Annex for The Netherlands

Steel Design 4

Composite structures

J.W.B. Stark

R.J. Stark

Colofon/Content

Annex for the Netherlands to *Composite structures* (Steel Design 4)

This annex has been prepared by prof.ir. J.W.B. Stark and is based on the original Dutch version of *Composite structures*, published in 2009 by Bouwen met Staal as *Staal-beton* by the same authors. References are made to each NA symbol in *Composite structures* and – where relevant – the corresponding clause in the Eurocode.
Annexes to *Composite structures* (Steel Design 4) are also available for Belgium, Luxembourg and Switzerland and can be downloaded free of charge from the website of Bouwen met Staal.

www.bouwenmetstaal.nl

Composite structures

1 Annex NL

p. 1-4 ***asymmetrical steel section***

No additional remarks for The Netherlands.

p. 1-5 ***welding headed studs***

It is required for welding headed studs that the profiled steel sheeting thickness does not exceed 1,25 mm and the zinc layer on both sides is not thicker than 0,03 mm (30 µm). In addition NEN-EN 1994-1-1, National Annex, annex D require that the top flange of the beam at the location of the studs is not coated.

p. 1-15 ***fully encased steel section***

No additional remarks for The Netherlands.

p. 1-18 ***holes in tubular columns***

No additional remarks for The Netherlands.

p. 1-24 ***EN 1994-1-1, annex A, B and C***

For The Netherlands the annexes A, B and C are normative.

p. 1-27 (a) ***EN 1994-1-1, National Determined Parameters***

Table NL1.1 gives an overview of the National Determined Parameters in the Dutch National Annex to EN 1994-1-1. The letter A in the third column indicates that the recommended value has been used.

For the partial factors of concrete and reinforcing steel (reinforcement), references are made to EN 1992-1-1 and for those of structural steel and dowels (other than studs) to EN 1993-1-1 respectively. The values for these factors are:

structural steel	γ_M = 1,00 (= γ_{M0})
reinforcing steel	γ_S = 1,15
concrete	γ_C = 1,50
shear connectors	γ_V = 1,25

The three informative annexes A, B and C are normative. The Dutch National Annex provides 'non-contradictory complementary information', more specifically:

cl. 2.1 additional requirements relating to design, calculation and execution;

cl. 3.5 (2) tolerances for profiled steel sheeting;

cl. 7.3.1 (4) simplified equations for the (approximate) calculation for the deflection in the case of partial shear connections (derived from the previously omitted standard NVN-ENV 1994-1-1).

Furthermore, the following five annexes have been added:

D Execution;
E Floors with prefabricated concrete slabs for buildings;
F Dowels other than headed studs in solid floor slabs;
G Simplified method for the calculation of cross-sectional capacity of double-symmetrical sections loaded in compression and bending;
H Simplified calculation method for composite columns with single-symmetrical cross-sections.

With exception of annex D, the information in the additional annexes is derived from NVN-ENV 1994-1-1.

NL1.1 Overview of National Determined Parameters in the Dutch National Annex to EN 1994-1-1. 'A' indicates that the recommended value has been adopted.

clause	parameter or item		choice or remark
2.4.1.1(1)	partial factor γ_P	A	γ_P = 1,0 for favourable and unfavourable effects
2.4.1.2(5)	partial factor γ_V	A	γ_V = 1,25
2.4.1.2(6)	partial factor γ_{VS}	A	γ_{VS} = 1,25
2.4.1.2(7)	partial factors γ_{Mf} and $\gamma_{Mf,s}$	A	for γ_{Mf} see National Annex to EN 1993-1-9 $\gamma_{Mf,s}$ = 1,0
3.1(4)	shrinkage of concrete		choice between EN 1992 or appendix C
3.5(2)	minimum thickness t of the profiled sheeting	A	t_{min} = 0,70 mm
6.4.3(1)h	assessment table lateral instability		table with distinction between HEA and HEB sections for wide-flange sections
6.6.3.1(1)	partial factor γ_V	A	γ_V = 1,25
6.6.3.1(3)	studs causing splitting forces		see EN 1994-2
6.6.4.1(3)	methods for anchoring steel sheets		no supplementary rules
6.8.2(1)	partial factor $\gamma_{Mf,s}$	A	$\gamma_{Mf,s}$ = 1,0
6.8.2(2)	partial factor γ_{Ff}		see National Annex to EN 1992-1-1 and EN 1993-1-9
9.1.1(2)	upper limit b_r/b_s	A	b_r/b_s = 0,6
9.6(2)	maximum deflection $\delta_{s,max}$		$\delta_{s,max}$ = L/180; in case accumulation has to be taken into account according to cl. 9.3.2(2) the following applies: $\frac{n}{n-1} = \frac{1}{1 - 0{,}117 \cdot 10^{-8} \frac{L^4}{I_{eff}}}$
9.7.3(4)	partial factor γ_{VS}	A	γ_{VS} = 1,25
9.7.3(8)	partial factor γ_{VS}	A	γ_{VS} = 1,25
9.7.3(9)	nominal factor μ	A	μ = 0,5
B.2.5(1)	partial factor γ_V	A	γ_V = 1,25
B.3.6(5)	partial factor γ_{VS}	A	γ_{VS} = 1,25

p. 1-27 (b) ***EN 1994-1-2, National Determined Parameters***

Table NL1.2 gives an overview of the National Determined Parameters in the Dutch National Annex to EN 1994-1-1. The informative annexes A to H are normative in The Netherlands. Annex I remains informative.

The Dutch National Annex to EN 1994-1-2 does not contain 'non- contradictory complementary information'.

p. 1-28 ***Literature***

Additional literature specific for The Netherlands:

9. *NVN-ENV 1994-1-1* (Eurocode 4. Ontwerp en berekening van staal-betonconstructies. Deel 1. Algemene regels en regels voor gebouwen), 1995 (vervallen).
   In English: *NVN-ENV 1994-1-1* (Eurocode 4. Design of composite steel and concrete structures. Part 1. General rules and rules for buildings), 1995 (withdrawn).

clause	parameter or item		choice or remark
1.116	concrete strength > C50/60		scope not expanded
2.1.3(2)	max. temperature increase $\Delta\theta_1$ $\Delta\theta_2$	A A	$\Delta\theta_1$ = 200 K $\Delta\theta_2$ = 240 K
2.3(1)P	partial factors $\gamma_{M,fi,a}$ $\gamma_{M,fi,s}$ $\gamma_{M,fi,c}$ $\gamma_{M,fi,v}$	A A A A	$\gamma_{M,fi,a}$ = 1,0 as in EN 1993-1-2 $\gamma_{M,fi,s}$ = 1,0 as in EN 1992-1-2 $\gamma_{M,fi,c}$ = 1,0 as in EN 1992-1-2 $\gamma_{M,fi,v}$ = 1,0
2.3(2)P	partial factor $\gamma_{M,fi}$	A	$\gamma_{M,fi}$ = 1,0
2.4.2(3)	reduction factor η_{fi}	A	two alternative options in note 1 and note 2
3.3.2(9)	thermal conductivity λ_c	A	use upper limit according to equation 3.6a
4.1(1)P	advanced calculation models		application permitted according to cl. 4.4
4.3.5.1(10)	buckling length L_{ei} L_{et}	A	L_{ei} = 0,5L L_{et} = 0,7L

NL1.2 Overview of National Determined Parameters in the Dutch National Annex to EN 1994-1-2. 'A' indicates that the recommended value has been adopted.

Annex NL 2

Composite beams

p. 2-2 ***EN 1994-1-1, National Determined Parameters***

See remarks to p. 1-27 (a).

p. 2-4 ***properties of shear connectors***

Annex F of the National Annex to EN 1994-1-1 provides additional rules for other types of shear connectors.

p. 2-6 ***headed studs in punched holes***

Studs in punched holes are mainly used in Germany, this is not common practice in The Netherlands and in the United Kingdom.

p. 2-9 ***effective width concrete slab***

No additional remarks for The Netherlands.

p. 2-26 ***number of connectors required***

No additional remarks for The Netherlands.

p. 2-29 ***number of headed studs***

No additional remarks for The Netherlands.

p. 2-30 (a) ***number of headed studs***

No additional remarks for The Netherlands.

p. 2-30 (b) ***reinforcement cantilever beam***

No additional remarks for The Netherlands.

p. 2-40 ***EN 1994-1-1, table 6.1***

The Dutch National Annex to EN 1994-1-1, cl. 6.4.3 provides a slightly more extensive table, see table NL2.1.

steel beam section	maximum depth h_{max}			
	S235	S275	S355	S420 and S460
IPE	600	550	400	270
HEA	800	700	650	500
HEB	900	800	700	600

NL2.1 Sections for which the instability of the compressive bottom flange does not need to be investigated, depending on the steel grade.

p. 2-42 ***slip of shear connectors***

Other countries may specify different rules on how to take slip of the shear connectors into account

p. 2-48 ***conditions to beams with composite slabs***

No additional remarks for The Netherlands.

p. 2-51 ***EN 1994-1-1, cl. 7.4.3(1)***

The Dutch translation of the English source text incorrectly indicates that both conditions (maximum bar diameter and maximum spacing) must be met.

p. 2-58 ***bending moment resistance model***

The recommended value $\gamma_{M,fi,a}$ = 1,0 is accepted, see also table NL1.2.

p. 2-66 ***Literature***

Additional literature specific for The Netherlands:

16. *Statisch bepaalde staal-beton liggers. Theorie en richtlijnen* (SG-CUR-rapport 1; waarin opgenomen de RSBL 1974 (Richtlijn voor het ontwerp en de vervaardiging van staal-beton liggers. Deel 1. Statisch bepaalde liggers onderworpen aan overwegend statische belasting)), Delft 1974.
    In English: *Simply supported steel-and-concrete composite beams* (SG-CUR report 3; containing RSBL 1974 (Guidelines for the design and manufacturing of composite beams. Part 1. Simply supported beams subjected to predominantly static loading)), Delft 1974
17. *Statisch onbepaalde staal-beton liggers. Theorie en richtlijnen* (SG-CUR-rapport 4; waarin opgenomen de RSBL 1983 (Richtlijnen voor het ontwerp en de vervaardiging van staal-beton liggers. Overwegend statisch belaste liggers)), Delft 1987.
    In English: *Continuous steel-and-concrete composite beams* (SG-CUR report 4; containing RSBL 1983 (Guidelines for the design and manufacturing of composite beams. Predominantly statically loaded beams)), Delft 1987.
18. *Staal-beton liggers. Praktijkvoorbeelden voor ontwerp en berekening* (CS-SG-CUR rapport 9), Rotterdam/Gouda 1993.
    In English: *Composite steel and concrete beams. Examples of design and calculation in practice* (CS-SG-CUR report 9), Rotterdam/Gouda 1993.

Annex NL3 Composite slabs

p. 3-2 ***EN 1994-1-1, cl. 9.1.1(2)***

The recommended value $b_r/b_s \leq 0{,}6$ is accepted

p. 3-3 ***EN 1994-1-1, cl. 3.5(2)***

The recommended minimum value 0,70 mm for the nominal thickness of the steel sheets is adopted. Clause 3.5 of the Dutch National Annex to EN 1994-1-1 specifies that if the tolerances of a profiled steel sheet given in table NL3.1 are exceeded, a recalculation or experimental assessment is required to prove that the composite structure will be sufficiently safe.

	plus tolerance	minus tolerance
total depth of steel sheeting	+4%	–1%
steel core thickness	+10%	-5%
size of embossments	n.a.	–10%
distance berween embossments	+5%	-59%

NL3.1. Tolerances for profiled steel sheeting.

p. 3-4 (a) ***imposed load during execution***

No additional remarks for The Netherlands.

p. 3-4 (b) ***EN 1994-1-1, cl. 9.6***

The recommended value for the deflection due to self-weight of the steel sheeting and the reinforced concrete $d_{s,max} = L/180$ is adopted.

p. 3-4 (c) ***EN 1994-1-1, cl. 9.3.2(2)***

Clause 9.6 of the Dutch National Annex to EN 1994-1-1 specifies that when the effect of ponding is to be taken into account the amplification factor shall be determined with:

$$\frac{n}{n-1} = \frac{1}{1 - 0{,}117 \cdot 10^{-8} \frac{L^4}{I_{eff}}}$$

Where:

L span;

I_{eff} second moment of area of the effective cross-section of the sheeting.

p. 3-12 (a) ***EN 1992-1-1, cl. 6.2.2***

No additional remarks for The Netherlands.

p. 3-12 (b) ***EN 1992-1-1, cl. 6.2.2***

The recommended value $C_{Rd,c} = 0{,}18/\gamma_C$ is accepted.

p. 3-12 (c) ***EN 1992-1-1, cl. 6.2.2***

The recommended value for V_{min} is accepted:

$$V_{min} = 0{,}035\sqrt{k^3}\sqrt{f_{ck}} = 0{,}035\sqrt{\left(1 + \sqrt{\frac{200}{d_p}}\right)^3}\sqrt{f_{ck}}$$

p. 3-13 (a) ***EN 1992-1-1, cl. 6.2.2***

No additional remarks for The Netherlands.

p. 3-13 (b) ***EN 1992-1-1, cl. 6.2***

The recommended values $C_{Rd,c} = 0{,}18/\gamma_c$ and $V_{min} = 0{,}035\sqrt{k^3}\sqrt{f_{ck}}b_w d_p$ are accepted. Provided that it is validated by tests, it is also allowed to take into account the contribution of the steel sheeting. The following additive model is then used:

$V_{v,Rd} = V_{c,Rd} + V_{s,Rd}$

Where:

$V_{c,Rd}$ design vertical shear resistance of the concrete part according to EN 1992-1-1, cl. 6.2.2;

$V_{s,Rd}$ design vertical shear resistance of the steel sheeting, according to EN 1993-1-3, cl. 8.1.5 or given by an European Technical Approval (ETA).

p. 3-17 ***EN 1994-1-1, cl. 9.7.3(4)***

The recommended value $\gamma_{vs} = 1{,}25$ is accepted.

p. 3-20 ***longitudinal shear force Vl,Ed***

No additional remarks for The Netherlands.

p. 3-22 (a) ***EN 1994-1-1, cl. 9.7.3(9)***

The recommended value is = 0,5 is accepted.

p. 3-22 (b) ***EN 1994-1-1, cl. 9.8.2(4) and (6)***

No additional remarks for The Netherlands.

p. 3-24 ***options to increase the fire resistance***

No additional remarks for The Netherlands.

p. 3-31 ***EN 1990, cl. 6.4.3.2(3) + cl. A1.1(1)***

The recommended partial factors for the accidental design situation $\gamma_G = \gamma_Q = 1{,}0$ are accepted.

p. 3-32 ***EN 1994-1-2, cl. 2.3(1)***

The recommended partial factor for concrete for the fire situation $\gamma_{C,fi} = 1, 0$ is accepted.

p. 3-36 ***Literature***

Additional literature specific for The Netherlands:

10. *Staalplaat-betonvloeren. Deel 1. Richtlijnen en rekenvoorbeelden* (CS-SG-CUR rapport 7; waarin opgenomen de RSBV 1990 (Richtlijnen voor het ontwerp en de vervaardiging van staalplaat-betonvloeren), Rotterdam/Gouda 1993
    In English: *Composite concrete-steel deck floors. Part 1. Specifications and worked examples* (CS-SG-CUR report 7; containing RSBV 1990 (Guidelines for the design and manufacturing of composite steel-concrete deck floors)), Rotterdam/Gouda 1993.
11. *Staalplaat-betonvloeren. Deel 2. Theorie* (CS-SG-CUR rapport 8), Rotterdam/Gouda 1991.
    In English: *Composite concrete-steel deck floors. Part 2. Theory* (CS-SG-CUR report 8), Rotterdam/Gouda 1991.

Composite columns

4 Annex NL

p. 4-12 ***EN 1994-1-1, cl. 6.7.3.4(5)***

The parameter k = n/(n – 1), which is often used in the Netherlands, can be obtained by using the definition $n = N_{cr,eff}/N_{Ed}$.

p. 4-22 ***EN 1994-1-2, cl. 4.3.5.1(10)***

The recommended values of the buckling lengths of the columns given in figure 4.20 are accepted in The Netherlands.

p. 4-29 ***EN 1994-1-2, annex H***

Annex H is normative in The Netherlands.

p. 4-30 ***fire resistance R30***

No additional remarks for The Netherlands.

p. 4-32 ***Literature***

Additional literature specific for The Netherlands:

6. *Brandwerendheid van staal-beton kolommen. Deel 1. Stalen I-profielen met beton tussen de flenzen; stalen I-profielen omstort met beton* (SG-CUR-rapport 5), Rotterdam/Gouda 1988.
   In English: *Fire resistance of composite columns. Part 1. Steel I-sections partially encased with concrete* (SG-CUR report 5), Rotterdam/Gouda 1988
7. *Brandwerendheid van staal-beton kolommen. Deel 2. Stalen buisprofielen gevuld met beton* (CS-SG-CUR rapport 6), Rotterdam/Gouda 1989.
   In English: *Fire resistance of composite columns. Part 2. Steel hollow sections filled with concrete* (CS-SG-CUR report 6), Rotterdam/Gouda 1989
8. *Staal-beton kolommen. Theorie en richtlijnen* (SG-CUR-rapport 3; waarin opgenomen de RSBK 1983 (Richtlijnen voor het ontwerp en de vervaardiging van staal-beton kolommen), Delft 1983.
   In English: *Composite columns. Theory and guidelines* (SG-CUR report 3; containing RSBK 1983 (Guidelines for the design and manufacturing of composite columns), Delft 1983

Annex NL 5

Composite joints

p. 5-9 ***EN 1994-1-1, annex A***

Annex A is normative in the Netherlands.

p. 5-11 (a) ***joint with bolted end-plate***

No additional remarks for The Netherlands.

p. 5-11 (b) ***EN 1993-1-8, table 5.2***

No additional remarks for The Netherlands.

Worked example cinema auditorium

6 Annex NL

No annex required for this chapter.