

Eurocode 2: Design of concrete structures

Part 2. Concrete bridges

**(together with United Kingdom
National Application Document)**

ICS 91.080.40; 93.040

Committees responsible for this Draft for Development

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British Cement Association
British Construction Steelwork Association Ltd.
British Precast Concrete Federation Ltd.
British Railway Board
British Waterways Board
County Surveyors' Society
Department of the Environment Transport and the Regions
(Highways Agency)
Institution of Civil Engineers
Institution of Structural Engineers
Steel Construction Institute
UK Steel Association
Welding Institute

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National foreword

This Draft for Development was prepared by Subcommittee B/525/10 and is the English language version of ENV 1992-2:1996 *Eurocode 2: Design of concrete structures — Part 2: Concrete bridges*, as published by the European Committee for Standardization (CEN). This Draft for Development also includes the United Kingdom (UK) National Application Document (NAD) to be used with the ENV in the design of buildings to be constructed in the UK.

ENV 1992-2 results from a programme of work sponsored by the European Commission to make available a common set of rules for the structural and geotechnical design of building and civil engineering works.

This publication should not be regarded as a British Standard.

An ENV is made available for provisional application, but does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard. The publication of this ENV and its National Application Document should be considered to supersede any reference to a British Standard in previous DD ENV Eurocodes concerning the subject covered by these documents.

The values for certain parameters in the ENV Eurocodes may be set by individual CEN Members so as to meet the requirements of national regulations. These parameters are designated by | _ | in the ENV.

During the ENV period of validity, reference should be made to the supporting documents listed in the National Application Document (NAD).

The purpose of the NAD is to provide essential information, particularly in relation to safety, to enable the ENV to be used for buildings constructed in the UK and the NAD takes precedence over corresponding provisions of the ENV.

Users of this document are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted to an EN.

Comments should be sent in writing to the Secretary of Subcommittee B/525/10, BSI, 389 Chiswick High Road, London W4 4AL, quoting the document reference, the relevant clause and, where possible, a proposed revision within two years of the issue of this document.

This document does not purport to include all the necessary provisions of a contract. Users of this document are responsible for its correct application.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to xxiv, the ENV title page, pages 2 to 45 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

National Application Document

**for use in the UK with
ENV 1992-2:1996**

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Introduction

This National Application Document (NAD) has been prepared under the direction of the Building and Civil Engineering Sector Committee. It has been developed from:

- a) a textual examination of ENV 1992-2:1996 and ENV 1992-1-1:1991, ENV 1992-1-3:1994, ENV 1992-1-4:1994, ENV 1992-1-5:1994 and ENV 1992-1-6:1994;
- b) a parametric calibration examination against BS 5400-4, supporting standards and test data;
- c) trial calculations.

1 Scope

This NAD provides information to enable ENV 1992-2:1996 (hereafter referred to as EC2-2) to be used with ENV 1992-1-1:1991, ENV 1992-1-3:1994, ENV 1992-1-4:1994, ENV 1992-1-5:1994 and ENV 1992-1-6:1994, as qualified by their respective NADs, for the design and construction of bridges in the UK.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this National Application Document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest editions of the publication referred to applies.

Standards publications

BS 5400-4, *Steel, concrete and composite bridges — Code of practice for design of concrete bridges*.

ENV 1991-3:1994, *Eurocode 1: Basis of design and actions on structures — Part 3: Traffic loads on bridges*.

ENV 1992-1-1:1991, *Eurocode 2: Design of concrete structures — Part 1-1: General rules and rules for buildings*.

ENV 1992-1-3:1994, *Eurocode 2: Design of concrete structures — Part 1-3: General rules — Precast concrete elements and structures*.

ENV 1992-1-4:1994, *Eurocode 2: Design of concrete structures — Part 1-4: General rules — Lightweight aggregate concrete with closed structure*.

ENV 1992-1-5:1994, *Eurocode 2: Design of concrete structures — Part 1-5: Unbonded and external prestressing tendons*.

ENV 1992-1-6:1994, *Eurocode 2: Design of concrete structures — Part 1-6: General rules — Plain concrete structures*.

Other documents

GREAT BRITAIN. HIGHWAYS AGENCY. *Design manual for roads and bridges. Vol. 1. Highway structures: approval procedures and general design — Section 3: General design — Loads for highway bridges*. Publication no. BD 37/88. London: The Stationery Office, 1994.

GREAT BRITAIN. HIGHWAYS AGENCY. *Manual of Contract Documents for Highway Works — Volume 1: Specification for Highway Works*. London: The Stationery Office, 1998.

3 Partial factors, combination factors and other values

The partial factors, combination factors and other values are as follows.

- The values for combination factors (ψ) should be those given in Table 3 and Table 4 of the NAD for use with ENV 1991-3:1994.
- The values for partial factors should be those given in EC2-2, except as modified by the UK NADs to the various parts of ENV 1992-1-1.
- ENV 1992-1-1:1991, **2.5.3.5.5** (5) should not be modified as indicated in Table 3 of its NAD.
- Other values should be those given in EC2-2 except for those given in Table 1 of this NAD.

Table 1 — Values to be used in referenced clauses instead of boxed values

Reference in ENV 1992-1-1	Reference in ENV 1992-1-3	Reference in ENV 1992-2	Definition	UK values
3.2.5.1 (5)			Minimum shear strength of welds	25 % of the tensile strength of the bar
4.1.3.3 (8)			Allowance for tolerance Δh in cover for precast elements	$\Delta h = 5$ mm
4.1.3.3 (8)			Allowance for tolerance Δh in cover for in situ concrete	$\Delta h = 5$ mm
4.2.1.3.3 (12)			Reduction factor α to take account of the effects of long-term loading on maximum compressive stress (compression zone decreasing in width)	0.85
4.2.3.4.1 (2)			Ratio of long-term relaxation to 1 000 h relaxation	2
4.3.2.4.4 (1)			Limit to $\cot\theta$ in the variable strut inclination method for beams with constant reinforcement	$0.5 < \cot\theta < 2.0$
4.3.3.1 (6)			Limits to $\cot\theta$ in torsion calculation	$0.5 < \cot\theta < 2.0$
4.3.4.5.2 (1)			V_{rd2}	2.0 [see also 6.3i) of this NAD]
		4.3.7.5 (101)	Fatigue stress range	See 6.3c) of this NAD
		4.4.2.2.1 (103)	Maximum bar spacing	300
	4.5.2 (103)		Limit to average bearing stress	$0.8f_{cd}$
Table 5.1			Minimum diameter of mandrels	See Table 7 of this NAD

Table 1 — Values to be used in referenced clauses instead of boxed values (*continued*)

Reference in ENV 1992-1-1	Reference in ENV 1992-1-3	Reference in ENV 1992-2	Definition	UK values
5.2.4.1.3 (1)			Limiting value of the clear spacing a , above which α_1 may take a value of 1.0 for compression and 1.4 for tension Limiting value of b to lapped bar above which α_1 may take a value of 1.0 for compression and 1.4 for tension	6ϕ 2ϕ
5.2.5 (3)			Extent of bar beyond bend in link	4ϕ instead of 5ϕ 8ϕ instead of 10ϕ
5.4.1.2.2 (4)			Factor by which minimum spacing should be reduced under defined circumstances In item ii), bar size near lap above which spacing of transverse steel should be reduced	0.67 20 mm
5.4.3.2.1 (4)			Maximum bar spacing in slab	300 mm
5.4.3.3 (2)			Minimum shear as a percentage of the total for beams	100 %
6.2.2 (1)			Tolerances	See 5.5 of this NAD

4 Loading documents

The loading documents to be used are:

ENV 1991-3 for traffic loads;
BD 37/88 for all other loads.

5 Reference standards

Standards including materials specifications and standards for construction are listed for reference in Table 2a), Table 2b) and Table 2c) of this NAD.

Table 2a) — References — References in ENV 1992-2 to other publications

Reference in ENV 1992-2	Document referred to	Document title or subject area	UK document	Highways Agency document
1.1.2 P(104)	Eurocode 1	Basis of design and actions on structures	BS 5400-1 BS 5400-2 ^a	BD 15/92 [1] BD 37/88
1.1.2 P(104)	Eurocode 8	Design of structures in seismic regions	—	—
1.1.2 (105)	Eurocode 1-1	Basis of design	BS 5400-1	BD 15/92 [1]
1.1.2 (105)	Eurocode 1-2-1	Actions on structures: densities, self-weight and imposed loads	BS 5400-2 ^a	BD 37/88
1.1.2 (105)	Eurocode 1-2-4	Actions on structures: wind actions	BS 5400-2 ^a	BD 37/88
1.1.2 (105)	Eurocode 1-2-5	Actions on structures: thermal actions	BS 5400-2 ^a	BD 37/88
1.1.2 (105)	Eurocode 2-1-2	Structural fire design	—	—
1.1.2 (105)	Eurocode 2-1-4	The use of lightweight aggregate concrete	BS 5400-4	BD 24/92 [2]
1.1.2 (105)	Eurocode 2-1-6	Plain concrete	BS 5400-4	BD 24/92 [2]
1.1.2 (105)	Eurocode 2-3	Concrete foundations	BS 8004	BD 32/88 [3]
1.1.2 (105)	Eurocode 7-1	Geotechnical design	BS 1377 BS 8004 BS 5930	BD 32/88 [3] BD 30/87 [4]
1.1.2 (105)	Eurocode 8-2	Earthquake resistant design of structures	—	—
1.4.1 P(104)	ENV 1991-1	Basis of design	BS 5400-1	BD 15/92 [1]
A107	prEN 10138	Prestressing steel	BS 4486 BS 5896	<i>Specification for Highway Works</i>
A107.1 (103)	ENV 1992-3	Types of stay cable	—	—
A107.4 (107)	ISO 161-1, ISO 3607 ^b or other relevant standards	Specification for high density polyethylene (HDPE)	—	—

^a This has been partially replaced by BS 5400-9.1:1983 and BS 5400-9.2:1983.
^b This has now been replaced by ISO 11922-1 and ISO 11922-2.

Table 2b) — References — References in ENV 1992-1-1 to other publications

Reference in ENV 1992-1-1	Document referred to	Document title or subject area	UK document	Highways Agency document
1.1.1 P(4)	Eurocode 8	Design of structures in seismic regions	—	—
1.1.1 P(5)	Eurocode 1	Basis of design and actions on structures	BS 5400-1 BS 5400-2 ^a	BD 15/92 [1] BD 37/88
3.2, 3.3 and 3.4	ENV 10080 and relevant standards	Reinforcing steel	BS 4449 BS 4482 BS 4483	—
	prEN 10138 and relevant standards	Prestressing steel	BS 4486 BS 5896	—
3.4	Relevant standards European Approval Documents	Anchorage	BS 4447	—
4.1.2.3 (3)	ISO/DP 9690 ENV 206	Classification of environmental conditions for concrete structures	—	—
4.2.3.4.1	Relevant standards	Relaxation of prestressing steel	BS 4486 BS 5896	—
6.3.2.2	Appropriate national or international documents	Specification of finishes	BS 5400-7	<i>Specification for Highway Works</i>
6.3.3.1 P(1)	Relevant Euronorms or CEN, ISO or national standards, National Building Regulations Control Authority	Requirements for reinforcing steel	BS 4449 BS 4482 BS 4483 BS 5400-7	<i>Specification for Highway Works</i>
6.3.3.2 P(3)	Appropriate international or national standards	Cutting and bending of reinforcement	BS 4466	<i>Specification for Highway Works</i>
6.3.3.3 P(3)	International or national standards	Welding of reinforcement	BS 7123	BA 40/93 [5] <i>Specification for Highway Works</i>
6.3.3.3 P(4)	Relevant standards	Fatigue requirements for welding of reinforcement	BS 5400-7 BS 5400-10	BD 9/81 [6], BA 40/93 [5]
6.3.3.3 P(5)	International or national standards	Production and checking of welded connections	BS 7123	BA 40/93 <i>Specification for Highway Works</i>
6.3.3.4 (3)	Standards or approval documents	Mechanical connectors	BS 5400-4	BD 24/92 <i>Specification for Highway Works</i>
^a This has been partially replaced by BS 5400-9.1:1983 and BS 5400-9.2:1983.				

Table 2b) — References — References in ENV 1992-1-1 to other publications (*continued*)

Reference in ENV 1992-1-1	Document referred to	Document title or subject area	UK document	Highways Agency document
6.3.4.1	Relevant Euronorms or CEN, ISO or national standards, National Building Regulations Control Authority	Requirements for prestressing steel	BS 4486 BS 5896	<i>Specification for Highway Works</i>
6.3.4.3	Standards or approval documents	Devices for jointing, anchorage and coupling of tendons	BS 4447	—
6.3.4.6.2 P(4)	EN 447	Types of cement for grouting	Concrete Society Technical Report No. 47 [7]	—
7.5	CEC or National Administrative Procedures	Control of design	—	BD 2/89 [8]
7.6.5	Relevant technical documents	All other structural materials	—	<i>Specification for Highway Works</i>

Table 2c) — References — References in ENV 1992-1-3 for precast concrete bridges to other publications

Reference in ENV 1992-1-3	Document referred to	Document title or subject area	UK document	Highways Agency document
6.2.1 (104)	Relevant CEN product standards	Tolerances of construction and workmanship	BS 5400-7	<i>Specification for Highway Works</i>
6.3.5 (101)	Relevant CEN product and other standards	Construction and workmanship of precast elements and structures	BS 5400-4 BS 5400-7	BD 24/92 <i>Specification for Highway Works</i>

6 Additional recommendations

6.1 Chapter 1. Introduction

a) *Clause 1.1.2 P(101)*

All references to ENV 1992-1-1 in EC2-2 shall be interpreted as being to ENV 1992-1-1 as qualified by its UK NAD.

b) *Clause 1.1.2 (105)*

All references to any ENV shall be interpreted as being to that ENV as qualified by its UK NAD.

6.2 Chapter 3. Material properties

a) *Clause 2.5.4.2 (4)*

Clause 2.5.4.2 (104) of ENV 1992-1-3:1994 is applicable only to pretensioning.

6.3 Chapter 4. Section and member design

a) Clause 4.1.3.3 (6)

For the relevant exposure class defined in Table 3 of this NAD, the nominal concrete cover to all reinforcement including links and stirrups should not be less than the appropriate values given in Table 4 of this NAD. However, for pretensioned precast units the values in Table 4 of this NAD should be reduced by 10 mm. Where de-icing agents are used in a region, structures shall be classified as exposure Class 3 unless it can be guaranteed that the type of de-icing agent to which the structure will be exposed will have no deleterious effect on the reinforcement. Bridges over non-electrified railways shall be classified as exposure Class 5b and the nominal cover to reinforcing bars should not be less than 45 mm.

Table 3 — Exposure classes related to environmental conditions

Exposure class		Environment	Examples
1 Moderate		Concrete surfaces above ground level and fully sheltered against all of the following: — rain; — de-icing salts; — sea water spray. Concrete surfaces permanently saturated by water with a pH > 4.5.	Surfaces protected by waterproofing or by permanent formwork. Interior surface of pedestrian subways, voided superstructures or cellular abutments. Concrete permanently under water.
2 Severe	2a Without frost	Concrete surfaces exposed to driving rain. Concrete surfaces exposed to alternative wetting and drying.	Wall and structure supports remote from the carriageway. Bridge deck soffits. Buried parts of structures.
	2b With frost	As 2a but also exposed to freezing and thawing	As 2a.
3 Very severe		Concrete surfaces directly affected by de-icing salts.	Walls and structures within 10 m of the carriageway, parapet edge beams and buried structures less than 1 m below carriageway level.
4 Extreme	4a Without frost	Concrete surfaces in saturated salt air. Concrete surfaces exposed to abrasive action by sea water. Concrete surfaces exposed to water with a pH ≤ 4.5.	Concrete adjacent to the sea. Marine structures. Parts of structure in contact with moorland water.
	4b With frost	As 4a but also exposed to freezing and thawing.	As 4a above.
5 Aggressive ^a	5a	Concrete surfaces exposed to a slightly aggressive chemical environment.	Concrete in an aggressive industrial atmosphere. Parts of structure in contact with contaminated ground.
	5b	Concrete surfaces exposed to a moderately aggressive chemical environment.	Parts of structure in contact with contaminated ground.
	5c	Concrete surfaces exposed to a highly aggressive chemical environment.	Parts of structure in contact with contaminated ground.

^a Chemically aggressive environments are classified in ISO/DP9690. The following equivalent exposure conditions may be assumed:

Exposure class 5a: ISO classification A1G, A1L, A1S;
Exposure class 5b: ISO classification A2G, A2L, A2S;
Exposure class 5c: ISO classification A3G, A3L, A3S.

Table 4 — Nominal cover requirements for normal weight concrete^a

Exposure class		Location	Nominal cover mm			
			Concrete grade			
			C20/25	C25/30	C30/37	C40/50 and above
1		3	55	45	40	35
2	2a	2	b	80	80	80
		3	b	55	45	40
	2b	2	b	80 ^a	80	80
		3	b	55 ^a	45	40
3		1	b	c	85 ^a	85
		2	b	c	80 ^a	80
		3	b	c	60 ^a	50
4	4a	1	b	b	85	85
		2	b	b	80	80
		3	b	b	75	65
	4b	1	b	b	85 ^a	85
		2	b	b	80 ^a	80
		3	b	b	75 ^a	65
5	5a 5b 5c		This exposure can occur alone or in combination with the above classes. In selecting an appropriate cover the designer should consider other relevant exposure classes, such as cement content, type of cement, water:cement ratio and the use of protective membranes.			
Location:		1 — tendons in slabs where the upper surface is directly exposed to de-icing agents (i.e. no protective membrane); 2 — cast against an earth face; 3 — other locations.				
NOTE For pretensioned precast units the tabulated values may be reduced by 10 mm.						
^a Air entrained concrete should be specified.						
^b Concrete grade not permitted.						
^c Parapet beams only, nominal cover = 70 mm.						

b) Clause 4.2.1.3.3 (11)

α should be taken as 0.85 for both short-term and long-term effects.

c) Clause 4.2.3.5.6

Where a pre-tensioned tendon or group of tendons is enclosed by transverse reinforcement with an area of at least 1 000 mm²/m β_b may be taken as 50 % of the appropriate value given in Table 4.7 for all strand with areas up to 225 mm².

d) Clause 4.3.2.2 (11)

In addition:

d) in the case of a pile cap, enhancement should be applied only to those portions of the section where the flexural reinforcement is fully anchored by passing across the head of a pile.

e) *Clause 4.3.2.3 (1)*

Equation (4.18)

Replace Equation (4.18) with:

$$V_{Rd1} = [0.21k (100\rho_1 f_{ck})^{0.33} + 0.15\sigma_{cp}] b_w d$$

Change the definitions as follows:

Delete:

$$\tau_{Rd}$$

Add:

$$k = (500/d)^{0.25}$$

$$\rho_1 = A_{s1} / b_w d \leq |0.03|$$

A_{s1} = the area of tension reinforcement extending not less than d beyond the section considered

Other terms are as defined previously.

Delete Table 4.8.

f) *Clause 4.3.2.4.3 (1)*

The equation should be replaced as follows:

Equation (4.22):

$$V_{Rd3} = V_{wd} + V_{cd} - 0.4$$

g) *Clause 4.3.2.5 (4)*

Delete:

 τ_{Rd} is taken from Table 4.8 in **4.8.2.3**

and insert:

 τ_{Rd} is given in the following Table 4.8. $\gamma_c = 1.5$ for different concrete strengths

f_{ck}	12.0	16.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
τ_{Rd}	0.18	0.22	0.26	0.30	0.34	0.37	0.41	0.44	0.48

h) *Clause 4.3.4.1 (9)*

Does not apply.

i) *Clause 4.3.4.2.1 (1)*

Items 1) and 2) should be replaced with:

- 1) In the case of a rectangular loaded area having a perimeter greater than $11d$ and/or a ratio of length to breadth greater than 2.0, the critical perimeter according to Figure 4.17 only should be taken into account, in the absence of a more detailed analysis.

j) *Clause 4.3.4.2.2 (1)*

If a part of a perimeter cannot, physically, extend $1.5d$ from the boundary of the loaded area, then the part perimeter shall be taken as far from the loaded areas as is physically possible and the value of V_{Rd1} , given in 4.3.4.5.1 (1), for that part may be increased by a factor $1.5d/x$, where x is the distance from the boundary of the loaded area to the perimeter actually considered.

k) *Clause 4.3.4.5.1*

Replace Equation (4.56) and the definitions with the following:

$$V_{Rd1} = [0.21k(100\rho_1f_{ck})^{0.33} + 0.15\sigma_{cp}] b_w d \quad (4.56)$$

where

$$k = (500/d)^{0.25};$$

$$\rho_1 = \sqrt{\rho_{1x} \rho_{1y}};$$

ρ_{1x} ρ_{1y} are ratios in the x and y directions calculated for a width equal to the side dimension of the column (or loaded area) plus $3d$ to either side of it (or to slab edge if it is closer);

$$d = (d_x + d_y)/2;$$

d_x and d_y are the effective depths of the slab at the points of intersection between the design failure surface and the longitudinal reinforcement, in the x and y direction respectively.

l) *Clause 4.3.4.5.1 (2)*

The upper limit of 0.015 applies to $\sqrt{\rho_{1x} \rho_{1y}}$ and not to ρ_1 .

m) *Clause 4.3.4.5.2 (1)*

In Equation (4.57), in addition to the limitation on V_{Rd2} given in Table 1 of this NAD the shear stress at the perimeter of the column should not exceed $0.9\sqrt{f_{ck}}$.

Equation (4.58) is applicable where $V_{Rd3} \leq 1.6V_{Rd1}$.

Where $1.6V_{Rd1} < V_{Rd3} \leq 2.0V_{Rd1}$, Equation (4.58a) should be used:

$$V_{Rd3} = 1.4V_{Rd1} + (0.3 \sum A_{sw} f_{ya} \sin \alpha) / u \quad (4.58a)$$

n) *Clause 4.3.5.3.5 P(101)*

The effective height, l_o , of a column may be determined using Table 5 of this NAD where l_{col} is the clear height between end restraints.

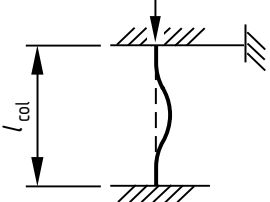
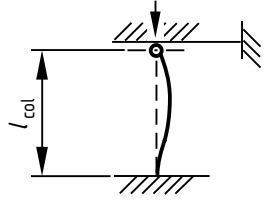
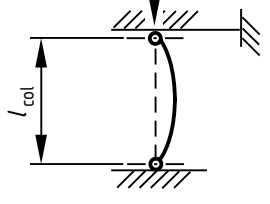
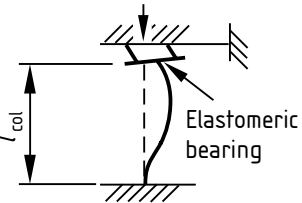
The values given in Table 5 are based on the following assumptions:

- rotational restraint is at least $4E_{cm}I_{col}/l_{col}$ for cases 1, 2 and 4 to 6 and $8E_{cm}I_{col}/l_{col}$ for case 7;
- lateral and rotational rigidity of elastomeric bearings are zero.

Where a more accurate evaluation of the effective height is required or where the end stiffness values are less than those values given in a), the effective heights should be derived from first principles.

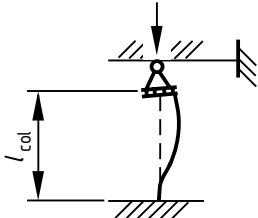
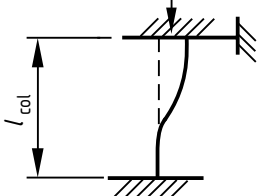
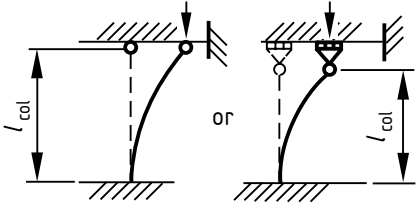
The accommodation of movements and the method of articulation chosen for the bridge will influence the degree of restraint developed for columns. These factors should be assessed as accurately as possible using engineering principles based on elastic theory and taking into account all relevant factors such as foundation flexibility, type of bearings, articulation system, etc.

Table 5 — Effective height, l_0 , for columns

Case	Idealized column and buckling mode	Restraints			Effective height, l_c
		Location	Position	Rotation	
1		Top	Full	Full ^a	0.70 l_{col}
		Bottom	Full	Full ^a	
2		Top	Full	None	0.85 l_{col}
		Bottom	Full	Full ^a	
3		Top	Full	None	1.0 l_{col}
		Bottom	Full	None	
4		Top	None ^a	None ^a	1.3 l_{col}
		Bottom	Full	Full ^a	

^a Assumed value [see 6.3n)].

Table 5 — Effective height, l_0 , for columns (continued)

Case	Idealized column and buckling mode	Restraints			Effective height, l_e
		Location	Position	Rotation	
5		Top	None	None	$1.4 l_{col}$
		Bottom	Full	Full ^a	
6		Top	None	Full ^a	$1.5 l_{col}$
		Bottom	Full	Full ^a	
7		Top	None	None	$2.3 l_{col}$
		Bottom	Full	Full ^a	

^a Assumed value [see 6.3n].

o) *Clause 4.3.5.6*

Notwithstanding the references to buildings in clause 4.3.5.6, it should be assumed that this clause is applicable also to bridge structures.

p) *Clause 4.3.5.6.4 (4)*

When Equation (4.72) is used to calculate the curvature $1/r$, then interaction of biaxial bending should be considered using:

$$\left(\frac{M_x}{M_{Rdx}}\right)^{\alpha_n} + \left(\frac{M_y}{M_{Rdy}}\right)^{\alpha_n} \leq 1.0$$

where

- M_x and M_y are the moments about the major x - x axis and minor y - y axis respectively due to ultimate loads;
- M_{Rdx} is the ultimate moment capacity about the major x - x axis assuming an ultimate axial load capacity, N_{ud} , not less than the value of the ultimate axial load, N ;
- M_{Rdy} is the ultimate moment capacity about the minor y - y axis assuming an ultimate axial load capacity, N_{ud} , not less than the value of the ultimate axial load, N ;
- $\alpha_n = 0.667 + 1.67 N/N_{ud} \geq 1.0$ and ≤ 2.0 .

However, when the curvature is calculated using a non-linear analysis in each of the x and y directions, α_n may be assumed to be 1.0.

q) *Clause 4.3.5.7 (2)*

The second of Equations (4.77) should be replaced with:

$$l_{ot} < 250 b^2/d$$

r) *Clause 4.3.7.1 (102)*

When applying b) to railway bridges the depth of ballast should not be included in assessing the depth of earth cover.

In addition to the situations listed in 4.3.7.1 (102), a fatigue verification for road bridges is not generally necessary for the local effects of wheel loads applied directly to a slab spanning between beams or webs provided that:

- 1) the clear span to overall depth ratio of the slab does not exceed 18;
- 2) the slab acts compositely with its supporting beams or webs;
- 3) either:
 - i) the slab also acts compositely with transverse diaphragms; or
 - ii) the width of the slab perpendicular to its span exceeds three times its clear span.

s) *Clause 4.3.7.5 (101)*

For road bridges, replace 70 N/mm^2 with the appropriate value from Table 6a) and Table 6b) of this NAD. It is emphasized that the fatigue resistance of welded bars shall be checked using 4.3.7.5 (102).

NOTE Table 6b) need only be applied to those slabs that do not conform to the criteria in 6.3r) of this NAD.

Table 6a) — Limiting stress ranges (N/mm²) — Longitudinal bending for unwelded reinforcing bars in road bridges

Span m	Adjacent spans loaded		Alternate spans loaded	
	Bars ≤ 16 mm ϕ	Bars > 16 mm ϕ	Bars ≤ 16 mm ϕ	Bars > 16 mm ϕ
<3.5	150	115	210	160
3.5 to 5	125	95	175	135
5 to 10	110	85	175	135
10 to 20	110	85	140	110
20 to 100	90	70	110	85
100 to 200	115	90	135	105
>200	190	145	200	155

Table 6b) — Limiting stress ranges (N/mm²) — Transverse bending for unwelded reinforcing bars in road bridges

Span mm	Bars ≤ 16 mm ϕ	Bars > 16 mm ϕ
<3.5	210	160
3.5 to 5	120	90
5 to 10	70	55

t) *Clause 4.3.7.5 (105)*

In line 1 replace “P(103)” with “P(104)”.

u) *Clause 4.3.7.6*

It is not necessary to apply 4.3.7.6, if only prestressing steel is present at the section under consideration.

v) *Clause 4.3.7.8*

In Table 4.117, the values of $\Delta\sigma_{Rsk}$ for straight and bent bars of 195 N/mm² and 180 N/mm², respectively, should be reduced to 162 N/mm² and 150 N/mm², respectively, for bars with a diameter greater than 16 mm.

Welds in reinforcing steel, including tack welds, should not be used in bridges carrying rail traffic without prior approval of the relevant authority.

Welds in reinforcing steel should not be used in a deck slab spanning between longitudinal and/or transverse members and subjected to the effect of concentrated wheel loads in a traffic lane. Lap welding should not be used to connect reinforcing bars subjected to fatigue loading.

w) *Clause 4.4.0.3 (102)*

In the case of continuous bridges consisting of precast pretensioned beams with their ends embedded in in-situ concrete crossheads at the supports, verification criterion B should be adopted for the embedded lengths of the beams during the construction phase.

x) *Clause 4.4.2.1 P(109)*

Replace the existing clause with the following:

“For design crack width, members prestressed with permanently unbonded tendons without bonded tendons may be treated as ordinary reinforced concrete members.”

y) *Clause 4.4.2.2.1 P(101)*

Replace the existing clause with the following:

“For reasons of durability and appearance of the concrete a minimum reinforcement area shall be provided in reinforced or prestressed bridge structures in order to prevent wide single cracks due to imposed deformations not considered in the design calculations, self-equilibrating stresses or distribution of prestress.”

z) *Clause 4.4.2.2.2 (101)*

Replace the existing clause with the following:

“The minimum reinforcement area according to Equation (4.19.4) should be placed in sections where, under the infrequent combination of actions, the concrete stresses are tensile or less than 1 N/mm^2 compressive. For box girders and I-beams the web and flanges may be treated separately for this purpose.”

aa) *Clause 4.4.2.2.3 (101)*

In the definition of ρ_p the words, “within an area of not more than 300 mm around the ordinary reinforcement” should be deleted.

bb) *Clause 4.4.2.2.3 (101)*

Replace definitions of A_{ct} , σ_s , k , N_{sd} with the following:

A_{ct} is the area of the tensile zone immediately prior to cracking of the cross section web or flange as appropriate taking the tensile strength of concrete as f_{ctm} ;

σ_s is the steel stress in the minimum reinforcement area according to Table 4.120, σ_s may be increased by a factor $\eta = (f_{ctm}/f_{ctm}^*)^{1/2}$;

where

$f_{ctm}^* = 2.5 \text{ N/mm}^2$;

and

f_{ctm} is the assumed mean tensile strength of concrete, σ_s should not exceed kf_{yk} ;

and

k is a coefficient which takes account of the effect of secondary crack formation which leads to a reduction of restraint forces;

$k = 1.0$ for webs or rectangular sections with $h \leq 0.3 \text{ m}$ or flanges with widths less than 0.3 m ; and

$= 0.65$ for webs or rectangular sections with $h \geq 0.8 \text{ m}$ or flanges with widths greater than 0.8 m , intermediate values may be interpolated;

N_{sd} is the axial force (compression force negative) at the serviceability limit state acting on the part of the cross section under consideration. N_{sd} should be determined considering characteristic values of prestress and axial forces under quasi-permanent combinations of actions or the minimum axial force that can co-exist with the bending moment considered.

In the definition of k_c add the following at the end:

If $k_c \leq 0$, no reinforcing steel is required.

cc) *Clause 4.4.2.3 (103)*

Replace the existing clause with the following:

“In design cases according to (102) above, the crack width may be considered adequately controlled if either the bar diameter does not exceed the values given in Table 4.120 or the maximum bar spacing does not exceed the limit in Table 4.121”.

In these tables, σ_s is the stress in the reinforcing steel unless there is prestressing steel alone, in which case σ_s is equal to $\Delta\sigma_p$.

The steel stress for the application of Tables 4.120 or 4.121 should be calculated under the relevant combination of actions using Equations (4.198) or (4.199), as appropriate.

dd) *Clause 4.4.2.3 (106)*

Replace the definition of σ'_s with the following:

“ σ'_s is steel stress in the reinforcing steel or change of stress in prestressing steel relative to the stress state at decompression, calculated in the cracked state assuming full bond under the relevant combination of actions.”

Add the following at end of definitions of ϕ_s and ϕ_p :

“However if there are a variety of sizes, ϕ shall be taken as the weighted average size ($4A_s/\Sigma\pi\phi$, that is 4 times total steel area over total steel perimeter).”

ee) *Clause 4.4.2.3, Table 4.120*

Add at the end of note at bottom “and the bar diameter shall be taken as the equivalent diameter of the tendon ϕ_p ”.

ff) *Clause 4.4.2.3, Tables 4.120*

Add “or $\Delta\sigma_p$ ” after σ_s in heading to the left-hand column.

gg) *Clause 4.4.2.3*

Replace the existing Table 4.121 with the following:

Table 4.121 — Maximum bar spacing for high bond bars

Maximum bar spacing (mm)			
Steel stress (bending) σ_s or $\Delta\sigma_p$ N/mm ²	Pure flexure (reinforced sections)	Pure tension (reinforced sections)	Pre-stressed sections
80	—	300	300
120	—	250	250
160	300	200	200
200	250	150	150
240	200	125	100
280	150	75	50
320	100	—	—
360	50	—	—

6.4 Chapter 5. Detailing provisions

a) *Table 5.1*

Table 5.1 should be replaced by Table 7 of this NAD, which gives minimum diameters of mandrels.

Table 7 — Minimum diameters of mandrels

	Hooks, bends, loops (see Figure 5.2 of ENV 1992-1-1)		Bent-up bars or other curved bars		
	Bar diameter		Value of minimum concrete cover, perpendicular to plane of curvature		
	$\phi < 20$ mm	$\phi \geq 20$ mm	> 100 mm and $> 7\phi$	> 50 mm and $> 3\phi$	≤ 50 mm and $\leq 3\phi$
Minimum diameter of mandrels for plain bars S 250	4ϕ	4ϕ	7ϕ	8.5ϕ	11.4ϕ
Minimum diameter of mandrels for high bond bars S 460	6ϕ	8ϕ	13ϕ	15.7ϕ	20.9ϕ

b) *Clause 5.2.6.3*

This clause does not apply to 40 mm diameter bars.

c) *Clause 5.4.3.2.3*

The additional recommendation in the NAD to EC2-1 is not appropriate when a full analysis (e.g. grillage or finite element) of a slab has been performed.