The 2nd Generation of EC2
DS/EN 1992-1-1:2023, including DK NA

Dansk Betondag 2026
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Agenda

Part 1

Overview

- 1st and 2nd Generation of EC2
- Consequence classes
- Robustness
- Safety, Partial factors
- Properties of materials
- Durability

Part 2

Design rules and detailing rules

- Examples of Evolution & Selected Changes

Part 1

Plan

For buildings, the building regulations determine when new Eurocodes apply.

New Eurocodes can be used from:

2028.01.01

There is a transition period until:

2029.01.01

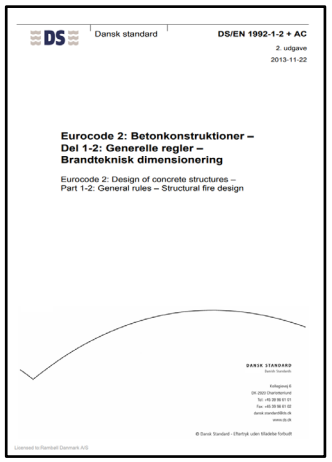
Vejdirektoratet and Banedanmark decide when the new Eurocodes should apply to design of infrastructures.

Existing Eurocodes for concrete

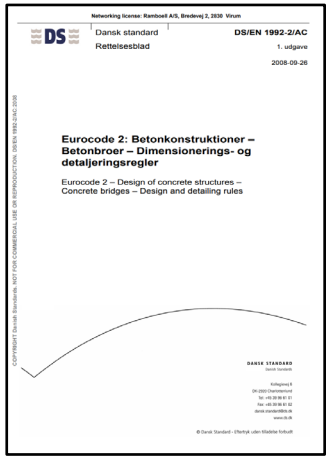
1992-1-1



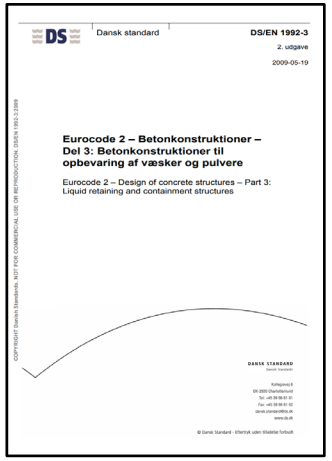
1992-1-2



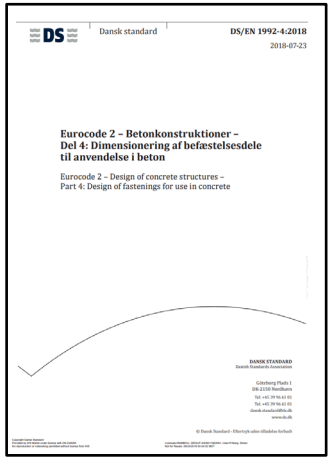
1992-2



1992-3



1992-4

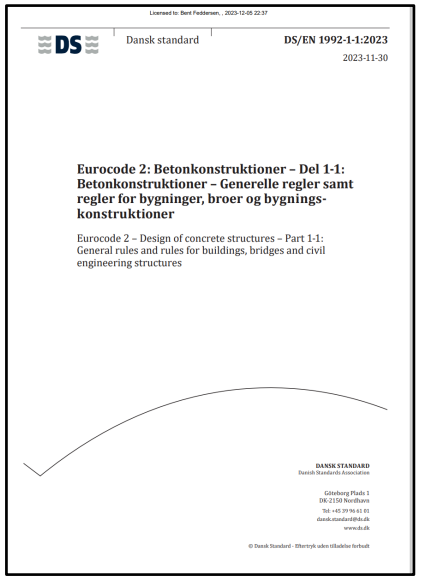


181 NDPs

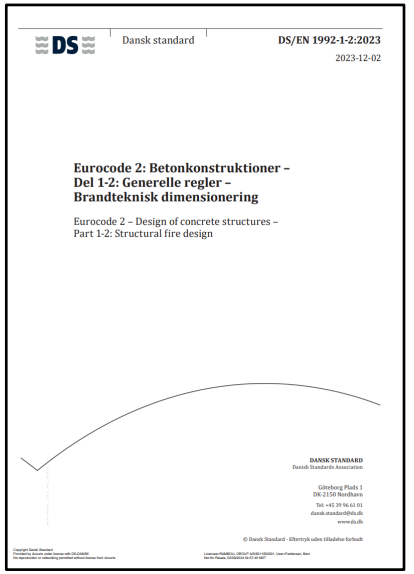
New Eurocodes for concrete

- Less national choices
- More mechanical based models
- Ease-of-use through levels of approximation
- Provisions supporting sustainability

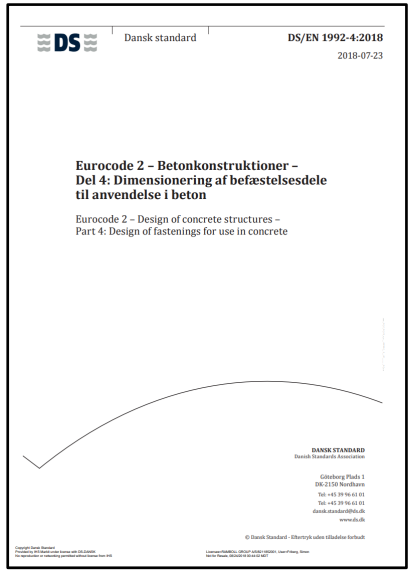
1992-1-1



1992-1-2



1992-4



82 NDPs

Content, Chapters

0. Introduction
1. Scope
2. Normative references
3. Terms, definitions and symbols
4. Basis of design
5. Materials
6. Durability and concrete cover
7. Structural analysis
8. Ultimate Limit State (ULS)
9. Serviceability Limit State (SLS)
10. Fatigue
11. Detailing of reinforcement and post-tensioning tendons
12. Detailing of members and particular rules
13. Additional rules for precast concrete elements and structures
14. Plain and lightly reinforced concrete structures

Red marked chapters have the same title as current code – only chapter numbers are changed.

Chapter about Lightweight aggregated concrete structures in current code is moved to an annex in the new code.

Content, Annexes

A. Adjustment of partial factors for materials (I/NA)

B. Time dependent behaviour of materials: strength, creep, and elastic strain of concrete and relaxation of prestressing steel (N)

C. Requirements for materials (N)

D. Evaluation of early-age and long-term cracking due to restraint (I/Awaiting)

E. Additional rules for fatigue verification (N)

F. Safety formats for non-linear analysis (I)

G. Design of membrane-, shell- and slab elements (N)

H. Guidance on design of concrete structures for water-tightness (I)

I. Assessment of existing structures (I/Awaiting)

J. Strengthening of Existing Concrete Structures with CFRP (I/NA)

K. Bridges (N/Awaiting)

L. Steel fibre reinforced concrete structures (I/Awaiting)

M. Lightweight aggregate concretes structures (N)

N. Recycled aggregates concrete structures (I)

O. Simplified approaches for second order effects (I)

P. Alternative cover approach for durability (NA)

Q. Stainless reinforcing steel (N)

R. Embedded FRP reinforcement (I/NA)

S. Minimum reinforcement for crack control and simplified control of cracking (I)

Eurocode/ DK NA

N : Normative

NA: Not applicable

I: Informative

Upcoming consequence classes in DS/EN 1990:2023 DK NA

Table A.1.1 NA - Classification of buildings in different consequence classes

Consequence class [c]	Description of consequence with associated limits for expected number of lives lost [d]	*Limits for expected number of lives lost*	Examples of classified buildings with associated limits for number of storeys and people in the building [c]	
			Limits for number of storeys in building	Limits for expected number of people in the building [a,b]
CC4	**Highest** Extreme risk of loss of human life – *or* economic, social, *or* environmental consequences are huge		Not intended for buildings but for special structures such as nuclear and other power plants and large-scale civil engineering structures where Eurocodes normally are only partly covering and special technical design bases and project-specific annexes need to be developed.	Not included in the classification system
CC3	**High** High risk of loss of human life - *or* economic, social *or* environmental consequences are very great	*≤ 300* *> 50*	Multi-storey buildings	7.500
			Single storey building	15.000
CC2b	**Medium high** Medium risk of loss of human life - *or* economic, social *or* environmental consequences are considerable	*≤ 50* *> 10*	Buildings up to 15 storeys above ground and a maximum 2 storeys below ground	1.500
			Single storey building	3.000
CC2a	**Medium low** Medium risk of loss of human life - *and* economic, social *or* environmental consequences are small	*≤ 10* *> 1*	Buildings up to 6 storeys above ground and a maximum of 1 storey below ground,	300
			Single storey building	600
CC1	**Low** Low risk of loss of human life - *and* economic, social *or* environmental consequences are small	*≤ 1*	Single occupancy houses or terraced house up to 3 storeys above ground and a maximum 1 storey below ground,	15
			Building up to 2 storeys above ground and a maximum 1 storey below ground,	15
			Single storey agriculture or storage building	30
CC0	**Lowest** Very low risk of loss of human life - *and* economic, social *or* environmental consequences are insignificant	*0*	Non-load-bearing structures, small sheds, etc. - *and* secondary buildings where only short-term stays occur	

a The expected number of people in the building is calculated as:
∑ (utilized area) · (occupancy intensity in accordance with table A.1.a NA).
The occupancy intensity is increased by a factor of 1,5 in buildings where people are not able to escape on their own. This applies, for example, for hospitals, daycare centres, prisons and some types of nursing homes.
Rooftop terraces and unused attic floors are assumed having no occupancy.

b If the foundation of the building is significantly lower than the foundation of the neighbouring building, the people in the neighbouring building affected by a possible collapse of the foundation is included in the calculation.

c The examples of classified buildings given in right column with the associated limits for number of storeys and people in the building are assumed to fulfil the corresponding limits for the specific consequence classes with regards to expected number of human lives lost (Table A.1.1 NA (left column)) and can be used to determine the consequence class for other buildings. See also (2) including NOTE 1.

d The number of expected lives lost is connected to arbitrary failure scenarios that can be different from failure scenarios connected to notational removal of elements.

Table A.1.9 NA — Consequence factors for building and geotechnical structures

Consequence class	Consequence factor k_F
CC3	1,1
CC2b	1,0
CC2a	1,0
CC1	0,9

NOTE Description of consequences see table A.1.1 NA.

Upcoming consequence classes in DS/EN 1990:2023 DK NA

(4) Buildings may be classified into consequence classes directly based on the limits for expected number of lives lost provided that all relevant failure scenarios are analysed using the expected occupancy intensities given in Table A.1.a NA and fatality factor k given in E.1.6.

k	is the fatality factor that represents the proportion of the expected number of human lives lost in relation to the people present in the building. The fatality factor depends on number of storeys: for 1-3 storey 0,15 is used, for 4 storeys or more 0,3 is used on all storeys including storey 1-3

Table A.1.a NA — Expected occupancy intensities for different building applications

No.	Building application	Occupancy intensity N_{PE} [a] [number of people/m²]
1	Residential building	0,05
2	Office	0,1
3	Hospital	0,1
4	Education – Classrooms (incl. hallways) and daycare centers (excl. larger gathering areas)	0,25
5	Commercial buildings (shopping malls, libraries, museums, restaurants)	0,25
6	Assembly areas, other (auditoriums, churches, assembly halls in schools, etc.) [b]	0,8
7	Assembly areas, dense (grandstands and standing concert) [b]	2,5
8	Industry and garages [b]	0,05
9	One family residential building	0,02
10	Agriculture and storage [b, c]	0,002

a Including access routes such as hallways, stairs, etc. Stairs and access routes can be included in the calculation with the same occupancy intensity as the adjacent areas.

b Alternatively, project specific values corresponding to the maximum number of people allowed according to the fire protection strategy can be used.

c Alternatively, project specific values can be used that also accounts for the expected number of animals lost (agriculture) and economic consequences (storage).

Example

14-storey building with a footprint of 70 × 50 m, featuring shops on the ground floor, an assembly hall on the first floor, offices on the second and third floors, and residential units on the remaining floors.

$NF = k \cdot 70 \cdot 50(1 \cdot 0.25 + 1 \cdot 0.8 + 2 \cdot 0.1 + 10 \cdot 0.05) = k \cdot 6125$

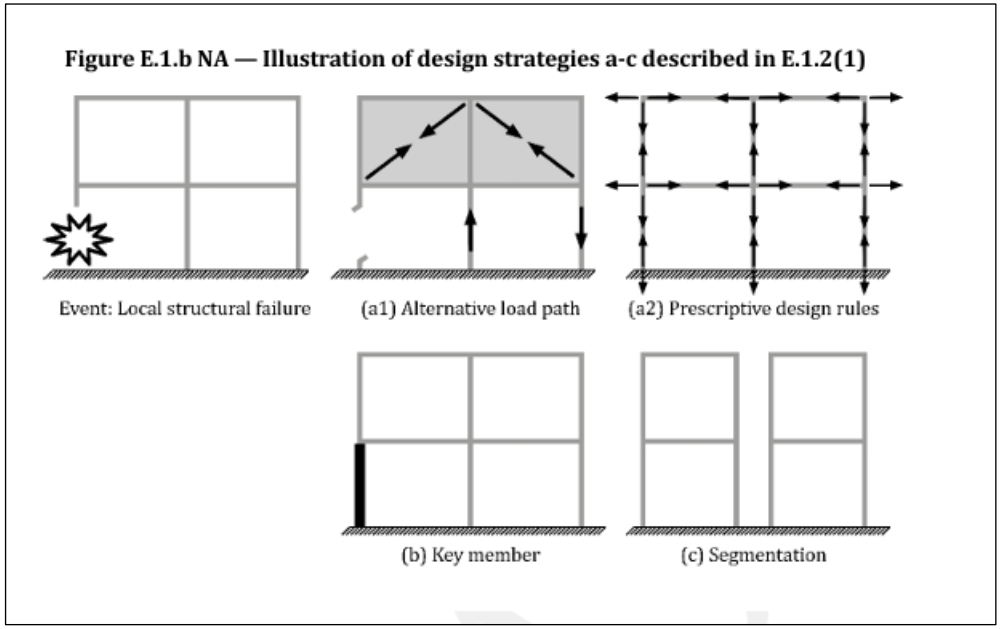
k = 0,3 results in CC4!!!!

Robustness

DS/EN 1990 DK NA, Annex E

Four methods:

- Alternative load path/Acceptable extent of collapse
- Key members
- Prescriptive design rules
- Segmentation (separation of the structure into statically independent parts)



DS/EN 1991-1-7 DK NA, Annex A

- Common prescriptive design rules alle materials

DS/EN 1992-1-1 DK NA

- Prescriptive design rules for concrete

Partial factors

Safety of load-bearing structures is a national concern.

Denmark has its own safety system.

Safety formats for non-linear analysis is included in Annex F.

Reliability index β

Upcoming DS/EN 1990 DK NA

Consequence class	1-year reference period β
CC3	4,6
CC2b	4,1
CC2a	4,1
CC1	3,5

Current DS/EN 1990 DK NA

Reliability class	Minimum values for ß
RC3 corresponding to CC3	4.7
RC2 corresponding to CC2	4.3
RC1 corresponding to CC1	3.8

Overall safety level is reduced

Partial factors

Partial factors (MFA-method) are in accordance with DS/EN 1990-1:2023, DK NA Annex FF, determined by:

$$\gamma_R = \frac{\gamma_1 \gamma_2 \gamma_3 \gamma_{2K}}{b_2 b_3}$$

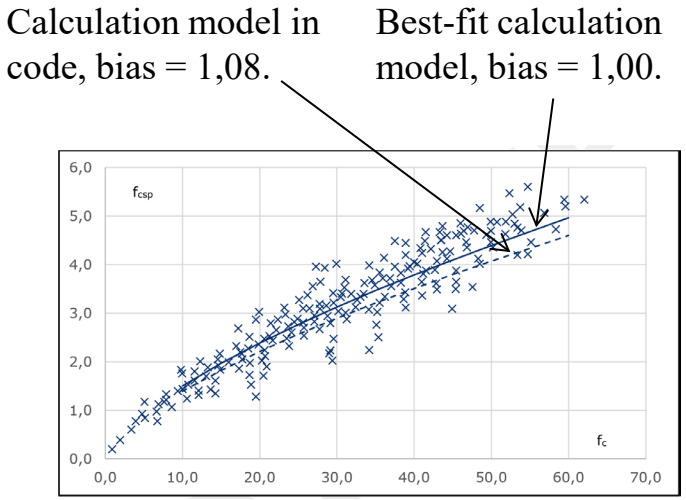
The values for the partial factors in EC2 are determined by analysing a large number of test results. Results are contained in a background report.



Partial factors for resistance determined by test is:

$$\gamma_R = \frac{\gamma_1 \gamma_3}{b_3}$$

γ_1	The failure type
γ_2	The uncertainty associated with the calculation model
b_2	The bias connected with the calculation model
γ_3	The uncertainty associated with the strength parameter or resistance determined by test
b_3	The bias connected with the strength parameter or resistance determined from test
γ_{2K}	Additional effect of calculation model uncertainty



Partial factors

γ_1

Failure mode

Concrete structures with at least minimum reinforcement.

Concrete structures with less than minimum reinforcement.

Type of failure	Warning of failure with residual resistance	Warning of failure without residual resistance	No warning of failure
γ_1	0,90 / 0,95	1,00	1,10

Ductility requirements according to EC2

Class A

$\varepsilon_{uk} \geq 2{,}5\%$

$\left(\frac{f_t}{f_y}\right)_k \geq 1{,}05$

Class B

$\varepsilon_{uk} \geq 5{,}0\%$

$\left(\frac{f_t}{f_y}\right)_k \geq 1{,}08$

Class C

$\varepsilon_{uk} \geq 7{,}5\%$

$\left(\frac{f_t}{f_y}\right)_k \geq 1{,}15 < 1{,}35$

(f_t/f_y) at least 1,10

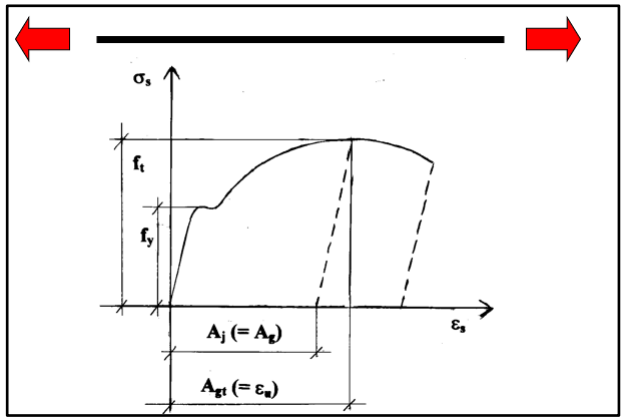
(f_t/f_y) at least 1,05

ε_u at least 5 %

Ductility class C

Ductility class B

Ductility class A



Partial factors

γ_2

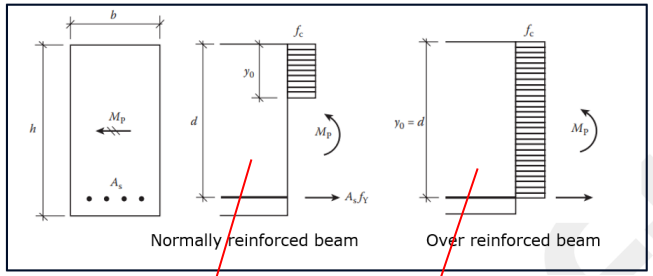
Uncertainty connected to calculation model.

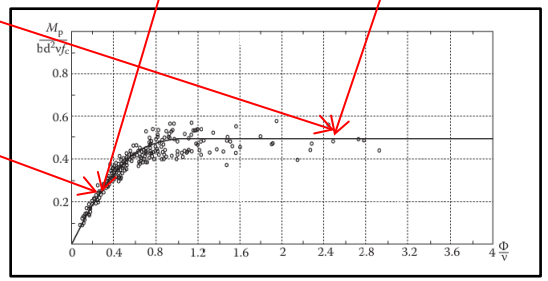
Based on test in laboratory.

Difference between test in laboratory and test on real structure.

Subject	Bias	COV $V_{2,XR}$	COV $V_{2,XRT}$	COV V_2	γ_2
Concrete (R)	1,00	10,10	5,00	11,27	1,04
Reinforcement	1,10	9,00	5,00	10,30	1,03

Capacity of reinforced beams in bending.





$$V_2 = \sqrt{V_{2,XR}^2 + V_{2,XRT}^2}$$

Coefficient of variation of the calculation model V_2	≤5 %	10 %	15 %	20 %	25 %
γ_2	1,00	1,025	1,075	1,125	1,175

Partial factors

γ_3

Uncertainty connected to strength parameter (material)

Subject	Bias	COV $V_{3,X}$	COV $V_{3,RT}$	COV V_3	γ_3
Concrete (R)	1,00	7,30	8,36	11,10	1,19
Reinforcement	1,00	5,00	0,00	5,00	1,18

Based on test in laboratory.

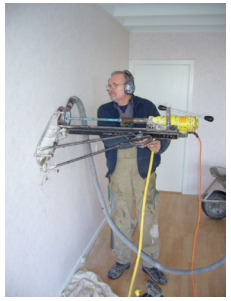
Concrete: Testing of in-situ cast cylinders in laboratory.



Reinforcement: Test in laboratory.

Difference between test in laboratory and test on real structure.

Concrete: Drilled out cores from structures.



$$V_3 = \sqrt{V_{3,R}^2 + V_{3,RT}^2}$$

Coefficient of variation for strength parameter or resistance V_3	≤5 %	10 %	15 %	20 %	25 %	30 %
γ_3	1,175	1,175	1,2375	1,30	1,40	1,50

Partial factors

Working document

Subject / Topic	Class	γ_M/γ_R Symbol	γ_1 Failure type	γ_1	γ_2 b_2	$V_{2,XR}$ %	$V_{2,XRT}$ %	V_2 %	γ_2	γ_3 b_3	$V_{3,R}$ %	$V_{3,RT}$ %	V_3 %	γ_3	$\gamma_{2\&3}$	γ_M/γ_R
Reinforced concrete		γ_c	WWRR	1,00	1,00	10,10	5,00	11,27	1,04	1,00	7,30	8,36	11,10	1,19	1,13	1,39
Compressive strengt concrete																
Modulus of elasticity concrete																
Plain concrete		γ_c	NW	1,10	1,00	10,10	5,00	11,27	1,04	1,00	7,30	8,36	11,10	1,19	1,13	1,53
Compressive strengt concrete																
Modulus of elasticity concrete																
Tensile strength concrete		γ_c	NW	1,10	1,00	10,10	5,00	11,27	1,04	1,00	11,00	-	16,00	1,25	1,00	1,43
Shear, members without shear reinforcement *1)		γ_v	NW	1,10	1,00	-	-	13,00	1,06	1,00	-	-	4,00	1,18	1,00	1,36
Reinforcement	B, C	γ_s	WWRR	0,91	1,10	9,00	5,00	10,30	1,03	1,00	5,00	0,00	5,00	1,18	1,21	1,20
- Non prestressed and prestressed	A	γ_s	NW	1,00	1,10	9,00	5,00	10,30	1,03	1,00	5,00	0,00	5,00	1,18	1,21	1,32
Yield strength																
Modulus of elasticity concrete																
Reinforcement		ε_{uc}													1,00	#DIV/0!
- Non prestressed and prestressed																
Ultimate strain limit																
Structures testing		γ_M														
Ductile failure															1,00	#DIV/0!
Brittle failure															1,00	#DIV/0!

Under construction

Note

NW No Warning
WWRR Warning Without Residual Resistance
WWR Warning With Residual

Reinforced concrete: Concrete structure that contains minimum reinforcement for the relevant impacts in agreement with DS/EN 1991-1-1:2023 and DS/EN 1992-1-1:2023 DK NA

Tensile strength concrete: The partial factor is used where the capacity is depending on the tensile strength of concrete, i.e. anchorage, laps and chapter 14.

*1) The value for V_3 is power 1/3 of 11 %

Used data is taken from the background document "Background data for determining partial factors for concrete structures in Eurocode 2, DSEN 1992-1-1-2023 DK NA, R0 20260227"

Values indicated in red color are values that needs further investigations.

Specification of concrete strength

DK NA

Rules for specification of concrete strength.

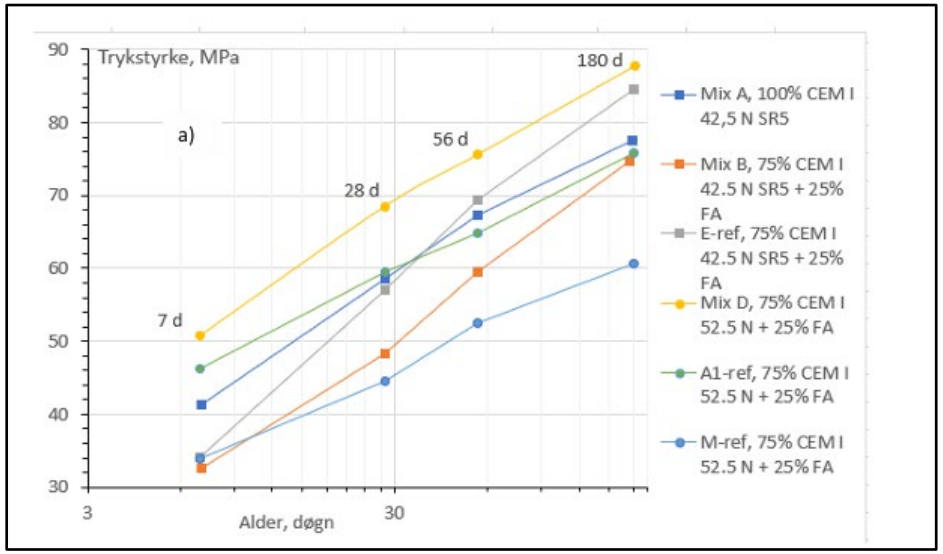
DS/EN 1992-1-1 allows up to 91 days.

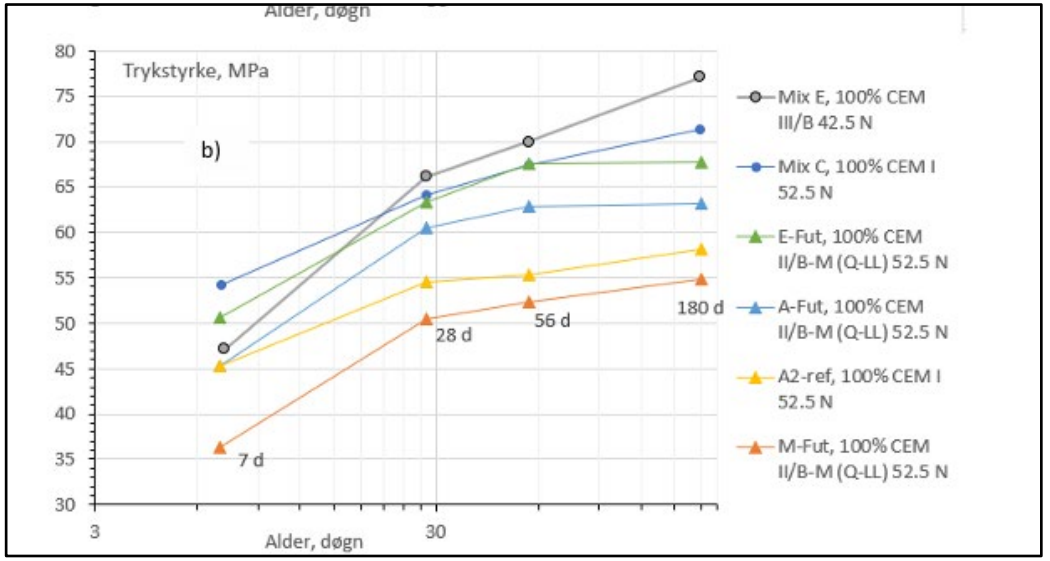
5.1.3(2) Strength

(NCCI)

A f_{ck} determined after 56 days (instead of after 28 days) can be used for specific projects. This requires that documented curves for the strength development of the specified concrete and documentation that ensures the characteristic strength at 56 days are available at the start of the project. The strength class must be documented both after 28 days and 56 days.

NOTE: When using the 56-day strength, it must be ensured that the strength development of the concrete has been considered in relation to the construction process - construction rate and temporary loads.





Durability and concrete cover

Chapter 6 sets out a new approach to the durability of concrete, with the principles being based on a "design" approach.

The old rules are given in Annex P.

Discussions are currently underway in Denmark, especially in relation to cover connected to carbonation and chlorides, including types of binders.

Table 6.3 (NDP) — Minimum concrete cover $c_{min,dur}$ for carbon reinforcing steel — Carbonation

ERC	Exposure class (carbonation)							
	XC1		XC2		XC3		XC4	
	Design service life (years)							
	50	100	50	100	50	100	50	100
XRC 0,5	10	10	10	10	10	10	10	10
XRC 1	10	10	10	10	10	15	10	15
XRC 2	10	15	10	15	15	25	15	25
XRC 3	10	15	15	20	20	30	20	30
XRC 4	10	20	15	25	25	35	25	40
XRC 5	15	25	20	30	25	45	30	45
XRC 6	15	25	25	35	35	55	40	55
XRC 7	15	30	25	40	40	60	45	60

NOTE 1 XRC classes for resistance against corrosion induced by carbonation are derived from the carbonation depth [mm] (characteristic value 90 % fractile) assumed to be obtained after 50 years under reference conditions (400 ppm CO_2 in a constant 65 %-*RH* environment and at 20 °C). The designation value of XRC has the dimension of a carbonation rate [mm/$\sqrt{}$(years)].

NOTE 2 The recommended minimum concrete cover values $c_{min,dur}$ assume execution and curing according to EN 13670 with at least execution class 2 and curing class 2.

NOTE 3 The minimum covers can be increased by an additional safety element $\Delta c_{dur,\gamma}$ considering special requirements (e.g. more extreme environmental conditions).

Table 6.4 (NDP) — Minimum concrete cover $c_{min,dur}$ for carbon reinforcing steel — Chlorides

ERC	Exposure class (chlorides)											
	XS1		XS2		XS3		XD1		XD2		XD3	
	Design service life (years)						Design service life (years)					
	50	100	50	100	50	100	50	100	50	100	50	100
XRDS 0,5	20	20	20	30	30	40	20	20	20	30	30	40
XRDS 1	20	25	25	35	35	45	20	25	25	35	35	45
XRDS 1,5	25	30	30	40	40	50	25	30	30	40	40	50
XRDS 2	25	30	35	45	45	55	25	30	35	45	45	55
XRDS 3	30	35	40	50	55	65	30	35	40	50	55	65
XRDS 4	30	40	50	60	60	80	30	40	50	60	60	80
XRDS 5	35	45	60	70	70	—	35	45	60	70	70	—
XRDS 6	40	50	65	80	—	—	40	50	65	80	—	—
XRDS 8	45	55	75	—	—	—	45	55	75	—	—	—
XRDS 10	50	65	80	—	—	—	50	65	80	—	—	—

NOTE 1 XRDS classes for resistance against corrosion induced by chloride ingress are derived from the depth of chlorides penetration [mm] (characteristic value 90 % fractile), corresponding to a reference chlorides concentration (0,6 % by mass of binder (cement + type II additions)), assumed to be obtained after 50 years on a concrete exposed to one-sided penetration of reference seawater (30 g/l NaCl) at 20 °C. The designation value of XRDS has the dimension of a diffusion coefficient [10^{-13} m^2/s].

NOTE 2 The recommended minimum concrete cover values $c_{min,dur}$ assume execution and curing according to EN 13670 with at least execution class 2 and curing class 2.

NOTE 3 The minimum covers can be increased by an additional safety element $\Delta c_{dur,\gamma}$ considering special requirements (e. g. more extreme environmental conditions).

Exposure classes

The former concept “miljøklasser” and “miljøpåvirkninger” is removed.

A DK NA table will be made reflecting Danish conditions. Min. compression strength are given for each exposure class

Tabel 6.1 NA – Exposure classes related to environmental conditions

Class	Description of the environment	Min. strength class[a]	Informative examples for exposure classes typical under Danish climate and environment
1 No risk of corrosion or attack			
X0	For concrete without reinforcement or other embedded metal: All exposures except where there is freeze/thaw, abrasion or chemical attack.	C12/15	Plain concrete where the structural capacity does not require reinforcement. For instance some foundations.
2 Corrosion of embedded metal induced by carbonation Where concrete containing steel reinforcement or other embedded metal is exposed to air and moisture, the exposure shall be classified as follows:			
			Concrete surfaces inside buildings with low air humidity, where the corrosion rate will

New classes

7 Mechanical attack of concrete by abrasion Where concrete is exposed to mechanical abrasion, the exposure shall be classified as follows:			
XM1	Moderate abrasion.	C35/45	Members of industrial sites frequented by vehicles with pneumatic tyres.
XM2	Heavy abrasion.	C35/45	Members of industrial sites frequented by vehicles with pneumatic tyres or solid rubber tyres.
XM3	Extreme abrasion.	C40/50	Members of industrial sites frequented by fork lifts with elastomer or solid rubber tyres.
NOTE	The examples can be deviated from if it can be demonstrated that a less aggressive exposure can be attributed.		
a	Minimum strength class for durability purpose.		

Part 2

Design compressive strength of concrete

5.1.6 Design assumptions

(1) The value of the design compressive strength shall be taken as:

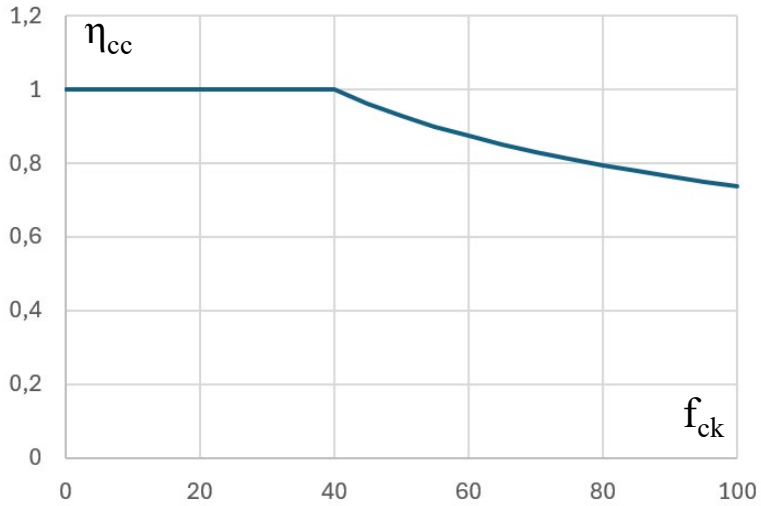
$$f_{cd} = \eta_{cc} \cdot k_{tc} \frac{f_{ck}}{\gamma_C} \qquad (5.3)$$

where

η_{cc} is a factor to account for the difference between the undisturbed compressive strength of a cylinder and the effective compressive strength that can be developed in the structural member. It shall be taken as:

$$\eta_{cc} = \left(\frac{f_{ck,ref}}{f_{ck}}\right)^{\frac{1}{3}} \leq 1{,}0 \qquad (5.4)$$

k_{tc} is a factor considering the effect of high sustained loads and of time of loading on concrete compressive strength.



DK NA: k_{tc} = 1,00 for $t_{ref} \leq$ 56 days.

- The new definition of f_{cd} includes a part of the “old” effectiveness factor.
- Effectiveness factor in new EC2 is generally higher than in old EC2
- Do not mix provisions of new and old EC2 in design projects

Triaxial compressive strength of concrete

8.1.4 Confined concrete

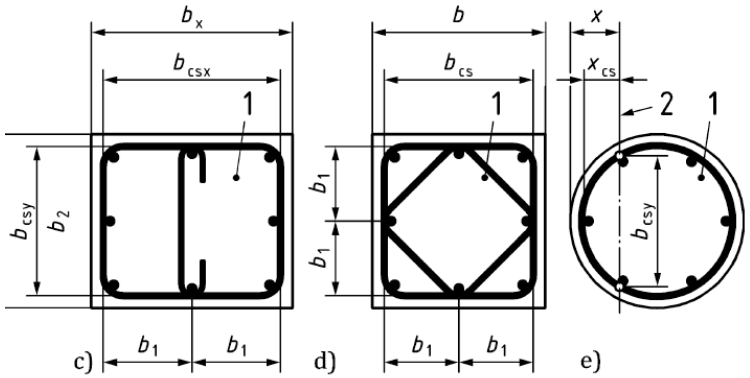
(1) The concrete compressive design strength f_{cd} may be enhanced by the favourable effect of confinement reinforcement or of triaxial compressive stresses.

(2) The compressive strength increase of a concrete with $d_{dg} \geq 32$ mm due to a transverse compressive stress σ_{c2d} may be calculated according to:

$$\Delta f_{cd} = 4 \cdot \sigma_{c2d} \qquad \text{for } \sigma_{c2d} \leq 0{,}6 f_{cd} \qquad (8.9)$$

$$\Delta f_{cd} = 3{,}5 \cdot \sigma_{c2d}^{3/4} \cdot f_{cd}^{1/4} \qquad \text{for } \sigma_{c2d} > 0{,}6 f_{cd} \qquad (8.10)$$

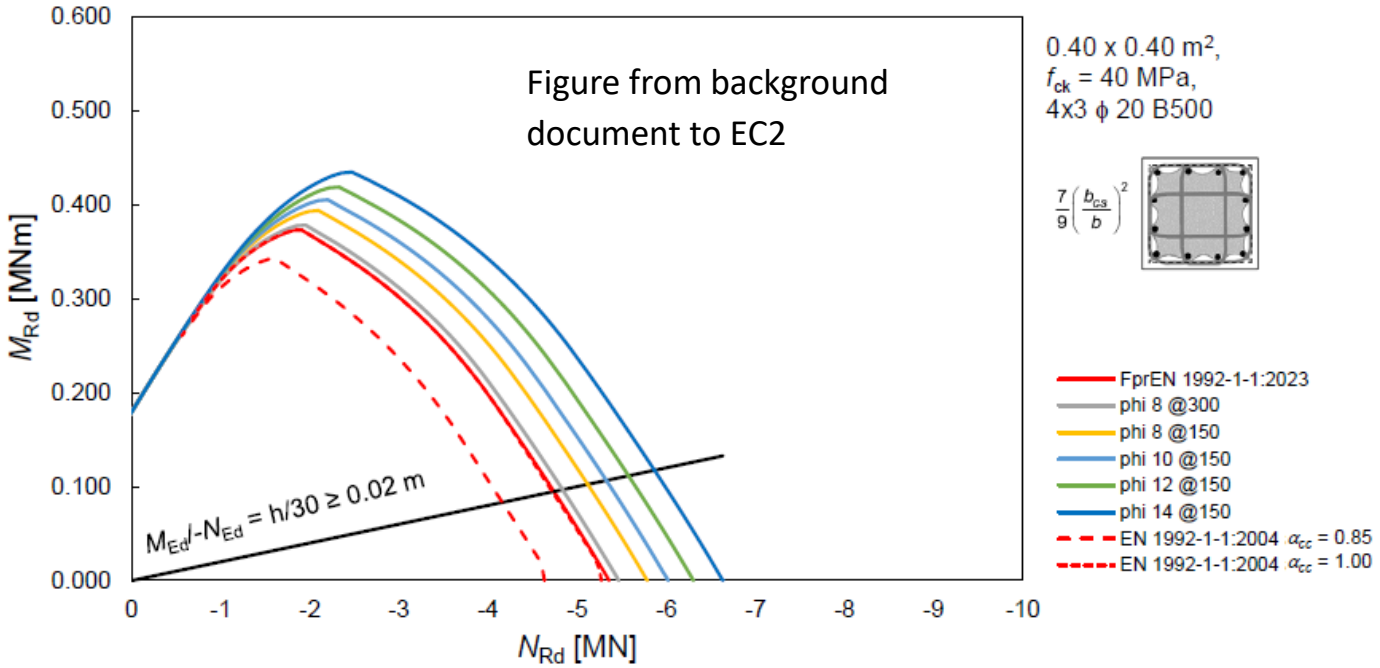
In case of concrete with $d_{dg} < 32$ mm, the strength increase Δf_{cd} according to Formulae (8.9) and (8.10) shall be reduced by factor $d_{dg}/32$ mm.



c) Rectangular section

d) Square section with multiple confinement reinforcement

e) Section with axial force and flexure



Members without shear reinforcement

New formula for the shear and punching shear capacity.

Based on the Critical Shear Crack Theory

The max size of aggregate is included in the calculations.

Safety factor γ_V

The chapter contains a lot of specific rules, e.g. in relation to lay-out of reinforcement, position of external loads, eccentricity or normal force, etc.

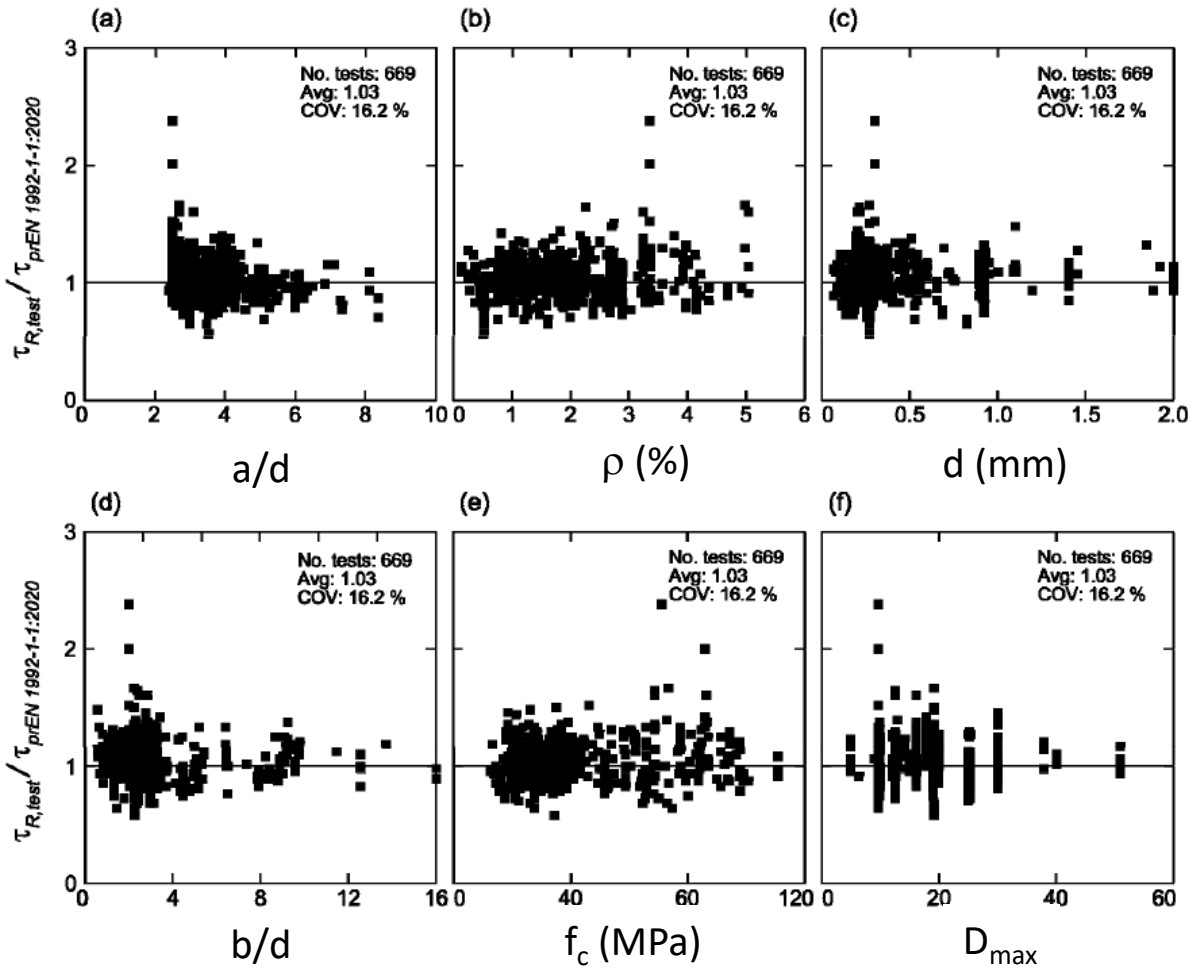


Figure C8.6: *Ratio $\tau_{R,test}/\tau_{R,FprEN2023}$ as a function of the main mechanical and geometrical parameters for the case of simply supported beams subjected to point load: (a) shear span-to-effective depth ratio a/d; (b) longitudinal reinforcement ratio ρ; (c) effective depth d; (d) width-to-effective depth ratio b/d; (e) cylinder compressive strength of concrete f_c; (f) aggregate size D_{lmax}*

Members with shear reinforcement

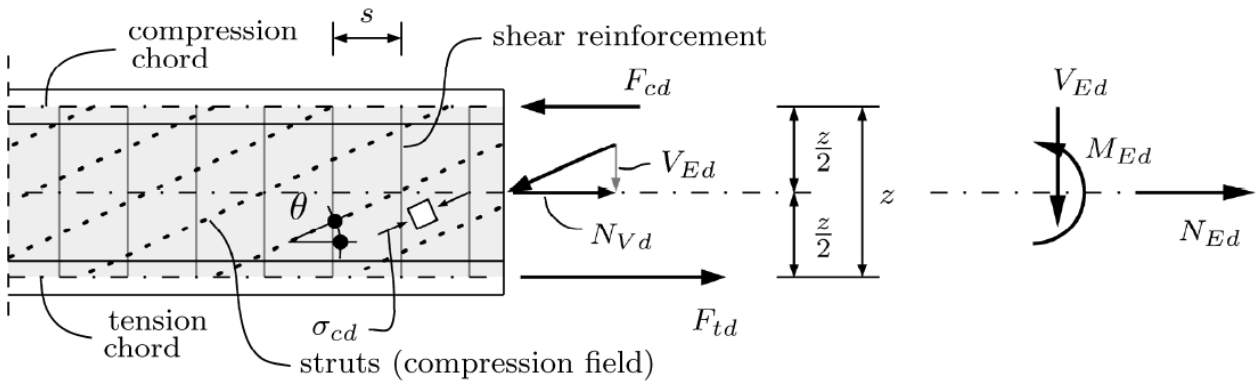


Figure 8.9: Model and notation for shear reinforced members

Simplified approach → (Cotθ ≤ 2,5)

(6) A value $\nu = 0{,}5$ may be adopted when using the angles of the compression field given in (4).

(7) Angles of the compression field inclination to the member axis lower than θ_{min} given in (4) or values of factor ν higher than according to (6) may be adopted provided that the ductility class of the reinforcement is B or C and that the value of factor ν is calculated on the basis of the state of strains of the member according to:

Semi-general approach →

$$\nu = \frac{1}{1{,}0 + 110 \cdot (\varepsilon_x + (\varepsilon_x + 0{,}001) \cdot \cot^2\theta)} \leq 1{,}0 \qquad (8.45)$$

A more refined calculation of the reduction factor of concrete may be performed using:

General approach (enables use of numerical methods) →

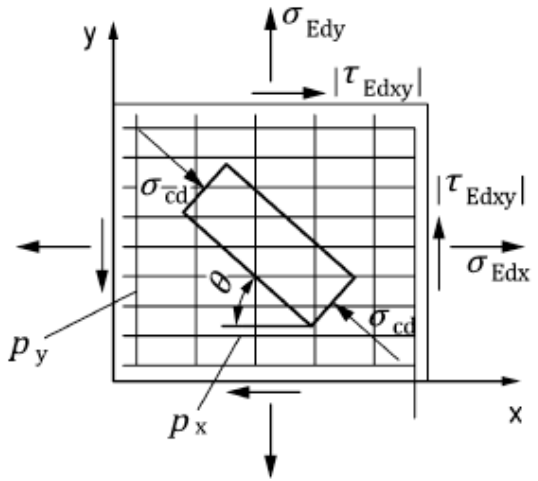
$$\nu = \frac{1}{1{,}0 + 110 \cdot \varepsilon_1} \leq 1{,}0 \qquad (G.9)$$

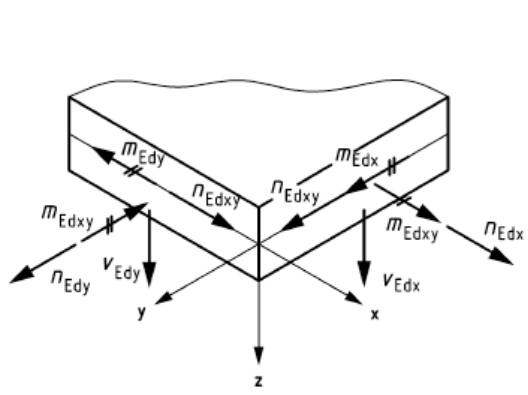
Annex G – Framework for design of plane stress problems – ULS & SLS

- ULS design of panels, slabs & shells
- SLS crack width formula for panels

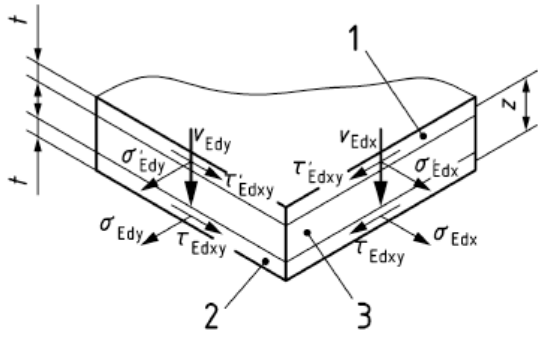
Table G.1 — Optimum reinforcement, concrete stress and strut inclination for membrane elements

Conditions	$\cot\theta^*$	f_{tdx}^*	f_{tdy}^*	σ_{cd}^*
$\sigma_{Edx} \geq -\lvert\tau_{Edxy}\rvert$ $\sigma_{Edy} \geq -\lvert\tau_{Edxy}\rvert$	1	$\sigma_{Edx} + \lvert\tau_{Edxy}\rvert$	$\sigma_{Edy} + \lvert\tau_{Edxy}\rvert$	$2\lvert\tau_{Edxy}\rvert$
$\sigma_{Edx} \leq \sigma_{Edy}$ $\sigma_{Edx} < -\lvert\tau_{Edxy}\rvert$ $\sigma_{Edx}\sigma_{Edy} \leq \tau_{Edxy}^2$	$\frac{-\sigma_{Edx}}{\lvert\tau_{Edxy}\rvert}$	0	$\sigma_{Edy} + \frac{\tau_{Edxy}^2}{\lvert\sigma_{Edx}\rvert}$	$\lvert\sigma_{Edx}\rvert\left(1+\left(\frac{\tau_{Edxy}}{\sigma_{Edx}}\right)^2\right)$
$\sigma_{Edx} \geq \sigma_{Edy}$ $\sigma_{Edy} < -\lvert\tau_{Edxy}\rvert$ $\sigma_{Edx}\sigma_{Edy} \leq \tau_{Edxy}^2$	$\frac{\lvert\tau_{Edxy}\rvert}{-\sigma_{Edy}}$	$\sigma_{Edx} + \frac{\tau_{Edxy}^2}{\lvert\sigma_{Edy}\rvert}$	0	$\lvert\sigma_{Edy}\rvert\left(1+\left(\frac{\tau_{Edxy}}{\sigma_{Edy}}\right)^2\right)$





a) shell element



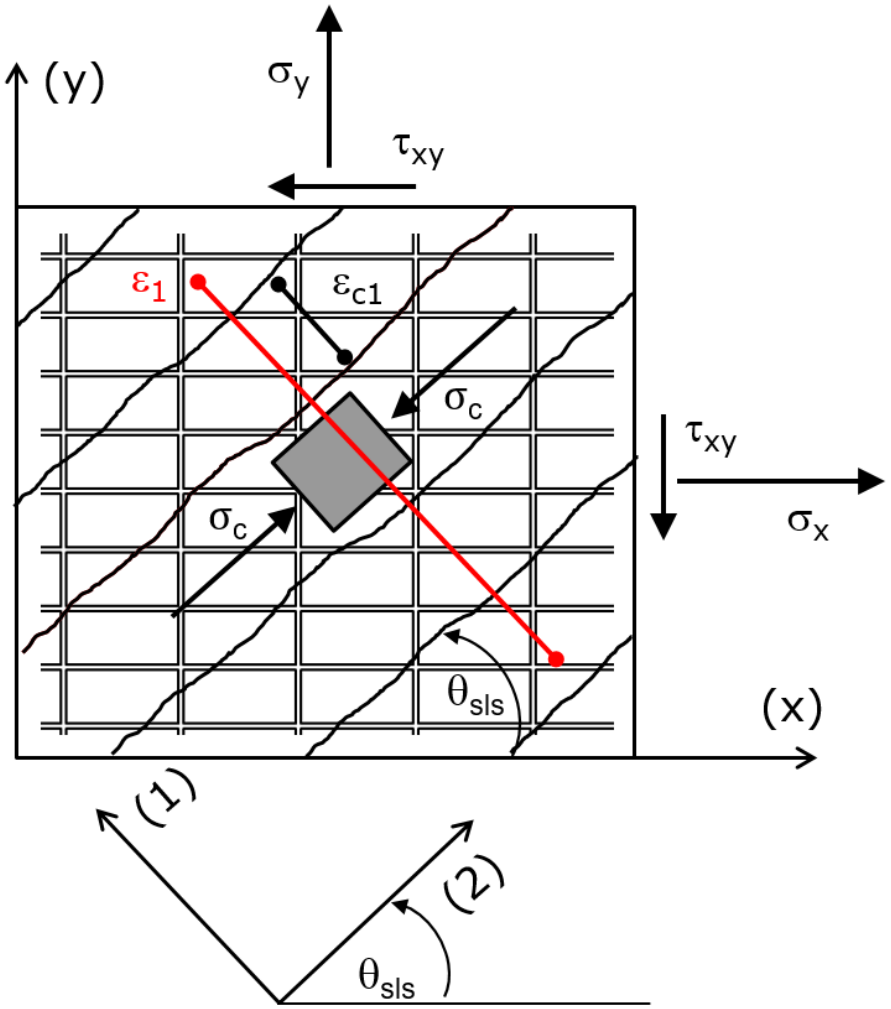
b) sandwich model

Annex G – Framework for design of plane stress problems – ULS & SLS

$$\frac{|\tau_{Edxy}|}{\rho_x}\cot^4\theta + \frac{\sigma_{Edx}}{\rho_x}\cot^3\theta - \frac{\sigma_{Edy}}{\rho_y}\cot\theta - \frac{|\tau_{Edxy}|}{\rho_y} = 0$$

$$s_{r,m,cal} = \frac{1}{\frac{\sin\theta}{s_{r,m,cal,x}} + \frac{\cos\theta}{s_{r,m,cal,y}}}$$

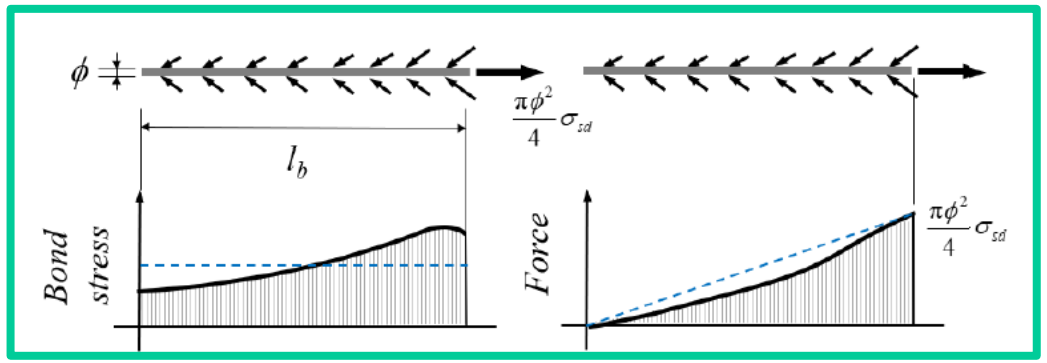
$$\varepsilon_{sm} - \varepsilon_{cm} = (\varepsilon_{smx} - \varepsilon_{cmx}) + (\varepsilon_{smy} - \varepsilon_{cmy}) + |\varepsilon_2|$$



Anchorage of straight bars

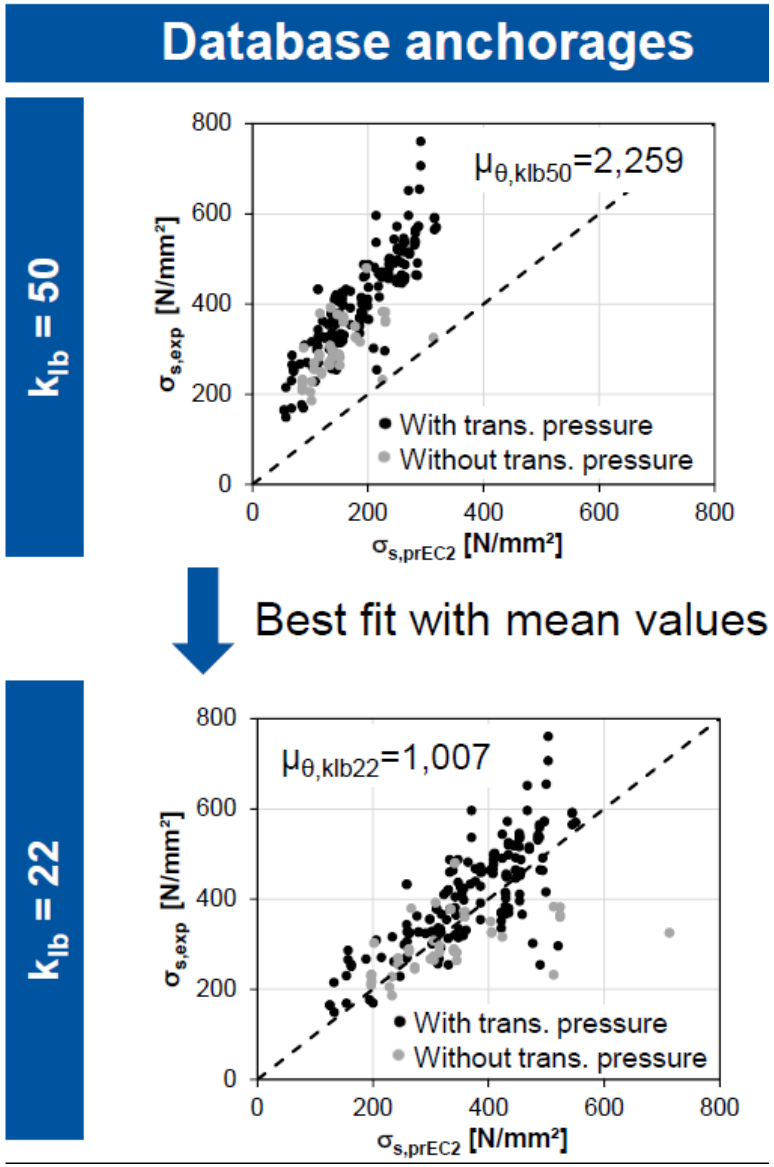
The *design* anchorage length is determined by:

$$l_{bd} = k_{lb} \cdot k_{cp} \cdot \phi \cdot \left(\frac{\sigma_{sd}}{435}\right)^{n_\sigma} \cdot \left(\frac{25}{f_{ck}}\right)^{\frac{1}{2}} \cdot \left(\frac{\phi}{20}\right)^{\frac{1}{3}} \cdot \left(\frac{1{,}5\phi}{c_d}\right)^{\frac{1}{2}}$$



In EC2 k_{lb} = 50

In DK NA k_{lb} is taken as $k_{lb} = 25\gamma_c$, where γ_c is the value connected the tensile strength of concrete. This means that the design anchorage length in DK NA is reduced with approximately 25 %.



Minimum reinforcement (ULS)

Reasons for minimum reinforcement are explained:

(1) In members designed as parts of reinforced concrete structures, minimum reinforcement $A_{s,min}$ shall be provided to:

a) ensure distributed cracking and to handle forces from restrained deformations where not considered explicitly in the design ((2) and (4));

b) ensure sufficient deformation capacity to contribute to structural robustness by allowing alternative load paths ((2) and (4));

c) avoid failures due to unpredicted cracking (3);

d) ensure applicability of design models in Clauses 8 and 9 and Annex G;

e) ensure constructability.

Minimum reinforcement (ULS)

Example of deem to work provision, new EC2:

(2) The area of minimum reinforcement $A_{s,min}$ shall provide nominal section strength which is at least equal to the effect causing cracking:

a) In members subjected to bending without or with axial force and any form of cross section, minimum reinforcement shall be provided so that:

$$M_{R,min}(N_{Ed}) \geq M_{cr}(N_{Ed}) \qquad (12.1)$$

Example of performance based provision, new EC2:

(3) Where $M_{Ed} < M_{cr}(N_{Ed})$, the member is designed as statically determinate and where no distribution of cracking is required, a sudden collapse after cracking may also be avoided with a minimum reinforcement designed for following resistance:

$$M_{Rd,min}(N_{Ed}) = k_{dc} \cdot M_{Ed} \qquad (12.3)$$

where $M_{Rd,min}$ is the design bending strength of the section in the presence of the simultaneous axial force N_{Ed}, M_{Ed} is the ULS bending force and k_{dc} is a coefficient which depends on the ductility class of the reinforcement:

— $k_{dc} = 1{,}3$ for ductility class A,

— $k_{dc} = 1{,}1$ for ductility class B,

— $k_{dc} = 1{,}0$ for ductility class C.

The area of reinforcement calculated need not be taken as greater than determined from Formula (12.1).

NOTE 3 Use of Formula (12.3) can result in wide cracks in SLS.

Minimum reinforcement (ULS)

Example of deem to work provision, new EC2:

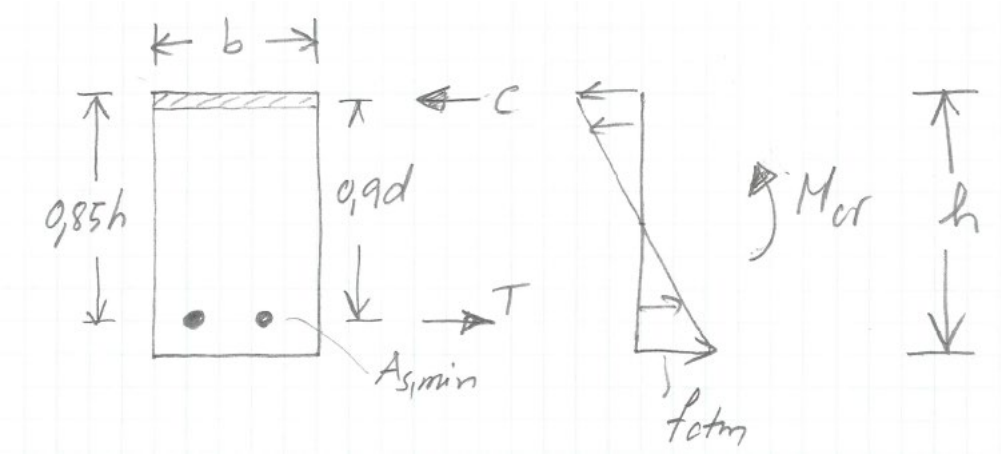
(2) The area of minimum reinforcement $A_{s,min}$ shall provide nominal section strength which is at least equal to the effect causing cracking:

a) In members subjected to bending without or with axial force and any form of cross section, minimum reinforcement shall be provided so that:

$$M_{R,min}\,(N_{Ed}) \geq M_{cr}(N_{Ed}) \qquad (12.1)$$

Example of deem to work provision, old EC2:

$$A_{s,min.} = 0{,}26\,\frac{f_{ctm}}{f_{yk}}\,b_t d \quad \text{dog ikke mindre end } 0{,}0013 b_t d \qquad (9.1N)$$



Minimum reinforcement (ULS)

The basic formula for minimum reinforcement is:

EC2:

$$N_{R,min} = A_{s,min} \cdot f_{yk} \geq A_c \cdot f_{ctm}$$

DK NA:

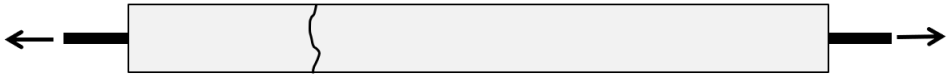
$$N_{R,min} = A_{s,min} \cdot f_{yk} \geq A_c \cdot k \cdot f_{ctm}$$

k < 1,0 is determined so that the structural member can establish a stabilized crack system, i.e. what is the minimum required reinforcement.

Tests have been performed in a M.Sc. project at DTU, spring 2026, to determinate the value of *k*.



Stabilized crack system, meaning that the member can form new cracks after the first crack is formed.



One and only one crack is formed, and the reinforcement will yield and rupture at this single crack.

Minimum reinforcement (ULS)

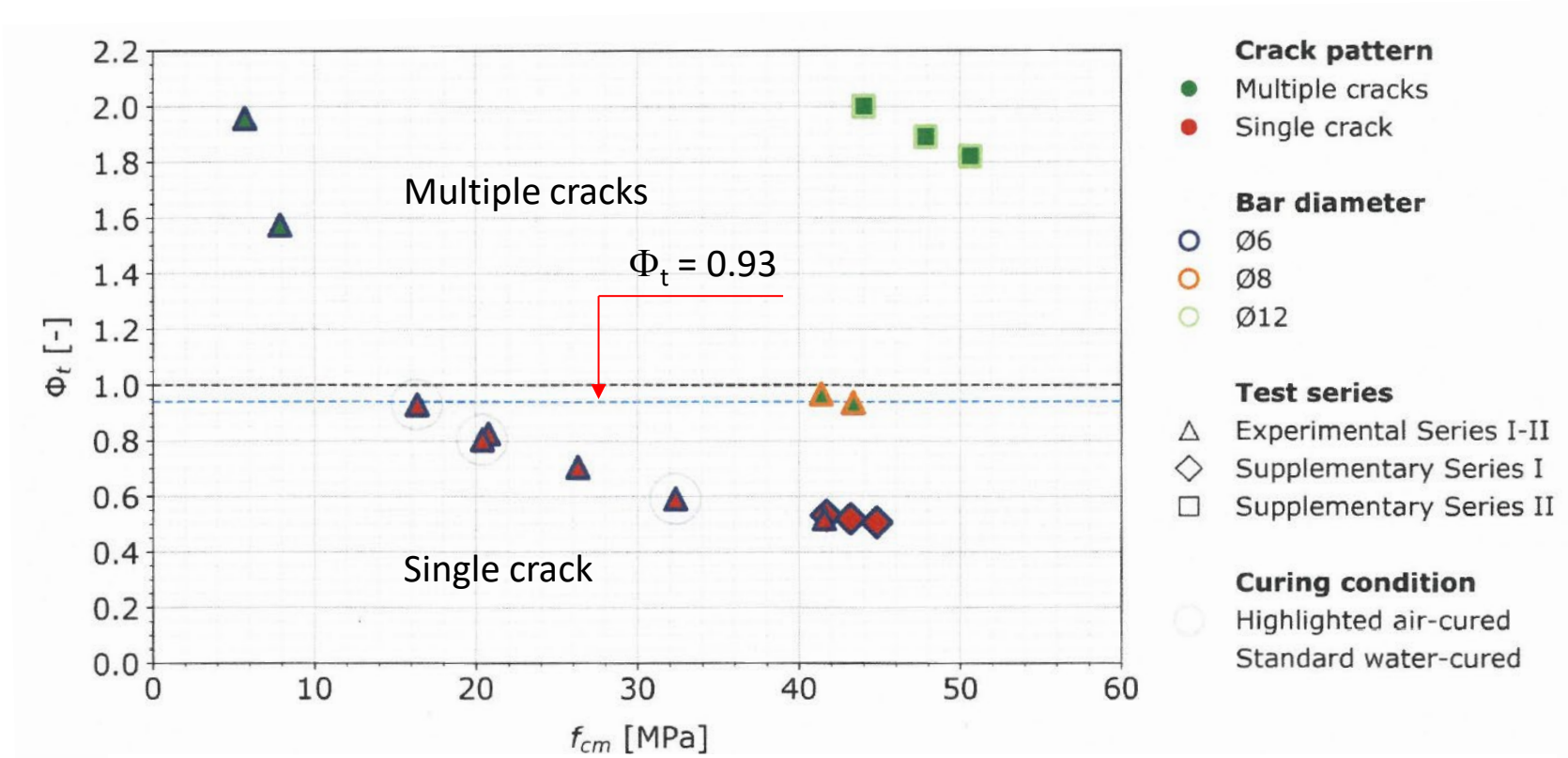
$$\Phi_t = \frac{A_s f_{ym}}{A_c f_{ctm}}$$

$$0,93 = \frac{A_s \cdot f_{ym}}{A_c f_{ctm}}$$

$$= \frac{A_s \cdot 1,08 f_{yk}}{A_c f_{ctm}} \Rightarrow$$

$$A_s f_{yk} = \frac{0,93}{1,08} A_c f_{ctm} \Rightarrow$$

$$A_{s,\min} f_{yk} = 0,86 A_c f_{ctm}$$

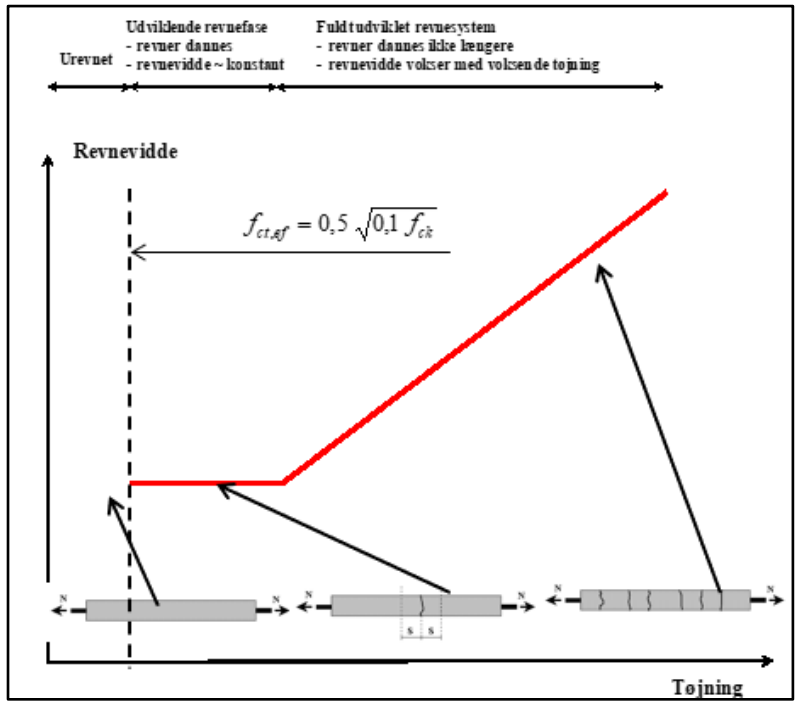


Boysen & Zimmermann: *Reduction of minimum reinforcement requirements in codes for concrete structures*, MSc, DTU Construct, 2026.

Minimum reinforcement areas for crack width control (SLS)

Annex S include rules for minimum reinforcement for controlling crack widths.

Rules included in the current DK NA is included.



(1) Regardless of analysis, fulfilment of a specific crack width may require a minimum amount of reinforcement that exceeds the minimum reinforcement determined according to clauses 9.2.2 and 12.2. This amount of reinforcement is denoted minimum reinforcement for crack width control. The minimum reinforcement according to clauses 9.2.2 and 12.2 only ensures a controlled crack formation.

As a simplification, the crack width can be considered constant for the phase where cracks are formed. For the phase where all cracks have formed, i.e. the stabilized phase, the crack width is determined by the formulas in Clause 9.2.3.

(2) Minimum reinforcement to ensure that the crack width requirement $w_{lim,cal}$ is met is for a tension zone determined by:

$$\rho_{min,Wlim} = \sqrt{\frac{\phi f_{ct,eff}}{4E_{sk}k_{fc}w_{\lim,cal}}} \qquad \text{(S.a NA)}$$

where

$f_{ct,eff}$ formally is taken as $0{,}5\sqrt{0{,}1f_{ck}}$. For the fine crack system $k_{fc} = 1$ is assumed and for the coarse crack system, $k_{fc} = 2$ is assumed, cf. figure 9.100 NA.

(3) For the fine crack system, the effective concrete area $A_{c,eff}$ is the sum of the largest concrete area with a centre of gravity that coincides with the centroid of the reinforcement, however, with a thickness not greater than ½h.

It should be noted that if the specified minimum reinforcement is not provided and a crack forms, the crack width will be larger than the prescribed requirement $w_{lim,cal}$.

The reinforcement given by (S.a NA) may be applied in cases where a structure or parts thereof to some extent is restrained against deformations due to shrinkage and/or temperature variations, and where joints are not provided to prevent cracking, or where any subsequent repair of single cracks of considerable widths is unacceptable.