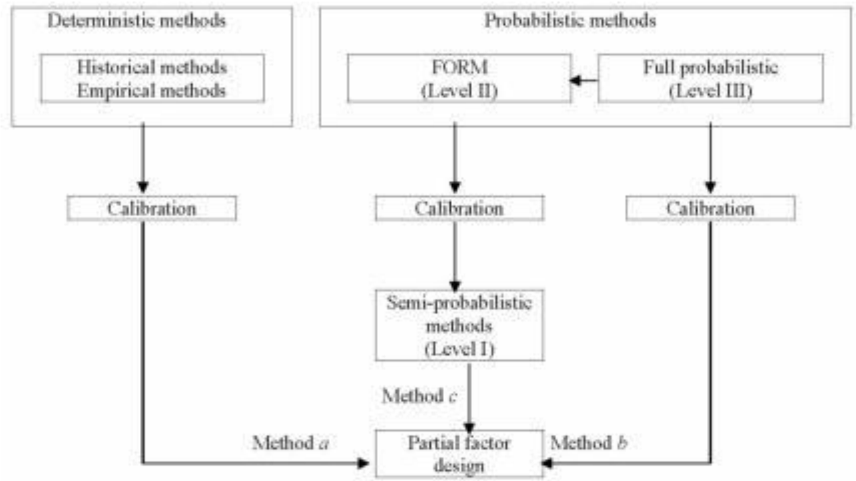
  $$N_{c,Rd} = \frac{Af_y}{\gamma_{M0}}$$

  - for cases when the resistance of members is influenced by buckling, the entire design equation is divided by the partial factor γ_{M1}, for example:

  $$N_{b,Rd} = \frac{\chi Af_y}{\gamma_{M1}}$$

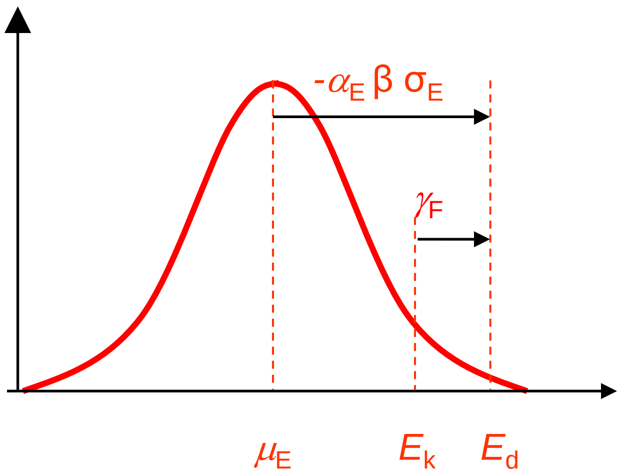
- From EN 1990, C.4(4) *The Eurocodes have been primarily based on method a. Method c or equivalent methods have been used for further development of the Eurocodes*





Basis of Load and Strength partial factors (Method b and c)

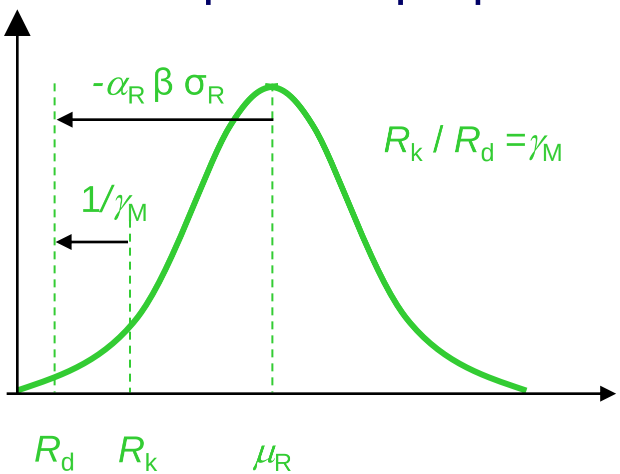
Loads



- Normal or Gumbel (extreme value) distribution usually taken
- Characteristic value
  - Mean value if variability small
  - Upper value (normally 95% fractile) if variability is not small
- Design value based on probability of failure

α_E and α_R from ISO2394

Material and product properties



- Log-normal distribution usually taken (resistance doesn’t have negative values)
- Characteristic (or nominal) value for resistance based on lower value (5% fractile)
- Design value based on probability of failure. For large sample of data and a normal distribution
  - 5% fractile = 1.64 σ_R
  - Design value = 0.8 x 3.8 σ_R = 3.04 σ_R ($\equiv P_f$ of 0.0012, which is equivalent to a probability of the actual resistance falling below the design resistance of 1 in 845)

Eurocode definitions

Some of the terminology used in the Eurocodes will be new to designers, but the terms have been chosen carefully, for clarity and to facilitate unambiguous translation into other languages.

Eurocode term	UK term
Actions	Loads, or imposed deformation (e.g. Temperatures or settlement)
Permanent action	Dead load
Variable action	Imposed, or live load
Design value of actions	Ultimate loads, or design loads
Verification	Check
Effects of Actions, or Action Effects	Internal bending moments, forces and deformations which result from the application of the actions
Resistance	Capacity, resistance
Effects of deformed geometry	Second order effects
Execution	Fabrication, erection (construction activity)

Eurocode symbols and format

The Eurocode system uses the ISO convention for symbols and sub-scripts. Where multiple sub-scripts occur, a comma is used to separate them. Four main sub-scripts and their definitions are given below:

Eurocode Subscript	Definition	Example	
Ed	Design value of an effect	M_{Ed}	Design bending moment
Rd	Design resistance	M_{Rd}	Design resistance for bending
el	Elastic property	W_{el}	Elastic section modulus
pl	Plastic property	W_{pl}	Plastic section modulus

The Eurocodes use a comma ',' decimal point rather than a dot '.' (e.g. 1,234 rather than 1.234)

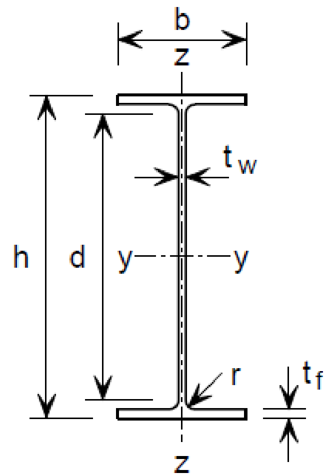
- Caused concern in the UK engineering fraternity that it might be mistaken for a separator (i.e. 1,000 could be read as 1000 rather than 1 if the precision was to three decimal places
- Likely that UK will keep to decimal point '.'

It's all Greek!

Alpha	α	Α	Nu	ν	Ν
Beta	β	Β	Xi	ξ	Ξ
Gamma	γ	Γ	Omicron	ο	Ο
Delta	δ	Δ	Pi	π	Π
Epsilon	ε	Ε	Rho	ρ	Ρ
Zeta	ζ	Ζ	Sigma	σ	Σ
Eta	η	Η	Tau	τ	Τ
Theta	θ	Θ	Upsilon	υ	Υ
Iota	ι	Ι	Phi	φ	Φ
Kappa	κ	Κ	Chi	χ	Χ
Lambda	λ	Λ	Psi	ψ	Ψ
Mu	μ	Μ	Omega	ω	Ω

Geometrical axes

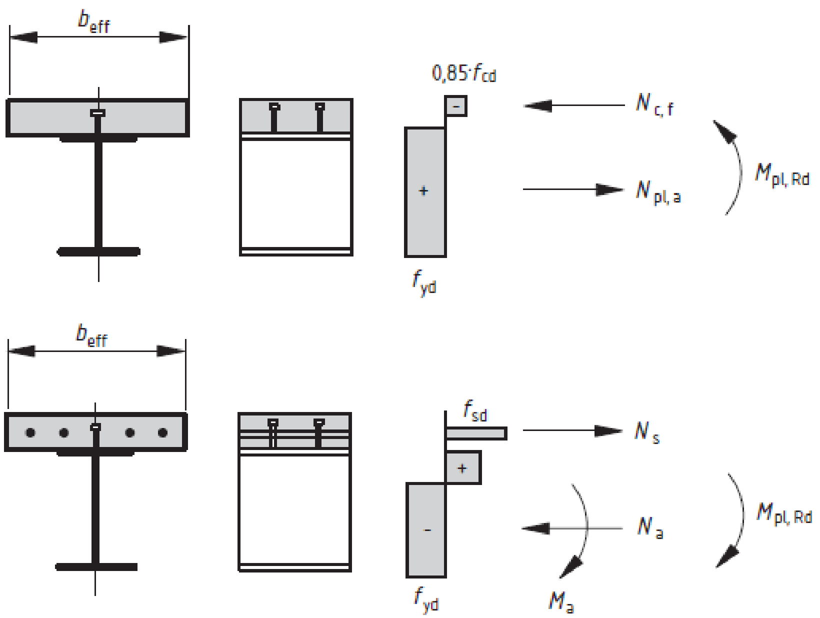
The convention for member axes and section dimensions used in the Eurocodes are shown below:



	Eurocode	BS5950
Major axis	y-y	x-x
Minor axis	z-z	y-y
Longitudinal axis	x-x	

Format of Eurocodes

- Eurocodes tend to give the rules for working out resistances but sometimes do not give precise equations (considered to be ‘text book’ material).



cf. BS5950-3.1, Appendix B

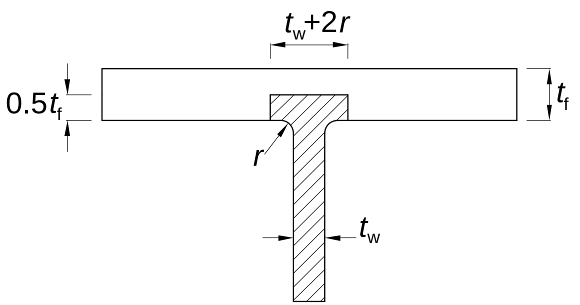
$$M_{pl,Rd} = N_{pl,a}\frac{h_a}{2} + N_{pl,c}\frac{h_c}{2} - \frac{\left(N_{pl,a} - N_{pl,c}\right)^2}{N_{pl,f}}\frac{t_f}{4}$$

Shear resistance comparison

- EN 1993-1-1, 6.2.6(2)

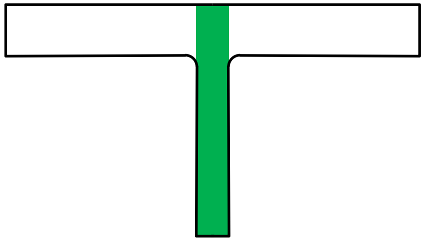
$$V_{pl,Rd} = \frac{A_v \left(f_y / \sqrt{3} \right)}{\gamma_{M0}}$$

$$A_v = A - 2bt_f + \left(t_w + 2r \right) t_f \geq \eta h_w t_w$$



- BS5950-1, 4.2.3

$$P_v = 0.6 p_y A_v$$



Column buckling resistance for Class 1, 2 & 3 cross-sections

- EN 1993-1-1

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}}$$

  - From the modified Perry-Robertson formula (α is an imperfection factor according to the buckling curve)

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} \leq 1.0$$

$$\phi = 0.5\left[1 + \alpha\left(\bar{\lambda} - 0.2\right) + \bar{\lambda}^2\right]$$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i}\frac{1}{\lambda_1}$$

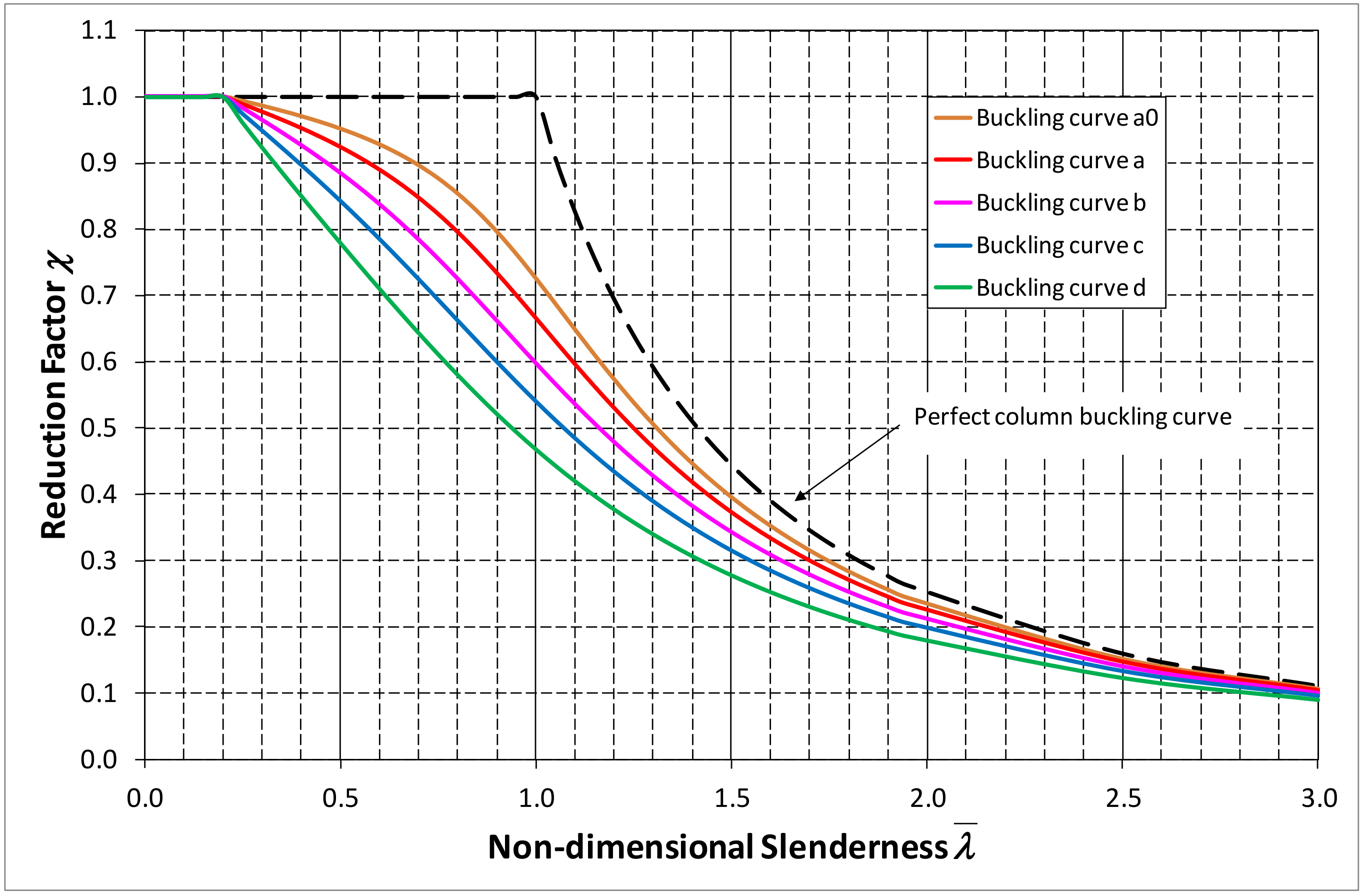
- BS 5950

$$P_c = A_g p_c$$

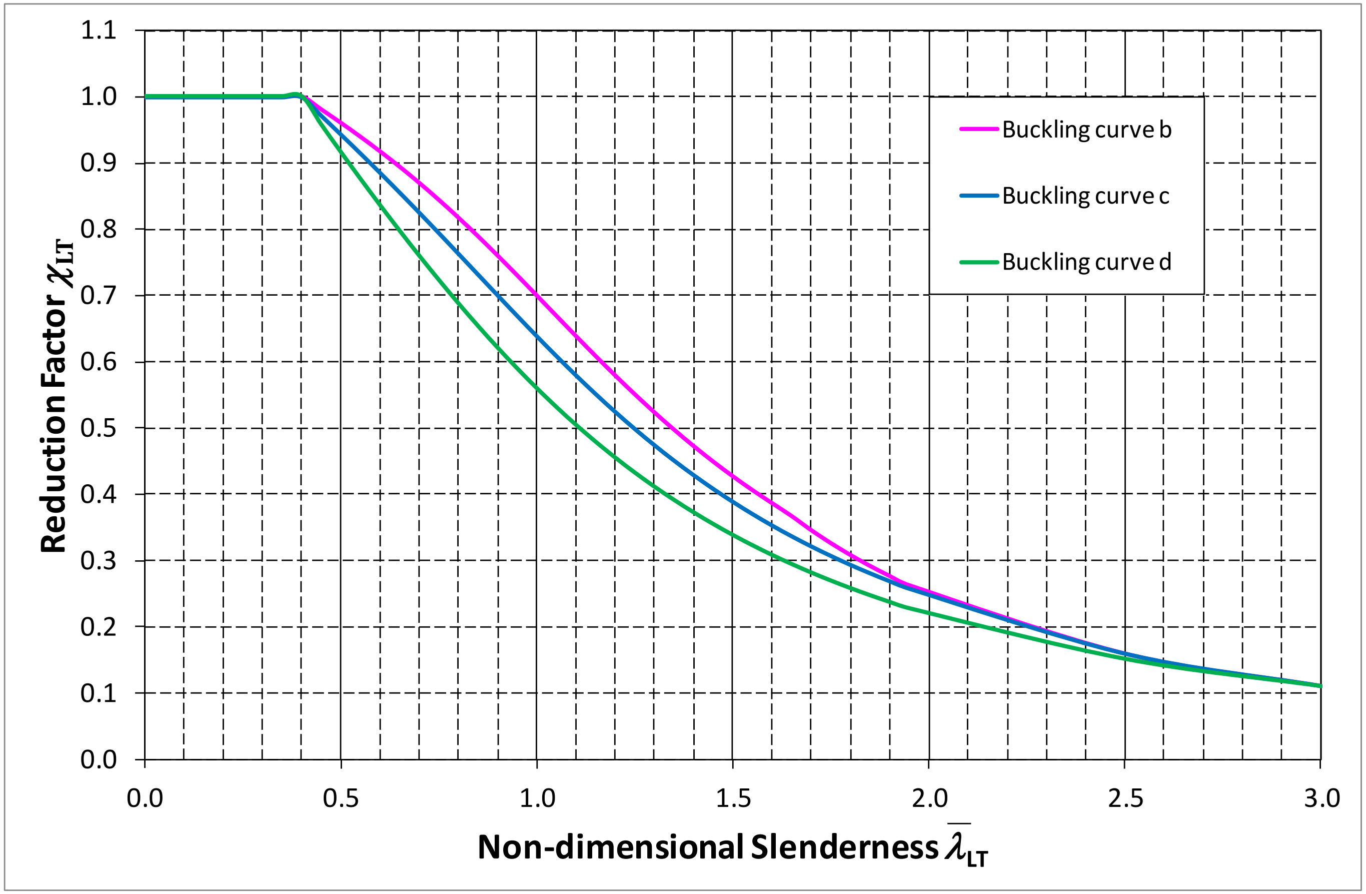
$$\frac{l/r_{yy}}{\lambda_1}$$

Euler buckling load $N_{cr} = \dfrac{\pi^2 EI}{L_{cr}^{\,2}}$

Eurocode 3 column buckling curves



Eurocode 3 lateral torsional buckling curves



Design buckling resistance moment

- Design buckling resistance moment $M_{b,Rd}$ of a laterally unrestrained beam (or segment of a beam):

- BS 5950 $$M_b = p_b \times \text{Modulus}$$

- EN 1993-1-1 $$M_{b,Rd} = \chi_{LT} W_y \frac{f_y}{\gamma_{M1}}$$

$$p_b = \chi_{LT} f_y$$
$$\chi_{LT} \leq 1.0$$

  - Very similar to axial compression with equations give to calculate χ_{LT} depending on:

$$\bar{\lambda}_{LT} = \frac{\lambda_{LT}}{\lambda_1} = \sqrt{\frac{W_y f_y}{M_{cr}}}$$

BUT M_{cr} is not given!

How to establish M_{cr}?

- Allowing for destabilizing loads

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{(kL)^2} \left\{ \sqrt{\left\{ \left(\frac{k}{k_w} \right)^2 \frac{I_w}{I_z} + \frac{(kL)^2 GI_T}{\pi^2 EI_z} + \left[C_2 z_g - C_3 z_j \right] \right\}} - \left[C_2 z_g - C_3 z_j \right] \right\}$$

- OR, use a simplified approach

- OR, use free software (see later in Eurocode transition tools and resources)

Non-Contradictory, Complimentary Information (NCCI)

National Annex

- The National Annex (NA) is a special type of informative annex that contains the choices made by a particular country.
- The contents of a NA are:
  - Scope
    - List of clauses that were left open by the Eurocodes for national choice.
  - Nationally Determined Parameters (NDPs)
    - Values of partial safety factors and classes applicable to that country
    - Country specific data (e.g. snow map)
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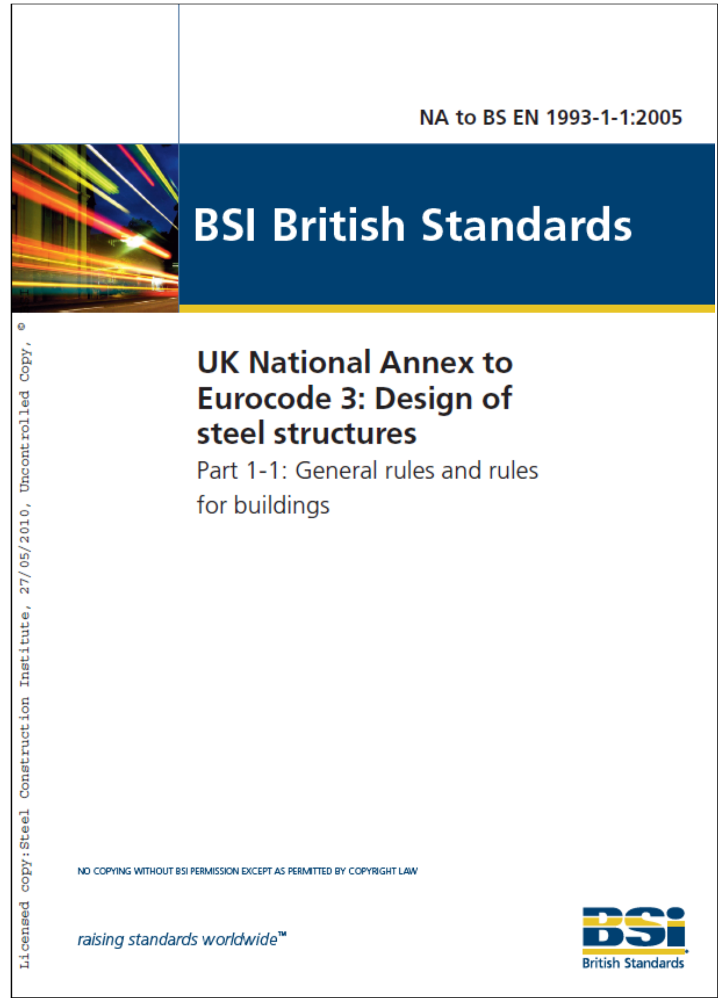
  - Decisions on the status of informative annexes.
  - References to non-contradictory complementary information (NCCI).


NA to BS EN 1993-1-1:2005

BSI British Standards

UK National Annex to Eurocode 3: Design of steel structures

Part 1-1: General rules and rules for buildings

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BSI British Standards

Non-Contradictory Complementary Information (NCCI)

- An NCCI is a way of introducing additional guidance to supplement the Eurocodes without contradicting them.
  - One example of an NCCI in the UK is a Published Document (PD), which is published by BSI (e.g. PD 6696-2 for steel-concrete composite bridges)
  - For steel together with composite steel and concrete structures, another NCCI source in the UK is http://www.steel-ncci.co.uk/
- Care may be required used the above NCCI's as they different territories may not necessarily accept them
- Other NCCI, which are more likely to be accepted within the Eurozone are published by the European Commission Joint Research Centre (JRC) http://eurocodes.jrc.ec.europa.eu/
  - For example: Design of floor structures for human induced vibrations, JRC Scientific and Technical Report, EUR 24084, 2009

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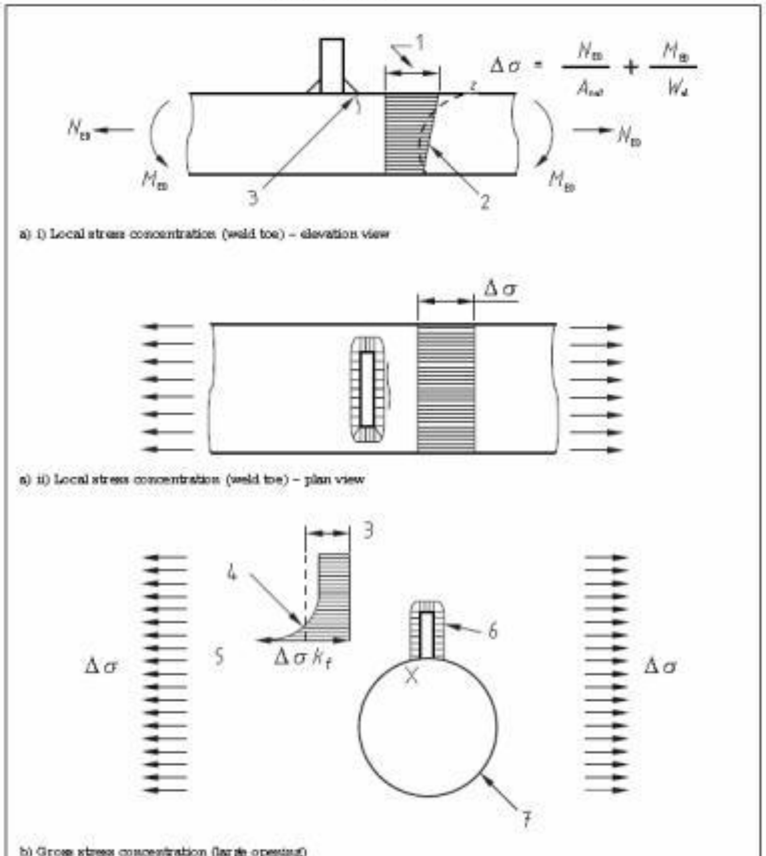
Published Document Examples

PD 6695-1-9 for fatigue to EN 1993-1-9

PD 6696-6 for composite bridges to EN 1994-2

PD 6695-1-9:2008

Figure 2 **Effect of stress concentrations on nominal and modified nominal stresses**



5.4 Design resistance of block connectors with hoops [BS EN 1994-2:2005, 1.1.3 (3)]

The shear resistance of a block connector with hoops in normal weight concrete and height of block, $0{,}5b_1$, not exceeding four times its thickness, l_b, may be taken as:

$$P_{Rd} = A_{c0}\sqrt{A_{c1}/A_{c0}}\, f_{cd} \leqslant 3{,}0 A_{c0} f_{cd}$$

where:

- A_{c0} is the area of the front surface of the block connector, equal to $0{,}5b_1 d_1$;
- b_1 and d_1 are shown in Figure 1;
- A_{c1} is the design distribution area at the rear surface of the adjacent connector, equal to $0{,}5b_2 d_2$;
- b_2 and d_2 are shown in Figure 1 and should be in accordance with BS EN 1992-1-1:2004, **6.7** as follows:

  $b_2 \leqslant b_1 + h$ and $b_2 \leqslant 3b_1$; $d_2 \leqslant d_1 + h$ and $d_2 \leqslant 3d_1$;

  A_{c0} and A_{c1} should be of similar shape.

The shear resistance of a block connector with hoops in lightweight aggregate concrete may be taken as:

$$P_{Rd} = A_{c0}\left[A_{c1}/A_{c0}\right]^{\rho/4\,400} f_{lcd} \leqslant 3{,}0(\rho/2\,200) A_{c0} f_{cd}$$

where:

ρ is obtained from BS EN 1992-1-1:2004, Table 11.1.

Vertical tie reinforcement to control splitting need not be provided in the slab.

 28/03/2014

Example UK NCCI

- Design of composite beams with large web openings by Lawson and Hicks
- Previous guidance given as an amendment to the European pre-Standard ENV 1993-1-1: 1992/A2: 1998, but was never published in the final version of EN 1993-1-1
- Currently being worked on by the Evolution Group for implementation within EN 1994-1-1

Execution and Product Standards

Execution and Product Standards

- The Eurocodes are concerned with design and not execution, but minimum standards of workmanship are required to ensure that the design assumptions are valid (e.g. the magnitude of the partial safety factor, which accounts for material and geometrical tolerances).
- As well as other related Eurocodes, a list of relevant execution standards, harmonized standards (hENs), material standards, product standards, test standards, European Technical Approvals (ETA's) and European Technical Approval Guidelines (ETAGs) are given at the beginning of each Eurocode

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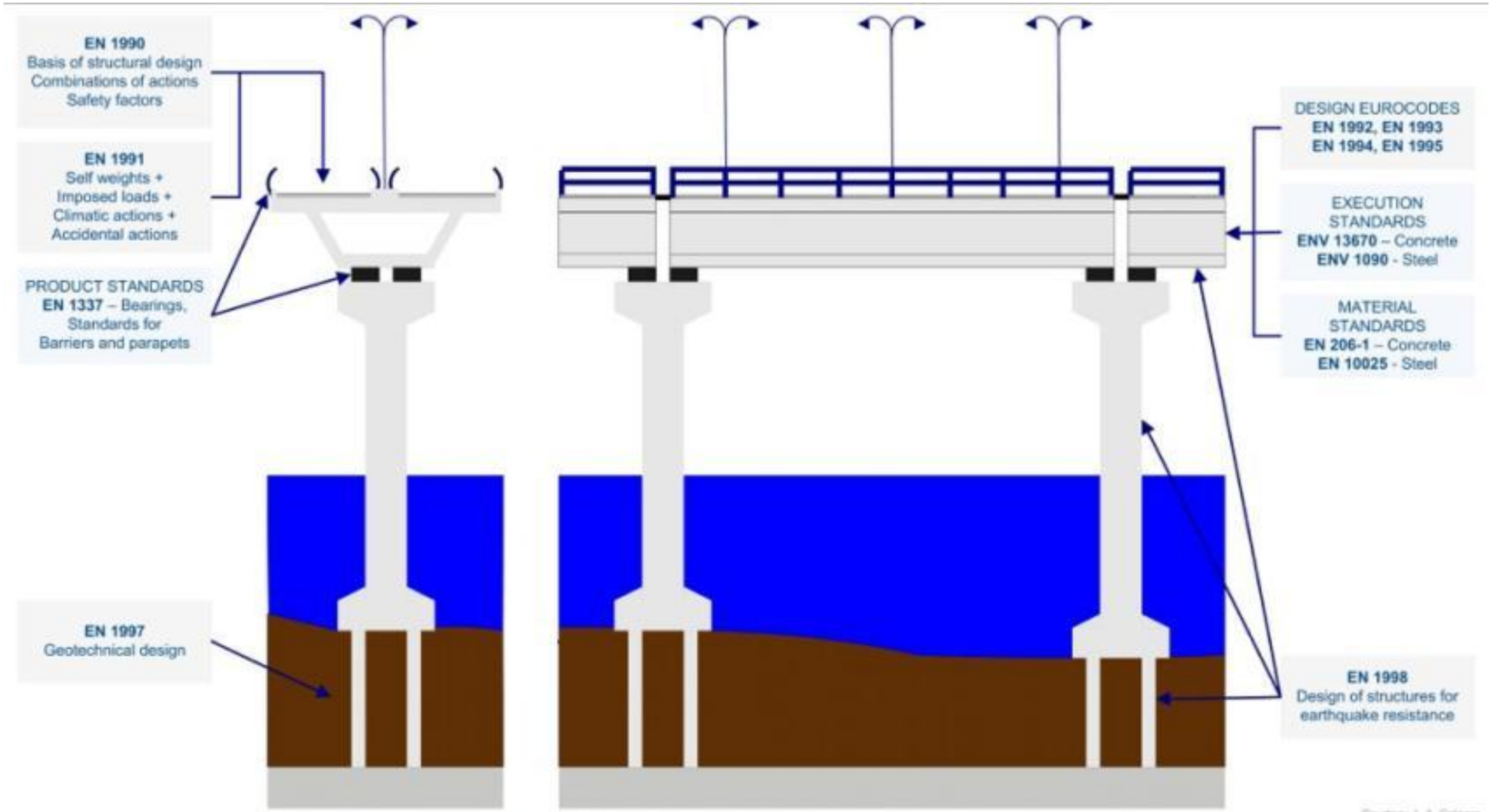
Relationship between different European Standards



Use of Eurocodes with other EN standards for the design of a bridge

EN 1090 Execution Class (EXC)

- EN 1090-1, introduces the concept of Execution Class (EXC). Execution Classes establish the required quality of fabrication and can be applied to the whole structure, an individual member or particular details.
- EXC are related to the Consequence Classes in EN 1990, which provide reliability differentiation for different types of structure.
- There are four Execution Classes with EXC4 being the highest level of quality control and EXC1 the lowest. In general, they apply to the following structures:
  - EXC1 - farm building (structures where the consequence of failure is deemed to be low)
  - EXC2 - the majority of buildings (default class)
  - EXC3 - bridges (and most structures subject to fatigue)
  - EXC4 - long-span bridges (structures where the consequence of failure is deemed to be particularly high)
- It is the Designers/Client's responsibility to select the Execution Class and recommendations for determining Execution Class are given in BS EN 1090-2.
- Steelwork contractors must have in place the correct certified FPC system for the correct Execution Class (e.g. steelwork contractors with EXC2 systems cannot fabricate EXC3 or EXC4 steelwork; those with EXC4 systems can fabricate all structures).
- For steel structures according to EN 1090-2, different EXC require different:
  - Identification, inspection documents and traceability
  - Steel thickness tolerances, surface conditions and special properties
  - Cutting, shaping and holing
  - Qualification of welding procedures and personnel
  - Erection
  - Inspection, testing and repair

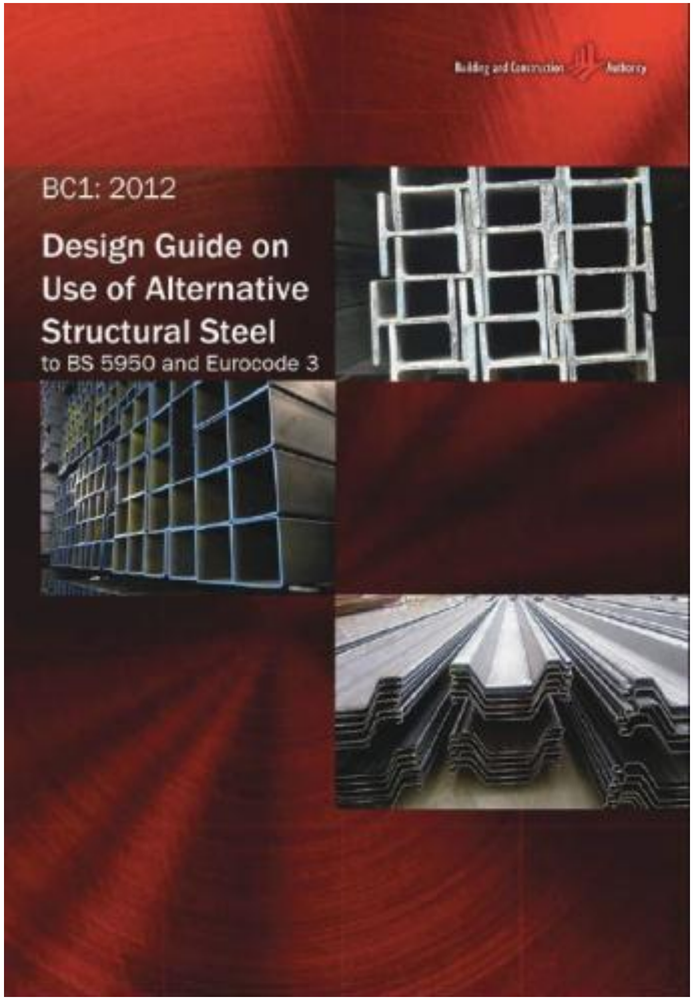
Harmonized Standards hENs

- EN standards are usually prepared at the request of industry. Standards prepared at the request of the European Commission (to implement European legislation) are known as 'mandated' standards.
- When 'mandated' standards are prepared under the 'new approach' directives, they are known as 'harmonized standards' (hENs) and are cited in the Official Journal of the European Communities (OJ).
- All harmonised product standards include an Annex Z, which differentiates between the mandatory and voluntary parts of the standard. Annex Z lists the relevant essential requirements, and against each characteristic, the clause or clauses in the standard that address the characteristic e.g. EN 10025-1 for steel products and EN 1090-1 for steel and aluminium structures.
- Products manufactured in accordance with harmonized standards benefit from a 'presumption of conformity' to the essential requirements of a given directive, which permits CE Marking.

The Construction Products Regulation (305/2011/EC)

- The Construction Products Directive (CPD) came into force in 1988 and introduced the concept of CE-Marking for all construction products permanently incorporated into ‘construction works’ such as:
  - Buildings
  - Bridges
  - Highways or other civil engineering projects
- The Construction Products Regulation (CPR) replaced the Construction Products Directive (89/106/EEC) in 2011
- As a result of the change, CE marking will soon become mandatory in the UK. Manufacturers and importers have until July 2013 to ensure that their construction products meet the CE requirements of the new Regulation.
- CPR intends to bring about:
  - Clarification of the basic concepts and of the use of CE marking
  - Simplification of the procedures, so as to reduce the costs incurred by enterprises, in particular SMEs
  - increased credibility for the whole system.
- The use of Eurocodes raises a presumption of conformity with the Basic Requirements 1 (Mechanical Resistance & Stability), and partially 2 (Safety in case of Fire) and 4 (Safety in Use) referred to in the CPR

Use of the Eurocodes outside EU (Singapore)



- Some countries outside the EU rely on imported steel, which isn't necessarily produced according to an hEN
- Singapore is in this position and has resolved this by identifying alternative certified steels that have been produced to the following standards:
  - ASTM (American)
  - JIS (Japanese)
  - AS/NZS (Australian and New Zealand)
  - GB (Chinese)
- Based on a 'reliability assessment', provides three classes of steel materials that has a third-party certified FPC:
  - Class 1 (certified steel materials manufactured with approved quality assurance): Full f_y given in product standards may be used in design.
  - Class 2 (non-certified steel materials which meet the material performance requirements through material testing, and are manufactured with approved quality assurance): Reduced f_y given in product standards may be used in design.
  - Class 3 (steel materials which do not meet at least one of the two requirements: material performance requirements and quality assurance requirements): effectively 'unidentifed steel' and f_y given in product standards severely reduced for design.

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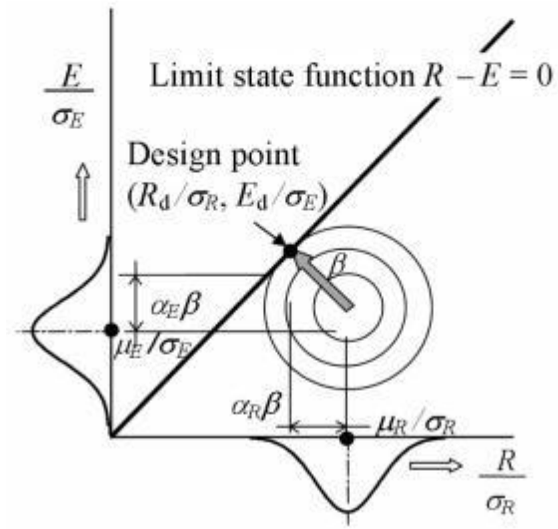
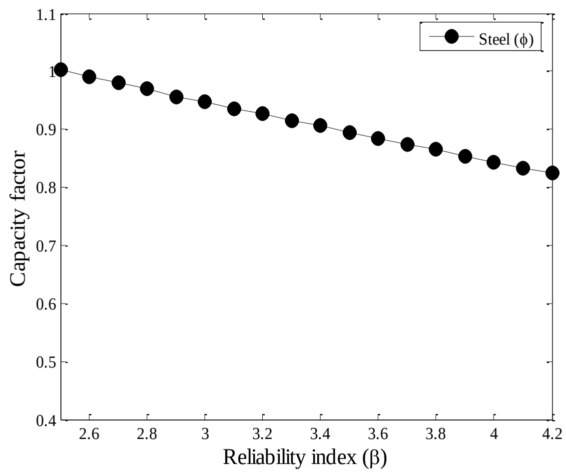
Use of alternative steels in other design standards

- Historically, New Zealand has accepted alternative steels supplied to EN and JIS product standards.
- Through the harmonization of the Australian and New Zealand steel and concrete bridge standard, these steels also need to be recognized.
- To demonstrate that the different dimensional tolerances and material variability didn't erode the safety margins required in the design standards, full structural reliability analyses undertaken.
- Capacity factors ϕ ($\phi = \gamma_M$) show that the existing values used for AS/NZS steels are appropriate, irrespective of the different manufacturing tolerances.





Eurocode transition tools and resources

Information for designers

- Books published by Thomas Telford:
  - EN 1990 by Gulvanessian, Calgaro & Holický
  - EN 1992-1-1 and EN 1992-1-2 by Narayanan & Beeby
  - EN 1993-1-1 by Gardner & Nethercot
  - EN 1994-1-1 by Johnson
- Books published by BSI
  - The Essential Guide to Eurocodes Transition Edited by John Roberts
  - Concise Eurocodes. Loadings on Structures BS EN 1991. Eurocode 1 by Burgess, Green & Abu
  - Concise Eurocode for Design of Timber Structures: BS EN 1995: Eurocodes 5 by Marcroft
  - Concise Eurocodes: Geotechnical Design – BS EN 1997: Eurocode 7 by Simpson
- Books by the Steel Construction Institute (http://www.steelbiz.org/)
  - Steel Building Design: Concise Eurocodes
  - Steel Building Design. Worked Examples
  - Joints in Steel Construction (‘green books’)
- Books by the Cement and Concrete Industry (http://http://www.concretecentre.com/)
  - Concise Eurocode 2
  - Worked Examples to Eurocode 2: Volume 1

Eurocodes PLUS

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News

New standard for aluminium available on Eurocodes Online

30 Sep 2010 | 04:00

A revised product standard for Aluminium bashing has been added to the collection of product standards recently added to Eurocodes Online. BS 8520-1:2009 : Aluminium bashing and tensile strength.

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- ( ) **Material Type**
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Title	Last Run Date
Creep, Shrinkage or composites	10 Jan 2011
Creep, Shrinkage	10 Jan 2011
Concrete Tensile Strength	10 Jan 2011
Axial Compression	10 Jan 2011

Active Notes

Edit

3 new notes added by a colleague in last 15 days

- **OrigCM has added a note to BS EN 1090-1:2009**
  Execution of steel structures and aluminium structures - Requirements for conformity assessment of structural components
  My Public Note
  This is a Note

- **SuperR has added a note to BS EN 1991-1-2:2002**
  Eurocode 1. Actions on structures - General actions. Actions on structures exposed to fire
  SuperR note
  Note 29-12

- **OrigCM has added a note to BS EN 1995-1-1:2004+A1:2008**
  Eurocode 5. Design of timber structures - General. Common rules and rules for buildings
  NOTE
  Note 27-12

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Title	Viewed Date
NA to BS EN 1996-1-1:2005 UK National Annex to Eurocode 6. Design of masonry structures - General rules for reinforced and unreinforced masonry structures	06 Jan 2011
BS EN 1990:2002+A1:2005 Eurocode. Basis of structural design	06 Jan 2011
BS EN 1992-1-1:2004 Eurocode 2: Design of concrete structures - General rules and rules for buildings	05 Jan 2011
BS EN 1997-2:2007 Eurocode 7. Geotechnical design - Ground investigation and testing	05 Jan 2011
NA to BS EN 1992-3:2006 UK National Annex	05 Jan 2011

Section 3 Materials

3.1 Concrete

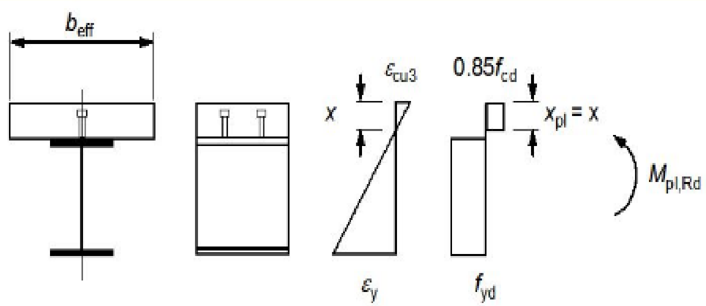
EXPERT COMMENT

Expert comment on Clause 3.1

AUTHOR: Stephen Hicks PUBLISHED DATE: 18/02/2011

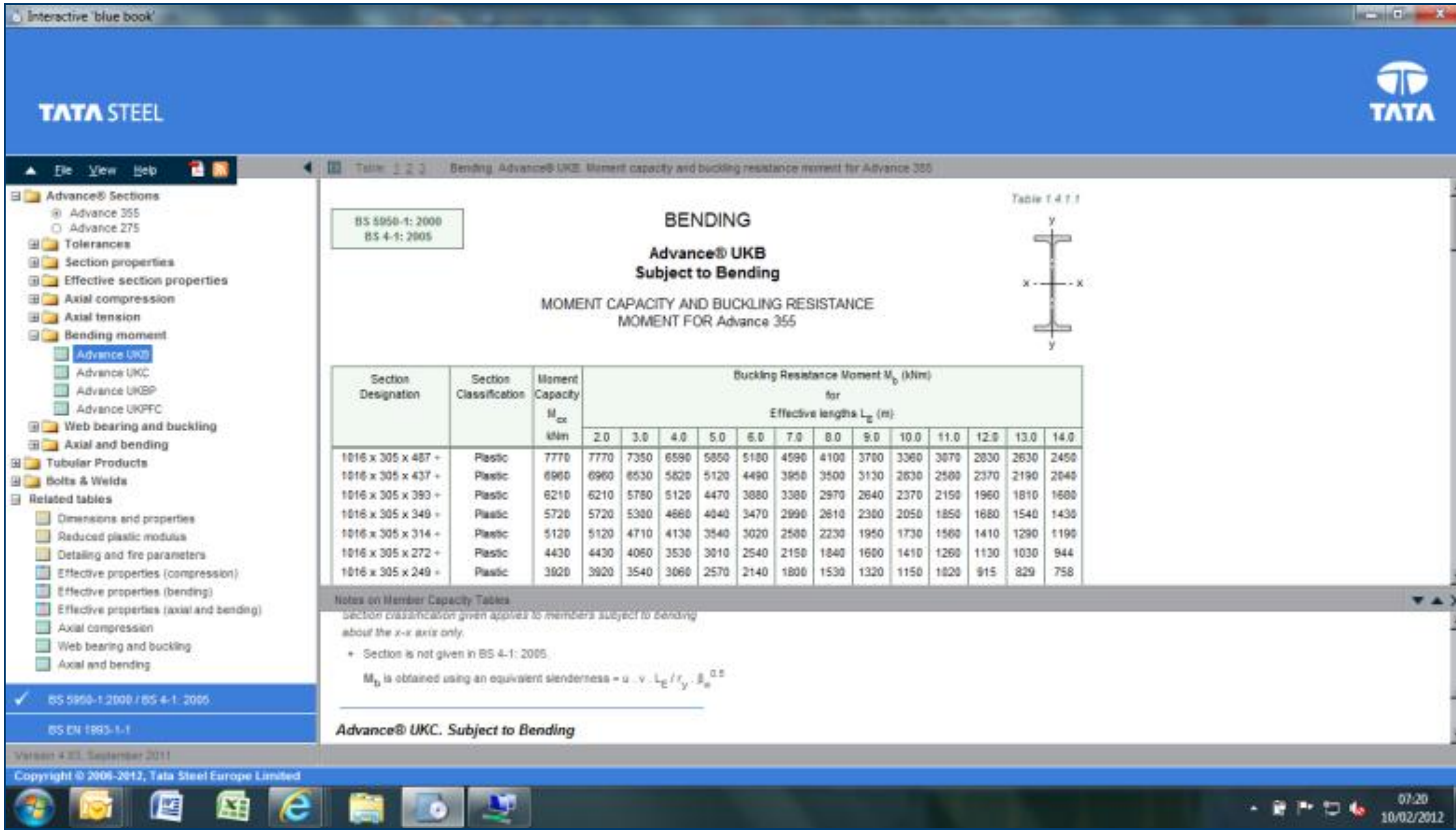
The treatment of the effective strength of the concrete and the effective height of the compression zone in BS EN 1992-1-1, 3.1.7 is different to that given in BS EN 1994-1-1 for rectangular stress blocks. As can be seen in the Figure below, the effective strength of the concrete is taken as $0.85f_{cd}$ in BS EN 1994-1-1 (the only exception to this is concrete filled tubes in BS EN 1994-1-1, 6.7.3.2(1)). Conversely, in BS EN 1992-1-1, it is taken as ηf_{cd} (where the value of η is a function of f_{ck}).

For the effective height of the concrete in the compression zone, rather than use the depth λx given in BS EN 1992-1-1, 3.1.7, BS EN 1994-1-1 permits the depth of the stress block to extend to the neutral axis position (see Figure below). This simplification introduces an error that is unconservative. Although this error is negligible when considering the plastic moment resistance of composite beams, it is not negligible for composite columns, which results in the introduction of the coefficient α_M in BS EN 1994-1-1, 6.7.3.6(1).



Eurocode 4

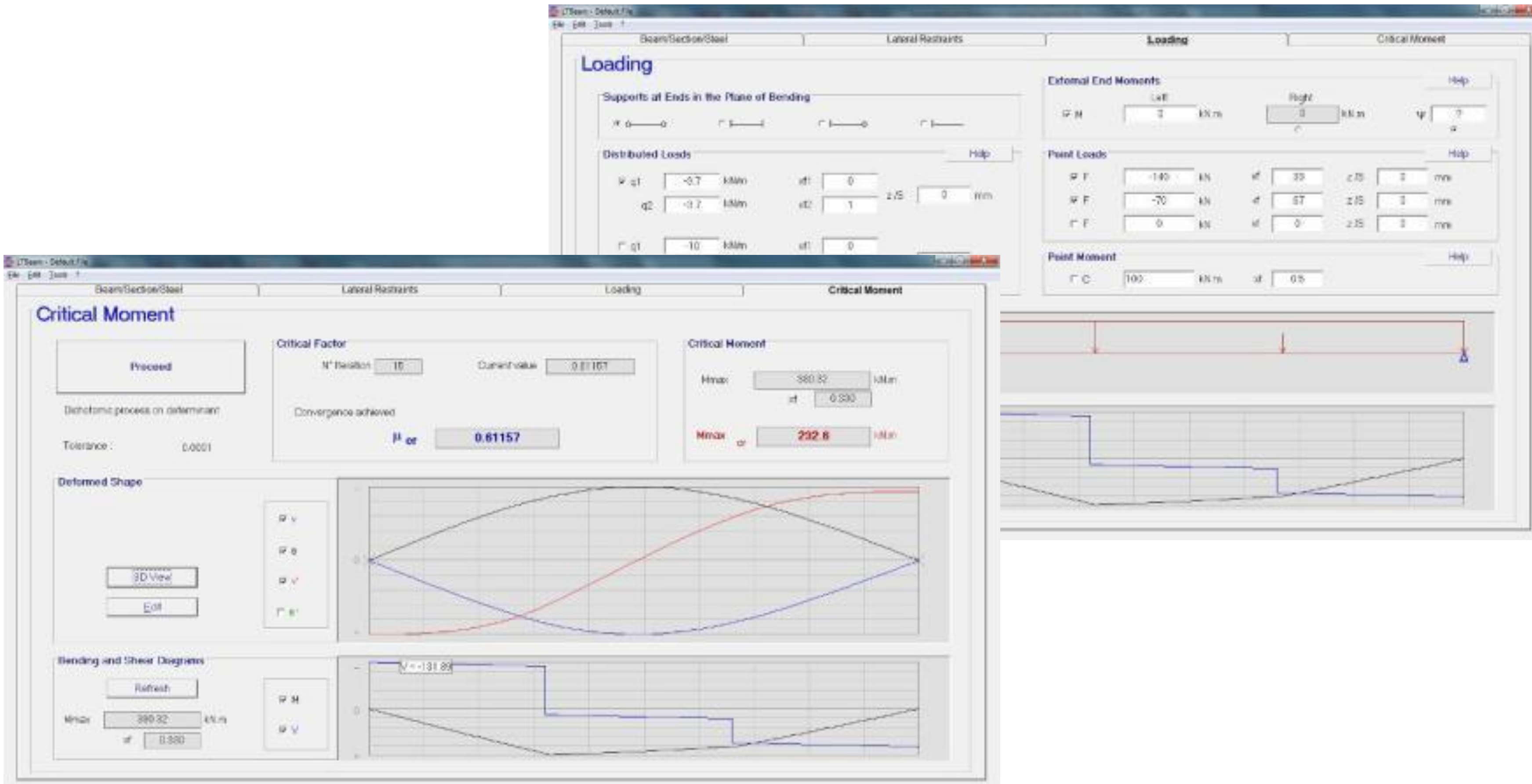
Electronic blue book free from
http://www.tatasteelconstruction.com/en/design_guidance/the_blue_book



Section Designation	Section Classification	Moment Capacity M_{cx} kNm	Buckling Resistance Moment M_b (kNm) for Effective lengths L_E (m)												
			2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0
1016 x 305 x 487 +	Plastic	7770	7770	7350	6590	5850	5180	4590	4100	3700	3360	3070	2830	2630	2450
1016 x 305 x 437 +	Plastic	6960	6960	6530	5820	5120	4490	3950	3500	3130	2830	2580	2370	2190	2040
1016 x 305 x 393 +	Plastic	6210	6210	5780	5120	4470	3880	3380	2970	2640	2370	2150	1960	1810	1680
1016 x 305 x 349 +	Plastic	5720	5720	5300	4660	4040	3470	2990	2610	2300	2050	1850	1680	1540	1430
1016 x 305 x 314 +	Plastic	5120	5120	4710	4130	3540	3020	2580	2230	1950	1730	1560	1410	1290	1190
1016 x 305 x 272 +	Plastic	4430	4430	4060	3530	3010	2540	2150	1840	1600	1410	1260	1130	1030	944
1016 x 305 x 249 +	Plastic	3920	3920	3540	3060	2570	2140	1800	1530	1320	1150	1020	915	829	758

LTBeam design software to evaluate M_{cr}

https://www.cticm.com/logiciels



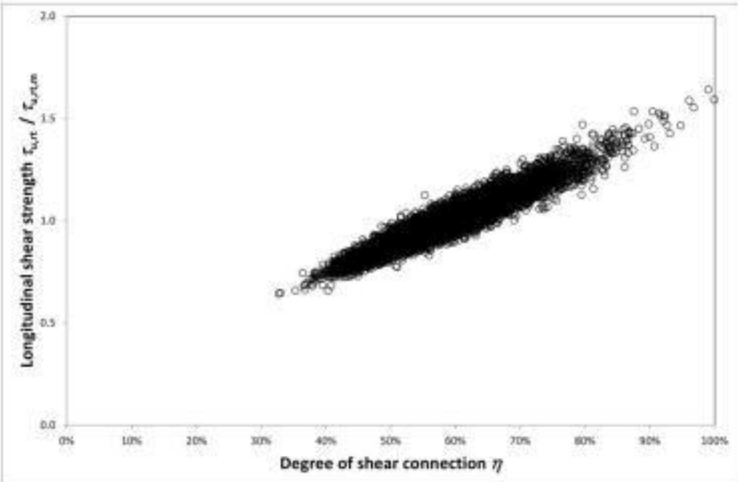
Future evolution of the Eurocodes

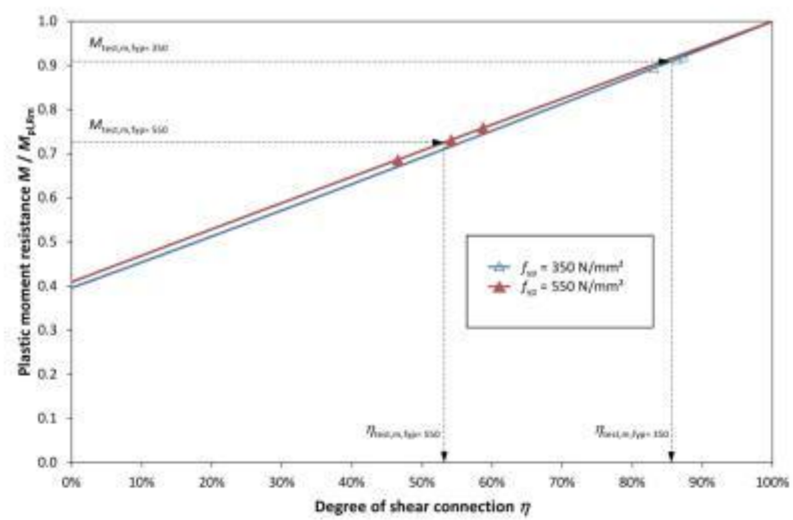
Mandate M/515 EN for the Evolution of Eurocodes

- Reduction in the number of Nationally Determined Parameters (NDPs) – JRC have been reviewing Member States National Annexes
- Refinement to improve the 'ease of use' of Eurocodes by practical users and including new technology within EN 1990 to EN 1999 ('Evolution Groups' formed)
- Development of a new Eurocode on Structural Glass
- Development of a new Eurocode on the Assessment and Retrofitting of Existing Structures
- Development of a Technical Specification, CEN/TS (which serves as normative document in areas where the actual state of the art is not yet sufficiently stable for a European Standard), for:
  - Fibre Reinforced Polymers (FRP)
  - Membrane Structures
- New rules for Robustness to be included.
- Where appropriate, adoption of ISO standards to supplement the Eurocodes (e.g. atmospheric icing of and actions from waves and currents on coastal structures

Using EN 1990 Method b, some work that might be considered by the Evolution Group for EN 1994-1-1

- For composite slabs, according to EN 1994-1-1, B.3.1(4), to reduce the number of tests as required for a complete investigation, the results obtained from a test series may be also used for other values of variables as follows:
  - a) For thickness of the steel sheeting *t* larger than tested.
  - b) For concrete with a specified characteristic compressive strength f_{ck} not less than 0.8 f_{cm}, where f_{cm} is the mean value of the concrete strength in the tests.
  - c) For steel sheeting having a yield strength f_{yp} not less than 0.8 f_{ypm}, where f_{ypm} is the mean value of the yield strength in the tests.
- Recent tests and reliability anlayses on sheetings that are available to the Hong Kong market show point (c) incorrect (existing rule likely to have been based on Deterministic methods) and propose that this should be revised to the following:
  - *c) For steel sheeting having a yield strength f_{yp} not larger than tested. The yield strength f_{yp} should not be less than 0.8 f_{ypm}, where f_{ypm} is the mean value of the yield strength in the tests*





Conclusions

- Eurocodes are a set of harmonized standards developed by the EU for the structural design of construction works
  - 109 harmonised European standards
  - Now being used by civil & structural engineers
  - A new approach to engineering practice
  - Became current British Standards on 1 April 2010
  - Increasingly mandatory for public procurement projects
- Care may be required when using Non-Conflicting Complimentary Information (NCCI) as different territories may not necessarily accept them
- The integration of EN product and execution standards can present problems for countries outside EU, who are developing supplementary guidance to suit their local conditions
- A wide range of Eurocode transition tools and resources are available
- Workplan established to extend the existing suite of Eurocodes

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