DOI: http://dx.doi.org/10.12989/scs.2005.5.4.327
Steel and Composite Structures, Vol. 5, No. 4 (2005) 327-343

Technical Report

Eurocode 4: A modern code for the design of composite structures

Jan Stark†

Delft University of Technology, Faculty of Civil Engineering and Geosciences, PO Box 5048, 2600 GA Delft, The Netherlands

(Received October 13, 2004, Accepted January 26, 2005)

Abstract. The European Standards Organisation (CEN) has planned to develop a complete set of harmonized European building standards. The Eurocodes, being the design standards, form part of this total system of European standards, together with standards for fabrication and erection and product standards. After a period of experimental use of the ENV(European Pre Standard)-versions of the Eurocodes, these are now converted into official EN's (European Standards). Design of composite steel and concrete buildings and bridges is covered by Eurocode 4. An overview will be given of the historic development of Eurocode 4, the structure and contents of the EN version and the present status and planning for completion. The Eurocode treatment of some selected technical items will be presented in more detail.

Key words: composite structures; standards; Eurocodes.

1. Introduction

In the past for the design of a building the choice was normally between a concrete structure or a steel structure. Looking at recent practice in Europe there is an evident tendency that designers also consider the combined use of concrete and steel in the form of composite or mixed structures as a serious alternative. Use of composite elements in the form of beams, columns and composite slabs is already common practice in many countries. The application is supported by accepted national standards or recommendations. However the development is going on. The national standards will be replaced by a harmonised European Standard : EN1994 - Eurocode 4, now in a final stage of completion.

This code is part of a complete set of design codes developed in the Eurocode-programme by CEN on the initiative of the Commission of the European Communities (CEC). Due to the special character of the Eurocodes on request of the Commission CEN has set up a Technical Committee TC 250: "Structural Eurocodes", which within CEN is solely responsible for all structural design codes. This TC has nine Subcommittees (SC), each responsible for one volume.

CEN/TC250/SC4 is responsible for Eurocode 4.

Detailed information on the Eurocode project is given by F.S.K. Bijlaard in his contribution to this session.

The Eurocode-programme is aiming at two dimensional harmonization:

†Professor, E-mail: janstark@planet.nl

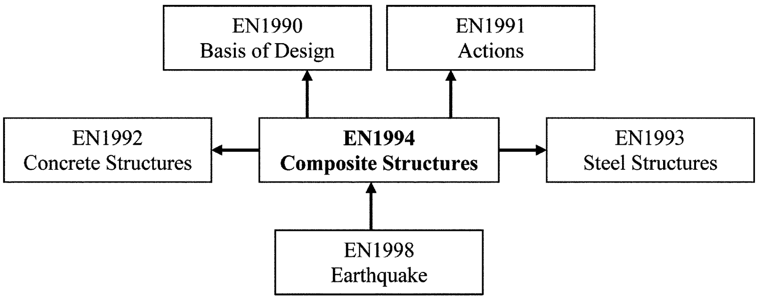


Fig. 1 Relation of EN 1994 (Eurocode 4) with other Eurocodes

(1) Harmonization across the borders of the European Countries;
(2) Harmonization between different construction materials, construction methods and types of building and civil engineering works to achieve full consistency and compatibility of the various codes with each other and to obtain comparable safety levels.

The second item is of particular interest for composite structures.

EN1994 (Eurocode 4) must be consistent on one hand with the material independent parts EN1990 and EN1991 and on the other hand with EN1992 (Eurocode 2) for concrete structures and EN1993 (Eurocode 3) for steel structures. The Eartquake code EN1998 (Eurocode 8) is related to EN1994 for composite structures. The relation is illustrated in Fig. 1.

2. Code development : EN1994 - Eurocode 4

2.1. Historic development

The first draft of Eurocode 4 was prepared in 1983/1984, and published by the CEC in 1985. Extensive and detailed comments on the 1985 draft were received from the twelve member states of the EEC in 1987. At that time the responsibility for further development was mandated to CEN.

The text of ENV1994 was developed from the 1985 draft. It was influenced by substantial changes in Eurocodes 2 and 3 between 1984 and 1992, by new research, by developments in practice, and by comments from the member states of the EEC and since 1991 from all 18 countries cooperating in CEN. Part 1.1 was approved in July 1992 and issued as ENV in the same year (1994). Later the set was completed with two further parts:

ENV 1994-Part 1.2: Structural fire design was issued in 1994, and

ENV 1994-Part 2: Composite bridges was issued in 1997.

These ENV's have been published accompanied by National Application Documents (NAD's). It was intended that the ENV's together with its NAD may be used optional to the national standard in force.

2.2. Conversion of ENV Eurocodes into EN's

The final step in the process is the conversion of the ENV's into EN's. As the documents reach this final stage, there will be a planned withdrawal of the national standards of each country, leaving the EN as the only accepted design Code within the Community.

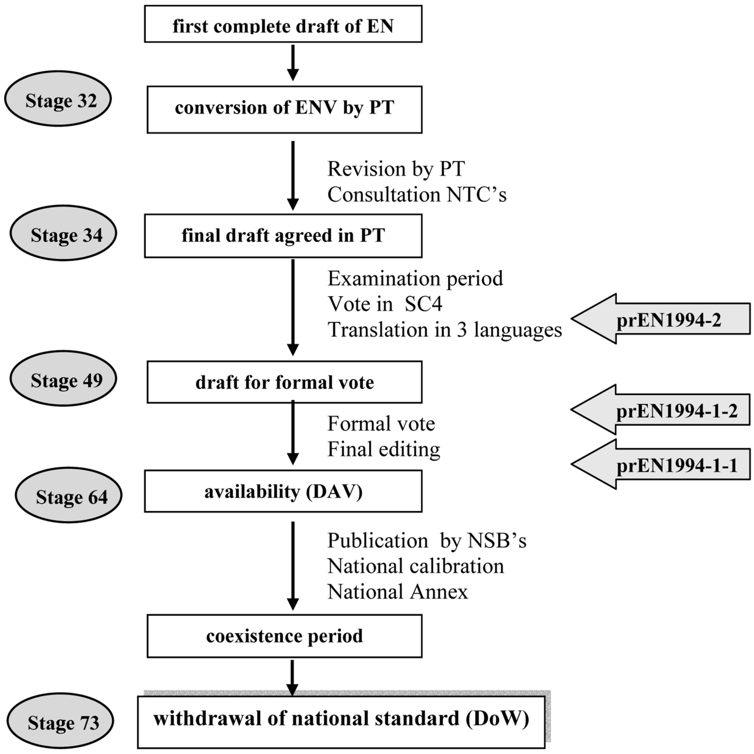


Fig. 2 Flow chart for the preparation of Eurocodes

The conversion work is being carried out by Project Teams comprising recognised experts in the relevant field of work. They have the task to produce agreed or consensus drafts taken into account the national comments on the ENV's. A Eurocode Coördination Group, consisting of the chairmen of the different Sub Committees, is responsible for the harmonised presentation and editing of those parts of the Code which are material independent. CEN has issued policy guidelines and procedures aiming at keeping the conversion effectively in accordance with the agreed programmes and procedures.

The conversion of all three parts of ENV1994 into EN has started and the status of development is indicated in the flow chart of the conversion process in Fig. 2.

2.3. Coordination

The structure of EN 1994, in terms of Parts and Sections, results from policy decided by SC4 (in respect of Parts) and TC250 (in respect of Sections within each Part).

The scope of the application rules in EN1994 is restricted to Buildings and Bridges.

So EN1994: "Design of composite steel and concrete structures" has 3 Parts.

EN1994-1-1: General rules and rules for buildings
EN1994-1-2: General rules – Structural fire design
EN1994-2: Rules for bridges

Part 1-1 and Part 2 have the standard structure as given in Fig. 3.

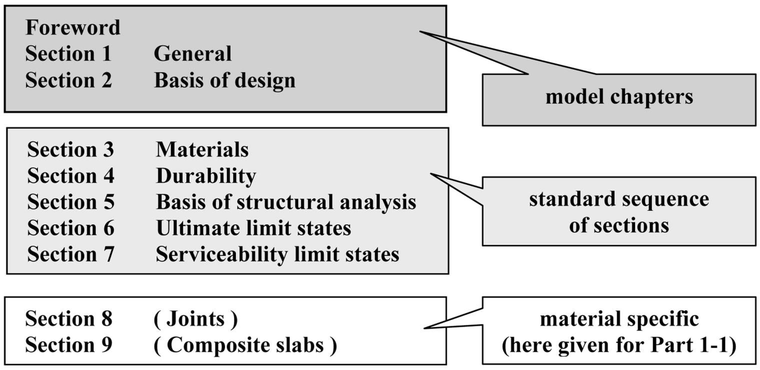


Fig. 3 Standard structure of Parts 1-1 and 2

Many civil engineering structures are made of combinations of several structural materials. Therefore it is important that the rules in the material dependent codes are consistent.

In the Eurocode Coordination group items for common application were discussed and harmonized.

A number of important items are listed below.

- Formulae for limit states verification
- Definition of R_d
- Statistical calibration → Annex D of EN1990
- Rules for indirect actions
  - prestress
  - imposed deformations
  - temperature effects
- Frame stability
- Treatment of imperfections

As shown in Fig. 1 EN1994 for composite structures is directly related to the concrete code EN1992 and the steel code EN1993.

In Fig. 4 related items concerning materials and material properties are given and ìn Fig. 5 related design rules.

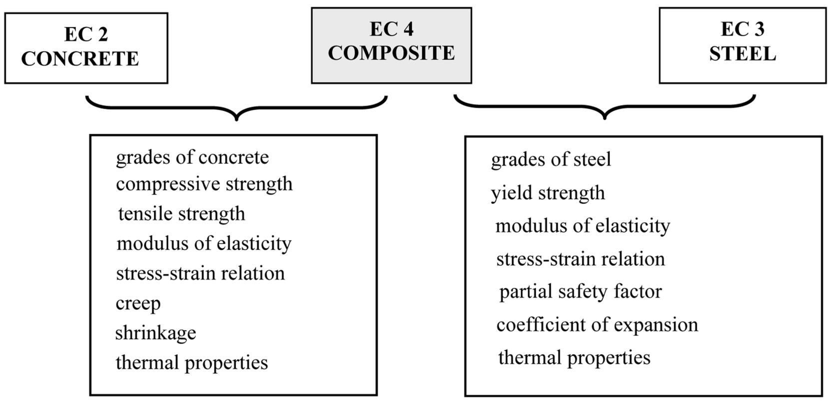


Fig. 4 Related items concerning materials and material properties

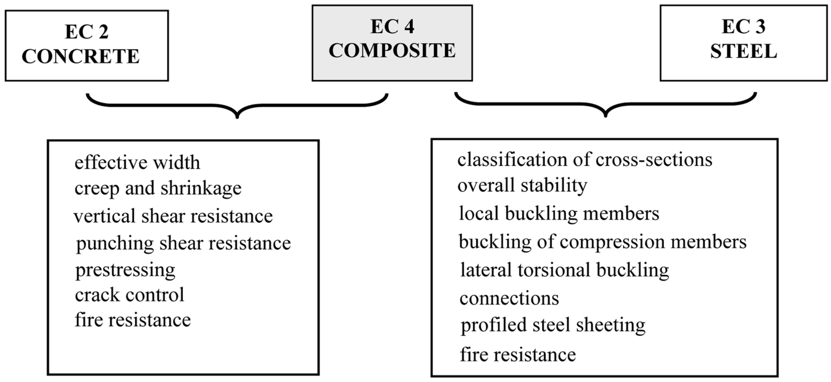


Fig. 5 Related design rules

3. Contents of EN1994

3.1. Draft prEN 1994- Part 1.1: General rules and rules for buildings

Part 1.1 gives a general basis for the design of composite structures together with specific provisions for buildings. In addition, Part 1.1 gives detailed application rules which are mainly applicable to ordinary buildings. Provisions in Part 1.1 specific to buildings have been placed at the end of clauses. The intention being to make clear what is specific to buildings and to avoid gaps in clause numbering in Part 2.

Contents of prEN1994-1-1:

Foreword

Section 1. General
(Scope; Distinction between Principles and Application Rules; Definitions; Units; Symbols)

Section 2. Basis of design
(General rules concerning limit state design; Actions; Combination of actions; Safety factors)

Section 3. Materials
(Properties of concrete, reinforcing steel, structural steel, shear connectors, profiled steel sheeting)

Section 4. Durability
(Reference to EN1990, EN1992, EN1993; Steel-concrete interface; Profiled steel sheeting)

Section 5 Structural analysis
(Structural modelling; Structural stability; Imperfections; Calculation of action effects; Classification of cross-sections)

Section 6. Ultimate limit states
(Beams; Resistances of cross-sections of beams; Resistance of cross-sections with partial encasement; Lateral-torsional buckling; Transverse forces on webs; Shear connection; Composite columns; Fatique)

Section 7. Serviceability limit states
(Limitation of stresses; Deflection of beams; Cracking of concrete)

Section 8. Composite joints in frames for buildings
(Analysis, modelling and classification; Design methods; Resistance of components)
Section 9. Composite slabs with profiled steel sheeting for buildings

Annexes:
Annex A: Stiffness of joint components in buildings. (Informative)
Annex B: Standard tests. (Informative)
Annex C: Shrinkage of concrete for composite structures for buildings. (Informative)

3.2. Draft prEN 1994- Part 1.2: General rules - Structural fire design

Contents of prEN1994-1-2 :
Foreword
Section 1. General
(Scope; Distinction between Principles and Application Rules; Definitions; Units; Symbols)
Section 2. Basis of design
(Requirements; Actions; Design values of material properties; Verification methods)
Section 3. Material properties
(General; Mechanical properties; Thermal properties; Density)
Section 4. Design procedures
(Introduction; Tabulated data; Simple calculation models; Advanced calculation models)
Section 5 Constructional details
(Introduction; Composite beams; Composite columns; Connections between composite beams and columns)

Annexes :
Annex A: Stress-strain relationships at elevated temperatures for structural steels. (Informative)
Annex B: Stress-strain relationships at elevated temperatures for siliceous concrete. (Informative)
Annex C: Concrete stress-strain relationships adapted to natural fires with a decreasing heating branch for use in advanced calculation models. (Informative)
Annex D: Model for the calculation of the fire resistance of unprotected composite slabs exposed to fire beneath the slab according to the standard temperature-time curve. (Informative).

3.3. Draft prEN 1994- Part 2: Rules for Bridges

Part 2 of Eurocode 4 gives rules for composite bridges in supplement of not only those given in Part 1 of Eurocode 4 but also in supplement of those in Parts 1 and 2 of Eurocode 2 and Eurocode 3 to which Eurocode 4 refers to. This interrelation requires a particular structure of the Parts 2 to facilitate the reference system and also a particular presentation of Part 2 of Eurocode 4 to avoid a cascade of indirect references that would complicate the use. Therefore it was agreed that the list of contents and the sequence of clauses in Parts 2 strictly follow the list of contents and the sequence of clauses in Parts 1 of each Eurocode. To avoid a multiple reference system it was also agreed that contrary to Eurocode 2 and Eurocode 3; Part 2 of Eurocode 4 includes all rules needed from Part 1 of Eurocode 4 in full text. In this way the references from Eurocode 4- Part 2 to Eurocodes 2 and 3 are direct; as illustrated in Fig. 6.

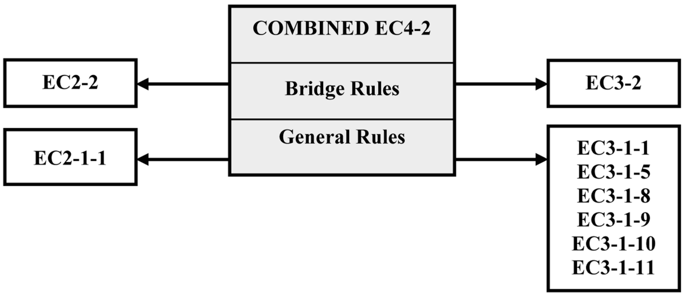


Fig. 6 Unique reference system for Eurocode 4- Part 2

Specific rules for bridges are given in Part 2 of Eurocode 4 as follows :

Section 1: 1.1.3. Scope of Part 2 of Eurocode 4
1.2.3. Additional general and other reference standards for composite bridges.
1.5.2. Definitions for filler beam deck and composite plates.
1.6. Symbols used in Part 2

Section 2 : 2.4.2. For combination of actions reference to Annex A2 of EN1990.

Section 3 : 3.2. For ductility characteristics of reinforcing steel reference to EN1992-2
3.3. For ductility characteristics of structural steel reference to EN1993-2
3.5. For prestressing steel and devices reference to EN1992-1-1
3.6. For tension components in steel (cables) reference to EN1993-1-11.

Section 4 : 4.2. Corrosion protection at the steel-concrete interface in bridges.

Section 5 : 5.1.1. Analysis of composite plates.
5.1.2. Exclusion of semi-continuous joints for bridge structures.
5.1.3. Ground-structure interaction : treatment of settlements.
5.2.2. For analysis reference to 1993-2.
5.3.2. Imperfections for bridges.
5.4.1. Global analysis for transient design situations during construction.
Specific rules for effective width.
5.4.2. Calculation of the St. Venant torsional stiffness of box girders.
Effects of cracking for multiple beam decks.
Effects of cracking on the torsional stiffness of box girders.
Effects of cracking on the longitudinal shear force at the interface between steel and concrete.
Treatment of temperature effects.
Prestressing by tendons.
Tension members in composite bridges.
Filler beam decks for bridges.
5.4.3. Combination of global and local action effects.
5.5.3. Classification of sections of filler beam decks for bridges.

Section 6 : 6.1.1. Ultimate limit state criteria for beams for bridges.
6.2.1. Additional rules for the bending resistance of beams in bridges.
Treatment of prestressing in non-linear analysis of the bending resistance.
Additional rules for calculation of elastic resistance to bending.

6.2.2. Additional rules for the vertical shear resistance of beams.
6.3. Ultimate limit states of filler beam decks.
6.4. Specific rules for lateral torsional buckling of beams in bridges.
6.6. Additional rules for verification of shear connection.
6.8. Additional rules for fatigue verification.
6.9. Rules for tension members in composite bridges.
Section 7 : 7.1. Additional clauses for serviceability limit state requirements.
7.2. Stress limitation for bridges.
7.3. Deformations in bridges.
7.4. Specific rules for cracking of concrete.
7.5. Filler beam decks.
Section 8 : Precast concrete slabs in composite bridges.
Section 9 : Composite plates in bridges.
Annex C : Headed studs that cause splitting forces in the direction of the slab thickness.

4. Presentation of some selected technical items

The Eurocode treatment of some selected technical items will now be presented in more detail.

4.1. Structural analysis

Structural analysis is covered in Section 5. Eurocode 4 follows as closely as possible the treatment given in Eurocode 3 for steel structures. This applies in particular for structural modelling in subsection 5.1; structural stability in subsection 5.2 and the treatment of imperfections in subsection 5.3.

For the calculation of action effects the following methods are included.

- Linear elastic analysis
- Non-linear analysis
- Linear elastic analysis with limited redistribution.
- Rigid plastic global analysis for buildings.

Shear lag in concrete flanges may be taken into account by using an effective width (see Fig. 7)

For elastic global analysis a constant effective width may be assumed over the whole of each span.

For buildings simplified methods are given to take into account the effects of creep and shrinkage and of cracking of concrete.

The effects of creep may be taken into account by the use of modular ratios for concrete.

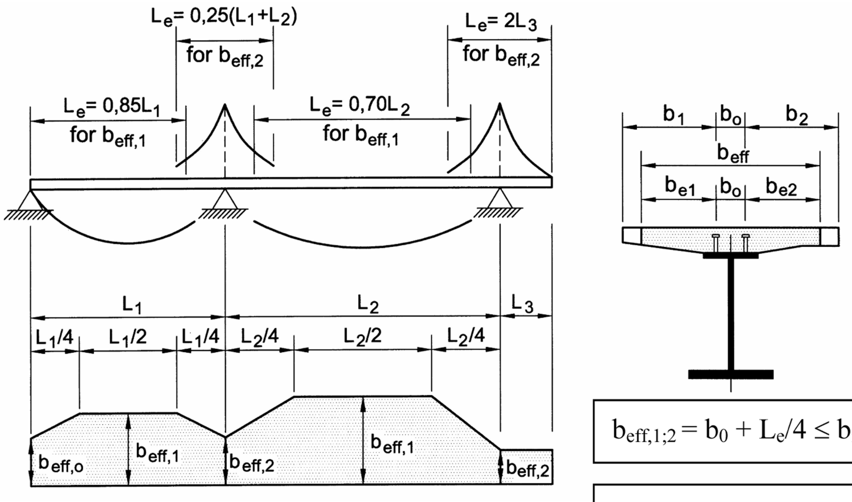
For building structures not sensitive to second order deformations an average modular ratio for both short-term and long-term loading corresponding to an effective modulus of elasticity for concrete of $E_{cm}/2$ may be used.

For continuous beams under certain conditions the effect of cracking of concrete over the supports may be taken into account by using the cracked flexural stiffness E_aI_2 over 15% of the span on each side of the support. By this method an iterative analysis is avoided.

For ultimate limit state verifications rigid plastic global analysis may be used under conditions.

The most important condition is that the rotation capacity at potential plastic hinge locations must be sufficient to enable the plastic mechanism to occur.

For composite beams in buildings, the rotation capacity may be assumed to be sufficient where:



$$b_{eff,1;2} = b_0 + L_e/4 \leq b_i$$

$$b_{eff,0} = b_0 + \Sigma\beta_i b_{ei}$$
$$\beta_i = (0{,}55 + 0{,}025L_e/b_{ei}) \leq 1{,}0$$

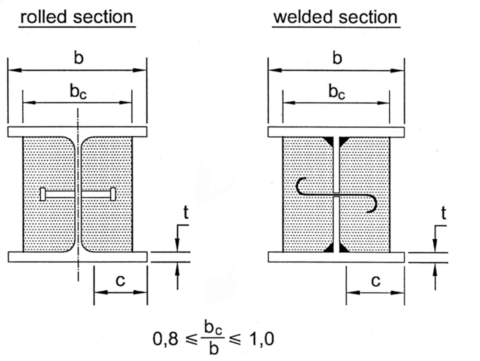
Fig. 7 Effective width of concrete flanges

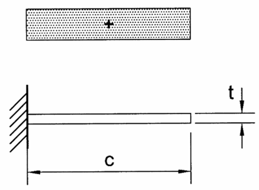
a) The grade of structural steel does not exceed S355,
b) The contribution of any reinforced concrete encasement in compression is neglected when calculating the design resistance moment,
c) All effective cross-sections at plastic hinge locations are in Class 1; and all other effective cross-sections are in Class 1 or Class 2,
d) Each beam-to-column joint has been shown to have sufficient design rotation capacity, or to have a design resistance moment at least 1,2 times the design plastic resistance moment of the connected beam,
e) Adjacent spans do not differ in length by more than 50% of the shorter span,
f) End spans do not exceed 115% of the length of the adjacent span,
g) In any span in which more than half of the total design load for that span is concentrated within a length of one-fifth of the span, then at any hinge location where the concrete slab is in compression, not more than 15% of the overall depth of the member should be in compression; this does not apply where it can be shown that the hinge will be the last to form in that span and
h) The steel compression flange at a plastic hinge location is laterally restrained.

For classification of cross-sections the same classification system as in Eurocode 3 is used.

Additional rules are given for composite cross-sections in hogging bending and for composite sections with concrete encasement (see for example Fig. 8).

For continuous composite beams use of plastic global analysis leads normally much more economical designs than use of linear elastic analysis. Therefore an intermediate method is introduced for cases where not all conditions for plastic design are met. This method is the linear elastic analysis with redistribution of moments. Limits to redistribution of hogging moments are given in Fig. 9.





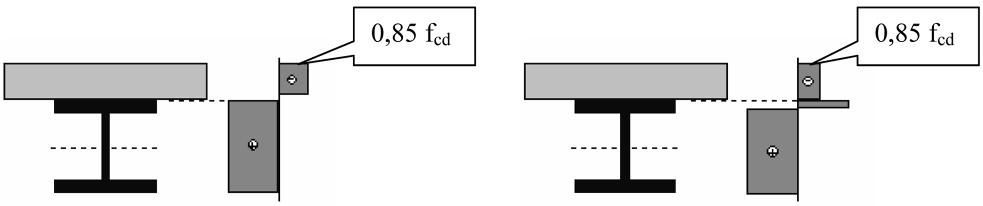
Stress distribution
(compression positive)

Class	Type	Limit
1	Rolled or welded	c/t $\leq 9\varepsilon$
2		c/t $\leq 14\varepsilon$
3		c/t $\leq 20\varepsilon$

Fig. 8 Classification of steel flanges in compression for partially encased sections

Class of cross-section in hogging moment region	1	2	3	4
For un-cracked analysis	40 %	30 %	20 %	10 %
For cracked analysis	25 %	15 %	10 %	0 %

Fig. 9 Limits to redistribution of hogging moments



Plastic neutral axis in concrete flange Plastic neutral axis in steel section

Fig. 10 Use of rectangular stress blocks for the calculation of the plastic resistance

4.2. Plastic resistance of cross-sections

Through the code the plastic resistance of composite cross-sections of beams, columns and slabs is calculated on the basis of rectangular stress blocks. This is illustrated in Fig. 10 for a cross-section of a beam in sagging bending. This simplifies the calculations considerably. To account for the effect of the limited compressive strain of concrete a calibration factor of 0,85 is applied for the compressive strength of concrete.

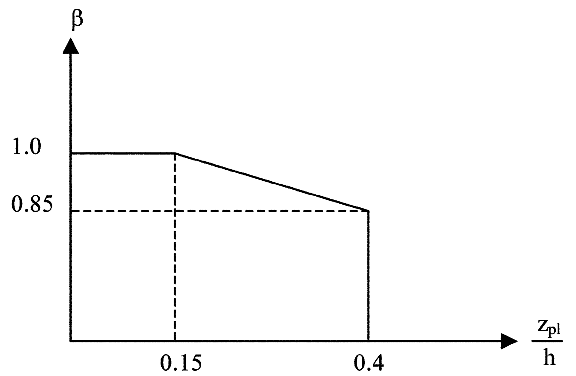


Fig. 11 Reduction factor β for $M_{pl.Rd}$

Developments in steel production have led to the availability of grades S420 and S460 (with a nominal yield strength of 420 and 460 N/mm^2) as structural materials. In the framework of an ECCS and ECSC (European Coal and Steel Community) research project an extensive numerical and experimental research program was carried out to investigate whether the rules developed for lower grade steels could be used for these steels without modification. Tests on composite beams have demonstrated that bending resistance can be based on a plastic method, despite the higher strains needed to develop yield in the steel. However from numerical calculations was concluded that some restriction is needed if the neutral axis in sagging bending becomes low, because of loss of strength in concrete at high strains. Therefore EC4 requires that if the depth of the neutral axis exceeds 15% of the total depth of the composite section, then a reduction factor β as given in Fig. 11 should be applied to the plastic moment of resistance. For hogging moment regions, there is need for a minimum amount of slab reinforcement in tension, to ensure sufficient rotation capacity. To avoid this becoming too onerous, redistribution of moment is restricted, compared to beams with lower grade structural steel. A higher minimum degree of shear connection is also required, as a further consequence of the high strains needed to reach yield in the steel section.

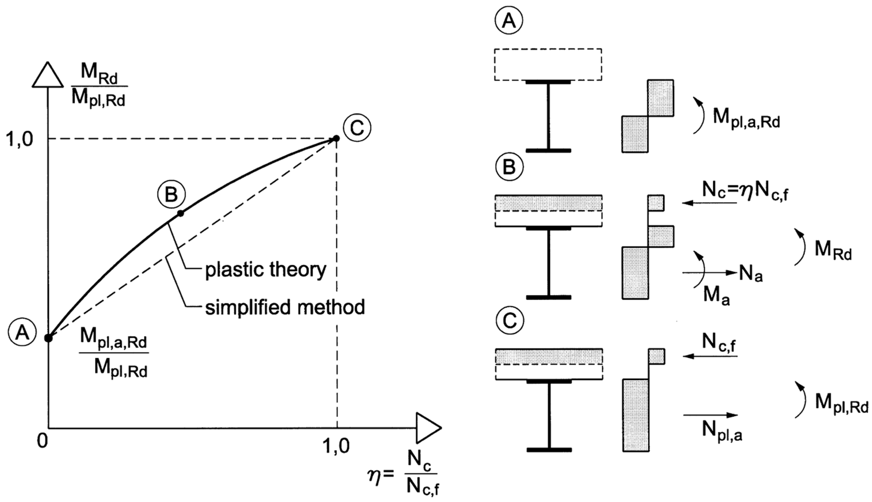


Fig. 12 Relation between M_{Rd} and η for ductile shear connectors

4.3. Partial shear connection

Often the most economic design is found by using less shear connectors than required for full shear connection. Eurocode 4 allows the use of partial shear connectors and provide rules for the calculation of the bending resistance dependent of the degree of shear connection η.

Where ductile shear connectors are used the resistance moment may be calculated by rigid plastic theory. The relation between the resistance moment and the degree of shear connection is qualitatively given by the convex curve ABC in Fig. 12. It is also allowed to use the linear interaction curve AC as a simplified method.

For non-ductile shear connectors the relation between M_{Rd} and η should be determined by non-linear theory. In this case the relation is different for propped and unpropped construction. For class 1 and class 2 cross-sections a simplified relation as qualitatively given in Fig. 13 may be used.

Headed studs with a diameter between 16 mm and 25 mm and with a length not less than 4 times the diameter may be considered as ductile within the span limits illustrated in Fig. 14.

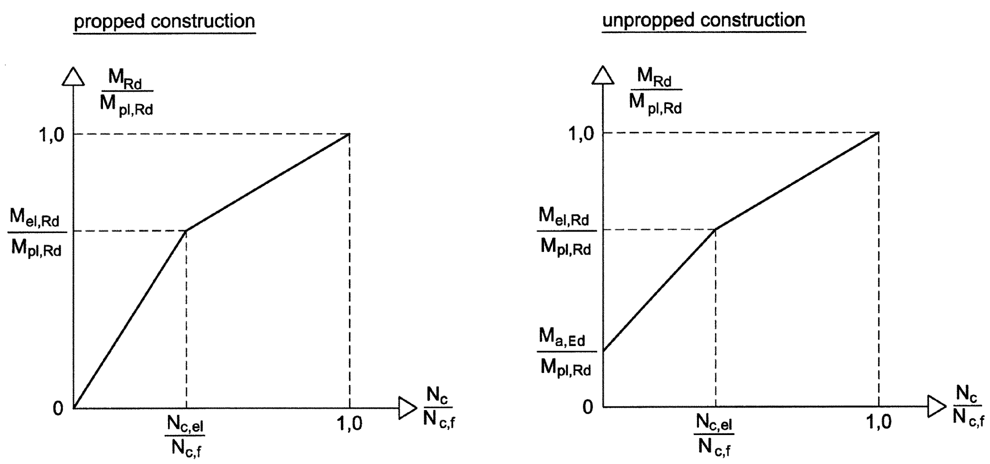


Fig. 13 Simplified relation between M_{Rd} and η for non-ductile shear connectors

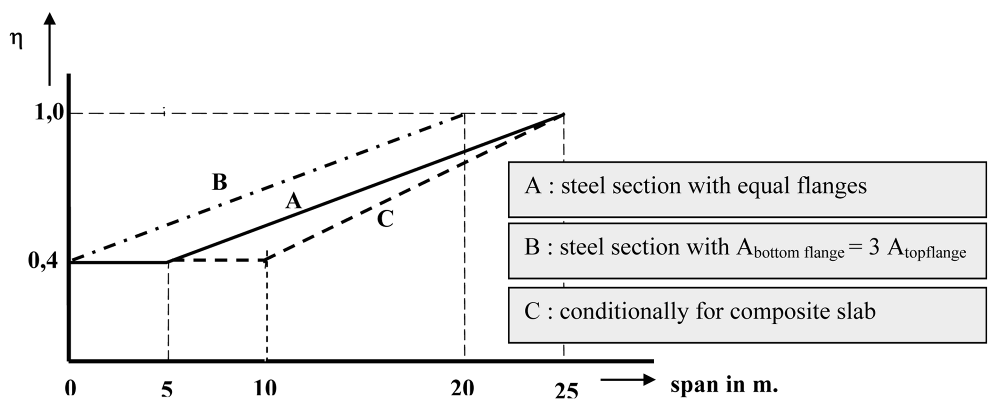


Fig. 14 Limits for the degree of shear connection

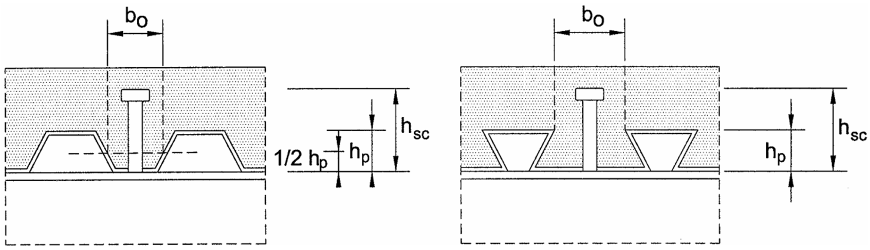


Fig. 15 Studs in ribs of composite slabs

4.4. Design resistance of stud shear connectors in solid slabs

$$P_{Rd} = \frac{0{,}8\, f_u \pi d^2 / 4}{\gamma_V} \quad \text{or : } P_{Rd} = \frac{0{,}29\, \alpha d^2 \sqrt{f_{ck} E_{cm}}}{\gamma_V} \quad \text{whichever is smaller}$$

$\alpha = 0{,}2\left(\frac{h_{sc}}{d} + 1\right)$ for $3 \le h_{sc} / d \le 4$ and $\alpha = 1$ for $h_{sc}/d > 4$

γ_V is the partial factor (recommended value = 1,25)
d is the diameter of the shank of the stud, 16 mm $\le d \le$ 25 mm;
f_u is the specified ultimate tensile strength of the material $\le$ 500 N/mm^2;
f_{ck} is the characteristic cylinder compressive strength of the concrete.
h_{sc} is the overall nominal height of the stud.

4.5. Design resistance of stud shear connectors in sheeting with ribs transverse to the beams

The design resistance of studs in ribs of composite slabs is according to Eurocode 4 to be calculated as the resistance in a solid slab multiplied by a reduction factor k_t

$$k_t = \frac{0{,}7}{\sqrt{n_r}} \frac{b_0}{h_p}\left(\frac{h_{sc}}{h_p} - 1\right) \le k_{t,\max}$$

n_r is the number of stud connectors in one rib, not to exceed 2 in computations.
$k_{t,\max}$ is an upper limit for k_t as given in Fig. 16

4.6. Partially encased composite sections

Typical cross-sections are shown in Fig. 16. The encasement is normally in place before erection of the beam, as it is difficult to concrete the sections in situ. Local areas for the connections are left exposed and encased later, after the frame has been erected.

The original purpose of the encasement was to improve resistance to fire. The lower unprotected flange of the steel section loses rather quickly bearing capacity during fire attack. However this loss of resistance can easily be compensated for by arranging reinforcement in the concrete between the flanges. This type of structure can easily attain 90 minutes of fire resistance. In prEN1994-1-2 design tables are included for fire design of partially-encased sections.

Number of studs per rib	Thickness t of sheet in mm	Studs ≤ 20 mm diameter welded through sheeting	Sheeting with holes Studs 19 mm or 22mm
$n_r = 1$	≤ 1,0	0,85	0,75
	> 1,0	1,0	0,75
$n_r = 2$	≤ 1,0	0,70	0,60
	> 1,0	0,8	0,60

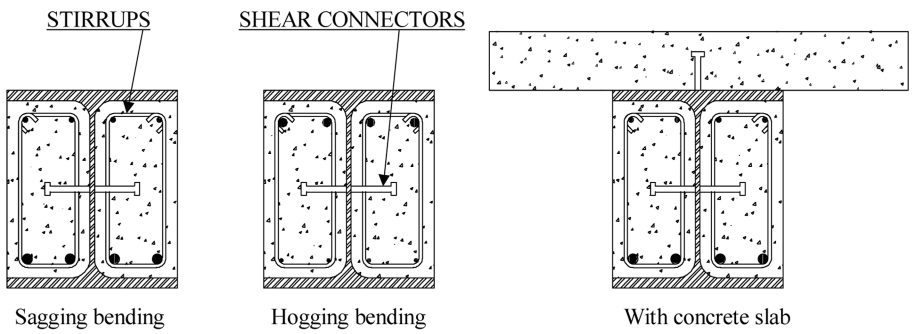


Fig. 16 Partially-encased beams

However in addition, the concrete encasement and the reinforcement can also be used to improve the bending and vertical shear resistance and the stiffness for both normal temperature design and fire design. Design rules are given in prEN1994-1-1.

4.7. Composite columns

For the member verification second-order linear elastic analysis is used. The effective flexural stiffness is determined from the following expression :

$$(EI)_{eff,\,II} = K_o(E_aI_a + E_sI_s + K_{e,\,II}E_{cm}I_c)$$

where:

$K_{e,II}$ is a correction factor which should be taken as 0,5;
K_o is a calibration factor which should be taken as 0,9.

Equivalent member imperfections are given for various types of cross-sections.

To verify the resistance of a column, the following condition should be satisfied:

$$\frac{M_{Sd}}{M_{pl,\,N,\,Rd}} = \frac{M_{Sd}}{\mu_d M_{pl,\,Rd}} \le 0{,}9$$

where:

M_{Sd} is the maximum bending moment within the column length, taking account of imperfections and second order effects, and
$M_{pl,N,Rd}$ is the plastic bending resistance taking into account the normal force N_{Sd}; this resistance is given by $M_{pl,N,Rd} = \mu_d\, M_{pl,Rd}$ where $M_{pl,Rd}$ is the plastic bending resistance (see Fig. 17).

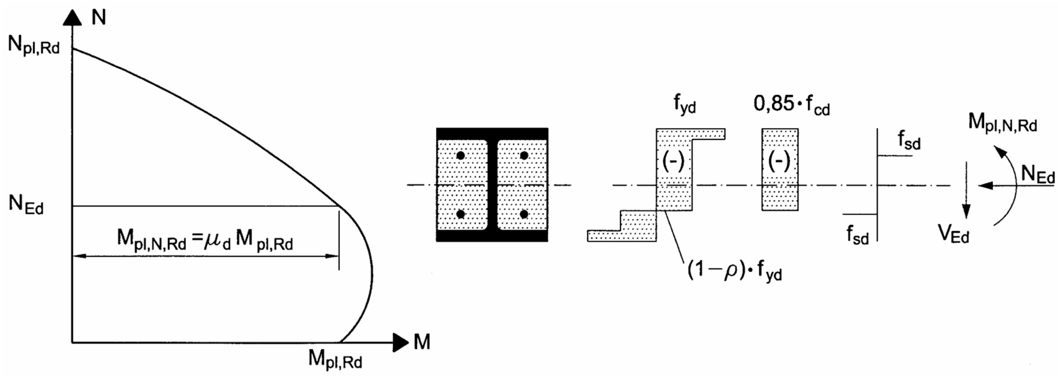


Fig. 17 Interaction curve for combined compression and uniaxial bending

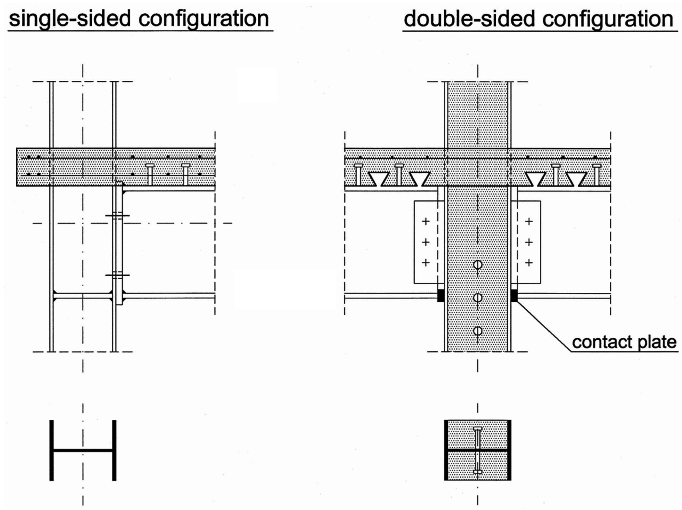


Fig. 18 Examples of composite joints

4.8. Composite joints

In braced steel framed buildings an economical design solution is to use low-cost nominally pinned joints. However in composite construction the floor slab is connected to the steel beam. Normally the slab is to be cast continuous over the supports. Negative reinforcement over the supports is required in order to limit cracking.

It is not well possible to design the joint then as a pinned joint. And it is technically and economically interesting to design the joint as a composite element in which the reinforcement is intended to contribute to the resistance and the stiffness of the joint. In Fig. 18 examples of composite joints are shown. Composite joints in frames for buildings are covered in section 8 of prEN1994-1-1. This Section is consistent with prEN 1993-1-8, which treats steel joints. A great advantage is that the design method in EN1993-1-8 is based on the so-called "component method" so only rules for properties of specific composite components had to be given in EN1994-1-1. The proposed EN provisions therefore

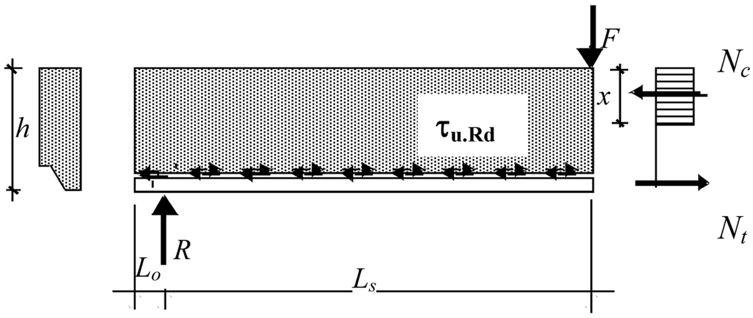


Fig. 19 Free body diagram giving the basis of the PSC method

deal only with what is peculiar to composite joints. It is assumed that the user will be familiar with EN 1993-1-8. Design moment resistance and rotational stiffness are each to be “determined in a manner analogous to that for steel joints”.

4.9. Longitudinal shear resistance of composite slabs

Eurocode 4 allows for the verification of the longitudinal shear resistance two alternative methods. The *m-k* method developed in the USA and the partial shear connection method developed in Europe. The PSC method is based on a simplified mechanical model as illustrated by the free body diagram in Fig. 19. A constant level of shear resistance is assumed to act over the length L_s of the shear span.

The value of $\tau_{u.Rd}$ is determined with a standard test method. Usually two series of full-scale experiments are performed representing the upper and lower boundaries for the L_s / h ratio for which longitudinal shear is critical. For the shorter shear spans usually a significantly higher value for τ_U is found as for the longer shear spans. The lowest value of τ_U is used in the PSC Method, which implies that the longer shear spans determine the design value for the shear resistance. This implies that for the shorter shear spans a conservative value is used for the shear resistance. The influence of span length on the test values of the longitudinal shear resistance τ_u can be reduced by assuming a fictitious frictional force μR at the end support. This is included as an option in prEN1994-1-1.

It was considered to delete the testing procedures from the EN and to refer to European Technical Approvals (ETA). But since not yet guidelines for such ETA’s exist the test procedures are kept in an Informative Annex.

5. Conclusions

In this paper the status of development of the harmonised European Standard EN1994: Eurocode 4 is described. After a long period of development the Eurocode project is now near to completion.

An arbitrary selection of technical items is discussed in this paper in some detail. A complete treatment is of course not possible in the framework of a conference paper. But handbooks are in preparation aiming at giving full background information of the rules in EN1994.

References

Anderson, D. (2000), "Composite construction in europe: Recent developments", *Composite and Hybrid Structures: Proc. of the 6th ASCCS Conf.*, March 22-24, Los Angeles.

Bergmann, R. (1999), "Steel concrete composite beams and columns", *Proc. of the Int. Conf. on Steel and Composite Structures*, 24-25 February 1999, Delft, The Netherlands. ISBN 90-6743-566-X.

Bode, H. and Dauwel, T. (1999), "Steel – concrete composite slabs – Design based on partial connection", *Proc. of the Int. Conf. on Steel and Composite Structures,* 24-25 February 1999, Delft, The Netherlands. ISBN 90-6743-566-X.

CEN/TC250, "Policy guidelines and procedures for CEN/TC250 Structural Eurocodes", CEN/TC250 Doc. N250, BSI, London.

Draft prEN1994-1-1:2003, "Design of composite steel and concrete structures", Part 1.1: "General rules and rules for buildings''

Draft prEN1994-1-2:2003, "Design of composite steel and concrete structures", Part 1.2 "Structural fire design"**.**

Draft prEN1994-2:2003, "Design of composite steel and concrete structures", Part 2: "Rules for bridges"**.**

ECCS (2000), "Composite beams with partial concrete encasement for buildings", *ECCS Publication No 107*, ECCS General Secretariat, Belgium, ISBN 92-9147-000-52.

ECCS (1999), "Design of composite joints for buildings", *ECCS Publication No 109*, ECCS General Secretariat, Belgium, ISBN 92-9147-000-52.

ECCS (1998), "Longitudinal shear resistance of composite slabs: Evaluation of existing tests", *Publication No. 106*, Brussels.

ENV1994: Eurocode 4, "Design of composite steel and concrete structures", Part 1.1: General rules and rules for buildings; Part 1.2: Structural fire design; Part 2: Bridges, CEN Central Secretariat, Brussels.

Johnson, R.P. and Anderson, D. (2004), "Designers'Guide to EN1994-1-1", Thomas Telford Publishing, London, ISBN 0 7277 31513.

Johnson, R.P. (2004), *Composite Structures of Steel and Concrete*, Blackwell Publishing, Oxford.

Kindmann, R. *et al*. (1993), "Effect of reinforced concrete between the flanges of the steel profile of partially encased composite beams", *J. Construct. Steel Research*, **27**, 107-122.

CC