danish housing and planning authority

DS/EN 1990 DK NA:2021

National Annex to
Eurocode 0: Basis of structural design

Foreword

This National Annex is a revision of DS/EN 1990 DK NA:2019 and supersedes the 2019 version as from 1 January 2021.

The reason for the changes in this version of DK NA is that, according to DS/EN 1990 DK NA, all foundations have until now been assigned to CC2, regardless of whether the construction work on the foundation was assigned to CC1.

In Table A1.2(A) DK NA NOTE 2 the following changes have been made:

The text *Consequences class CC1 is not applied for geotechnical structures* has been deleted.

In Table A1.2(B+C) DK NA NOTE 4 the following changes have been made:

The text *Consequences class CC1 is not applied for geotechnical structures* has been deleted.

The bottom bullet has been changed to:
Consequences class CC1: KFI= 0,9 *however for geotechnical structures KFI*= 1,0.

This NA lays down the conditions for the implementation in Denmark of EN 1990 for construction works in conformity with the Danish Building Regulations.

This NA applies to construction works covered by section 16(1) of the Danish Building Regulations as well as to construction works covered by sections 24 to 27 of the Danish Building Regulations. However, the following do not apply to construction works covered by sections 24 to 27 of the Danish Building Regulations:

- Annex B5 DK NA, inspection during execution
- Annex F DK NA, Partial factors for resistance (8).

An NA contains national provisions, viz. nationally applicable values or selected methods. The NA may furthermore give non-contradictory complementary information.

This NA includes:

- an overview of possible national choices and clauses containing non-contradictory, complementary information;

- national choices;
- non-contradictory, complementary information.

Overview of possible national choices and complementary information

The list below identifies the clauses where national choices are possible and the applicable/not applicable informative annexes. Furthermore, clauses giving complementary information are identified. Complementary information is given at the end of this National Annex.

Clause	Subject	National choice [1)]	Complementary information2[)]
A1.1(1)	Field of application (design working life)	Unchanged	
A1.2.1(1)	Combinations of actions - General Modifications of combinations of actions for geographical reasons	Unchanged	
A1.2.2 / Table A1.1	Values of ψ factors	National choice	
A1.3.1(1)/ Table A1.2(A)-(C)	Design values of actions in persistent and transient design situations	National choice	
A1.3.1(5)	Design values of actions in persistent and transient design situations: Choice of design approach for geotechnical actions	National choice	
A1.3.2 (Table A1.3)	Design values of actions in accidental and seismic design situations	National choice	
A1.4.2(2)	Serviceability criteria	National choice	
A1.4.3	Deformations and horizontal displacements		Complementary information
A1.4.4	Vibrations	Choice in A1.4.2(2)	Complementary information
Annex B	Management of structural reliability for construction works	Applicable	
Annex C	Basis for partial factor design and reliability analysis		Complementary information
Annex D	Design assisted by testing		Complementary information
Annex E	Robustness	Applicable	
Annex F	Partial factors for resistance	Applicable	

1)

Unchanged: Recommendations in the Eurocode to be followed.
National choice: A national choice has been made.
Applicable: The Annex is applicable and has status as normative.

2)

Complementary information Non-contradictory, complementary information to assist in the use of the Eurocode.
Complementary rules: National complementary requirements

National choices

A1.2.2 / Table A1.1 DK NA Recommended values of ψ factors for buildings

Values given in Table A.1.1 DK NA.

Table A1.1 DK NA ψ factors for buildings

Action	ψ_0	ψ_1	ψ_2
Imposed loads in buildings, see EN 1991-1-1			
Category A: domestic, residential areas	0,5	0,3	0,2
Category B: office areas	0,6	0,4	0,2
Category C: congregation areas	0,6	0,6	0,5
Category D: shopping areas	0,6	0,6	0,5
Category E: storage areas	0,8	0,8	0,7
Category F: traffic area, vehicle weight $\leq$ 30 kN	0,6	0,6	0,5
Category G: traffic area, 30 kN < vehicle weight $\leq$ 160 kN	0,6	0,4	0,2
Category H: roofs	0	0	0
Snow loads			
For combinations with leading imposed loads of category E or leading thermal actions	0,6	0,2	0
For combinations with leading wind actions	0	0	0
for all other conditions	0,3	0,2	0
Wind actions			
For combinations with leading imposed loads of category E	0,6	0,2	0
for all other conditions	0,3	0,2	0
Thermal actions	0,6	0,5	0

A1.3.1(1)/Table A1.2(A)-(C) DK NA Design values of actions in persistent and transient design situations

Combinations of actions and partial factors for EQU, UPL, STR and GEO are listed in Tables A1.2(A) DK NA and A1.2(B+C) DK NA.

Table A1.2(A) DK NA Design values of actions for persistent and transient design situations (EQU and UPL) (Set A)

Limit state				**EQU / UPL**	**UPL**
Combination of actions				**1**	**2**
Reference equation				**(6.10)**	**(6.10)**
Permanent action	Weight, general (**)	Unfavour-able	$\gamma_{Gj,sup}$	$1{,}1 \cdot K_{FI}$	$1{,}0 \cdot K_{FI}$
		Favourable	$\gamma_{Gj,inf}$	0,9	1,0
	Weight of soil and (ground) water, geotechnical struc-tures (***)	Unfavour-able	$\gamma_{Gj,sup}$	$1{,}1 \cdot K_{FI}$	$1{,}05 \cdot K_{FI}$
		Favourable	$\gamma_{Gj,inf}$	0,9	1,0
Variable action (*)	Leading	Unfavour-able	$\gamma_{Q,1}$	$1{,}5 \cdot K_{FI}$	$1{,}5 \cdot K_{FI}$
	Accompanying	Unfavour-able	$\gamma_{Q,i}$	$1{,}5 \cdot \psi_0 \cdot K_{FI}$	$1{,}5 \cdot \psi_0 \cdot K_{FI}$

(*) Variable actions are those considered in Table A.1.1 DK NA.
(**) Comprises all types of permanent self-weight, see clause 2.1 in EN 1991-1-1.
(***) Comprises the weight of soil and (ground) water affecting the geotechnical structure as geotechnical action, see 1.5.2.1 in EN 1997-1.

NOTE 1 – Combination of actions 2 is applied only for geotechnical structures where the water pressure is maximised by means of overflow arrangements, see DS/EN1997-1 DK NA.

NOTE 2 – K_{FI} depends on the consequences class defined in Annex B, Table B3, as follows:

- consequences class CC3: $K_{FI} = 1{,}1$
- consequences class CC2: $K_{FI} = 1{,}0$
- consequences class CC1: $K_{FI} = 1{,}0$.

NOTE 3 – Anchors or similar devices added in order to achieve static equilibrium are to be designed for the design force necessary to ensure static equilibrium.

Table A1.2(B+C) DK NA Design values of actions for persistent and transient design situations (STR/GEO) (sets B and C)

Limit state				**STR/GEO**				**STR**
Combination of actions				**1**	**2**	**3**	**4**	**5**
Reference equations				**(6.10a)**	**(6.10b)**	**(6.10a)**	**(6.10b)**	**(6.10a)**
Partial factors for actions								
Permanent action	Weight, general (**)	Unfavourable	$\gamma_{G;sup} \cdot K_{FI}$	$1{,}2 \cdot K_{FI}$	$1{,}0 \cdot K_{FI}$	1,2	1,0	1,0
		Favourable	$\gamma_{G;inf}$	1,0	0,9	1,0	0,9	1,0
	Weight of soil and (ground) water, geotechnical structures (***)	Unfavourable	$\gamma_{G;sup}$	1,0	1,0	1,0	1,0	1,0
		Favourable	$\gamma_{G;inf}$	1,0	1,0	1,0	1,0	1,0
Variable action(*)	Leading	Unfavourable	$\gamma_{Q,1} \cdot K_{FI}$	0	$1{,}5 \cdot K_{FI}$	0	1,5	0
	Accompanying	Unfavourable	$\gamma_{Q,i} \cdot K_{FI}$	0	$1{,}5 \cdot \psi_0 \cdot K_{FI}$	0	$1{,}5 \cdot \psi_0$	0
Coefficient applied to partial factors for strength parameters and resistance								
Structural materials, cf. EN 1992, EN 1996 and EN 1999			γ_0	1,0	1,0	K_{FI}	K_{FI}	1,2 K_{FI}
Soil parameters and resistance, cf. EN 1997-1				1,0	1,0	K_{FI}	K_{FI}	1,0 ($\gamma_M = \gamma_R = 1{,}0$)

(*) Variable actions are those considered in Table A.1.1 DK NA.
(**) Comprises all types of permanent self-weight, see clause 2.1 in EN 1991-1-1.
(***) Comprises the weight of soil and (ground) water affecting the geotechnical structure as geotechnical action, see 1.5.2.1 in EN 1997-1.

NOTE 1 – Equations 6.10a and 6.10b are applied for STR as well as GEO. Equation 6.10a relates only to permanent actions.

NOTE 2 – For structures not subject to geotechnical actions, verification can be achieved solely by applying combinations of actions 1 and 2.

For structures partially subject to geotechnical actions, verification is to be achieved by applying combinations of actions 1 and 2, combinations of actions 3 and 4 and combination of actions 5.

For structures solely subject to geotechnical actions, verification may be achieved by applying combinations of actions 3 and 4 and combination of actions 5.

For K_{FI} = 1,0, combinations of actions 1 and 2 are identical to combinations of actions 3 and 4. For $K_{FI} \neq 1{,}0$, the factor K_{FI} may be applied to the effects of actions (internal forces and moments) instead of to the action, provided that the effects of actions are linearly proportional to the associated action.

Geotechnical actions are actions transmitted to the structure by the ground, fill, standing water or ground water. In addition to the weight, the actions from the ground and fill are determined by the strength and deformation properties of the ground and fill, e.g. expressed as the angle of shearing resistance. Examples of geotechnical actions include soil and water pressures on a wall structure.

NOTE 3 – Coefficient γ_0 for the partial factor for strength parameters and resistances is obtained as follows.

For combinations of actions 3 and 4 used for geotechnical structures, cf. EN 1997-1, the K_{FI} factor is applied to all relevant partial factors for the strength parameters and resistance of the ground, and for the material strengths and resistances, respectively.

For combination of actions 5 which is used for verification of STR for structural materials forming part of geotechnical structures, the usual partial factors are applied for structural materials multiplied by 1,2 K_{FI}. For strength parameters and resistances of the ground, a partial factor of $\gamma_M = \gamma_R$ =1,0, cf. EN 1997-1, is applied.

NOTE 4 – K_{FI} depends on the consequences class defined in Annex B, Table B3, as follows:

- consequences class CC3: K_{FI} = 1,1
- consequences class CC2: K_{FI} = 1,0
- consequences class CC1: K_{FI} = 0,9 however for geotechnical structures K_{FI} = 1,0.

See also EN 1991 to EN 1999 for γ values for imposed deformations.

NOTE 5 – The characteristic values of all permanent actions from one source are multiplied by $\gamma_{Gj,sup}$, if the total resulting load effect is unfavourable, and by $\gamma_{Gj,inf}$, if the total resulting load effect is favourable. As an example, all actions originating from the self-weight of the structure may be considered as coming from one source; this also applies where different materials are involved.

Design values for fatigue actions

(1) Design values for fatigue actions should be determined by applying a partial factor equal to 1,3 for loads where the uncertainty of the individual stress spans is described by a coefficient of variation of the magnitude 30 %. For loads where the coefficient of variation is less than 10 %, a partial factor equal to 1,0 is applied. For other values of the coefficient of variation, the partial factor should be determined by linear interpolation. The coefficient of variation may be stated in connection with the action specification.

A1.3.1(5) Design values of actions in persistent and transient design situations - Choice of design approach for geotechnical actions

Design approach 3 is applied, see DS/EN 1997-1 DK NA.

A1.3.2 Design values of actions in accidental and seismic design situations

Combinations of actions are listed in Table A1.3 DK NA.

Table A1.3 DK NA Design values of actions for use in accidental and seismic combinations of actions

Design situation	Permanent actions		Leading accidental or seismic action	Accompanying variable actions[1)]	
	Unfavourable	Favourable		Main (if any)	Other
Fire (Equation 6.11*a*/*b*)	$G_{kj,sup}$	$G_{kj,inf}$	A_d	$\psi_{1,1}\, Q_{k,1}$	$\psi_{2,i}\, Q_{k,i}$
Other accidental (Equation 6.11*a*/*b*)	$G_{kj,sup}$	$G_{kj,inf}$	A_d	$\psi_{2,1}\, Q_{k,1}$	$\psi_{2,i}\, Q_{k,i}$
Seismic[2)] (Equation 6.12*a*/*b*)	$G_{kj,sup}$	$G_{kj,inf}$	A_d	$\psi_{2,i}\, Q_{k,i}$	

[1)] Variable actions are those considered in Table A.1.1 DK NA.
[2)] Seismic actions are determined according to EN 1998-1 including the associated National Annex

Seismic actions include actions taken into account to ensure the structure's strength and stability against ground motions. Seismic actions are the smallest horizontal actions assumed to affect a structure.

NOTE 1 – Seismic actions are used to evaluate the structure for the seismic design situation. Seismic actions do not include imperfections of the structure as imperfections are considered according to rules specified in EN 1992 to EN 1999, including associated National Annexes

Structures are not to be designed for seismic and wind actions acting simultaneously.

A1.4.2(2) Serviceability criteria
Empirical values for vertical vibrations are given in clause A1.4.4 of this NA.

A1.4.3 Deformations and horizontal displacements
For serviceability limit states that relate to the functionality and appearance of the structure, reference is made to the EN 1992 to EN 1999 series.

Non-contradictory, complementary information.

Annex A, Application for buildings

A1.4.4 Vibrations – Vertical

Requirements regarding natural frequencies may be based on the empirical values in Table A1.4 DK NA. If a more detailed analysis is carried out, the functionality of the structure will normally be satisfactory if the variation of the structure's accelerations originating from the stated action does not exceed the acceleration limit in the table.

The risk of unsatisfactory functionality increases with increasing span and the risk is particularly great for lightweight or poorly damped structures. For these structures, the natural frequency requirement in the table does not always result in satisfactory functionality.

Table A1.4 DK NA Empirical values for acceptable natural frequencies and acceleration limits

Structure	Action	Normally satisfactory functionality	Often unsatisfactory functionality	Acceleration limit in % of the gravity acceleration
Grandstands, fitness centres, sports halls and public premises	Rhythmic load caused by movement of people	$n_e > 10$ Hz	$n_e < 6$ Hz	10 %
Residential buildings	Load from walking	$n_e > 8$ Hz	$n_e < 5$ Hz	0,1 %
Office premises	Load from walking	$n_e > 8$ Hz	$n_e < 5$ Hz	0,2 %
NOTE – Natural frequencies and accelerations are calculated during normal use, where the fluctuating action is typically considerably less than the action corresponding to the quasi-permanent combination specified in clause 6.5.3 of EN 1990. The acceleration requirement for office premises is based on the disturbing vibrations occurring several times per hour.				

Annex B, Management of structural reliability for construction works

Annex B may be used with the following modifications:

- Table B1 DK NA (Consequences classes)
- Table B2 DK NA (Minimum values for reliability index)
- B4 DK NA (Design supervision differentiation)
- B5 DK NA (Inspection during execution)
- B6 is not applied.

Table B1 DK NA Definition of consequences classes

Consequences class	Consequences of failure	Examples
CC3 High consequences class	High consequence for loss of human life, *or* economic, social or environmental consequences very great	– Buildings with several storeys where the height to the floor of the uppermost storey is more than 12 m above the terrain, if they are often used for accommodating people, e.g. residential or office buildings; – Buildings with large spans, if they are often used by many people, e.g. for concerts, sporting events, theatrical performances, or exhibitions; – Grandstands; – Large road bridges and tunnels; – Large masts near urban areas or traffic areas; – Large silos near urban areas; – Dams and similar structures where a failure would result in considerable damage.
CC2 Medium consequences class	Medium consequence for loss of human life. Economic, social or environmental consequences considerable.	Buildings or structures not belonging to CC3 or CC1.
CC1 Low consequences class	Low consequence for loss of human life, *and* economic, social or environmental consequences small or negligible	– 1 and 2 storey buildings with moderate spans, which people enter only occasionally, e.g. storage buildings, sheds and small agricultural buildings; – Masts remote from urban areas and traffic areas; – Silos remote from urban areas; – Secondary structural members, e.g. partitions, window and door lintels and cladding.

(1) Consequences for adjacent structures and surroundings can be decisive when determining the consequences class.

(2) Structural members that are not part of the main structure can often be referred to a lower consequences class than the main structure.

NOTE – The main structure is the part of a load-bearing structure, where failure will have considerable consequences for the reliability and functionality of the entire structure. Examples of structural members that are often considered not to be part of the main structure include roofs, independent decks, stairways and balconies.

Table B2 DK NA Minimum values for reliability index β (ultimate limit states) for a 1 year reference period.

Reliability class	Minimum values of β
RC3 corresponding to CC3	4.7
RC2 corresponding to CC2	4.3

RC1 corresponding to CC1	3.8

NOTE 2 – When determining the reliability index for RC2 it is assumed that permanent actions have a normal distribution, and variable actions have a Gumbel distribution. All strength parameters and model uncertainties should be assumed to have a log-normal distribution. Information on the choice of coefficients of variation is given in DS/INF 172 *Baggrundsundersøgelser i forbindelse med udarbejdelse af Nationale Annekser til EN 1990 og EN 1991 - Sikkerhedsformat, lastkombinationer, partialkoefficienter, udmattelse, snelast, vindlast, mm. (English translation: Background investigations in relation to the drafting of National Annexes to EN 1990 and EN 1991 - Reliability verification formats, combination of actions, partial factors, fatigue, snow loads, wind loads, etc.*(Available in Danish only). The reliability index β is defined in Annex C.

B4 DK NA Design supervision differentiation

(1) Design supervision consists of checking of the project material related to the load-bearing structures, i.e. basis of design, static calculations, drawings/models and execution specifications. The basis of design comprises the specifications on which the design is based, including the structural system and mode of operation, robustness, fire, material properties, actions, etc.

NOTE – Design supervision is to contribute to ensuring:
- that the assumptions of the basis of design are correct and are used as a basis for the structural design;
- that the assumptions made in the static calculations have been correctly incorporated into any other project material;
- that drawings and execution specifications are adequate for the execution of the load-bearing structures.

(2) All design supervision, except self-checking, is to be documented in accordance with guidelines drawn up in advance. The method, scope, any points of focus and the results of the design supervision are to be stated in the documentation.

(3) For all project material, the people responsible for preparation and design supervision, respectively, are to be identified.

(4) For structures not comprised by consequences class CC3 of the Danish Building Regulations, where the consequences of failure are particularly severe, special requirements apply to the design supervision.

(5) Examples of structures covered by (4) include:
- Buildings with more than 15 storeys above the terrain, if they are used for accommodating people, e.g. residential, office or educational buildings;
- Hospitals with more than 5 storeys above the terrain;
- Industrial buildings where failure would have a particularly major societal impact;
- Buildings with large spans, provided they are used by many people, e.g. for concerts, theatrical performances, exhibitions, sporting events, or entertainment;
- Grandstands.

(6) The following types of design supervision are used: self-checking, independent checking and third party checking. The types of design supervision are defined in Table B4a DK NA.

Table B4a DK NA Definition of types of design supervision

Type of design supervision	Definition
Self-checking	Checking performed by the same person who has prepared the design
Independent checking	Checking performed by a person who has not been involved in the design of the load-bearing structures. Checking may be carried out by a person from the same organization.
Third party checking	Checking performed by a person who is neither directly nor indirectly linked financially or organizationally to the person(s) or organization(s) involved in the design of the load-bearing structures.

(7) Self-checking shall always be carried out.

(8) Independent checking and third party checking shall be based on checking plans.

(9) Independent checking and third party checking shall be documented.

NOTE – Third party checking does not replace independent checking.

(10) Minimum requirements for the type of design supervision depend on the structural class to which the structure is assigned. The minimum requirements are specified in Table B4b DK NA.

Table B4b DK NA Minimum requirements for types of supervision for project material

Structural Class [1)]	Independent checking	Third party checking
KK1		
KK2	X[2)]	
KK3	X	
KK4	X	X

[1)] For structures not covered by the Danish Building Regulations, “structural classes” are replaced by “consequences classes”, where CC1 replaces KK1, CC2 replaces KK2, CC3 replaces KK3 and "CC3 covered by B4 DK NA (4)" replaces KK4.

[2)] The requirement for independent checking in KK2 only applies to the basis of design. For any other project material, checking may be carried out by persons who have not been involved in the design of the relevant section of the construction work.

B5 DK NA Inspection during execution

NOTE – For the application of Annex B5 DK NA, see foreword of this NA.

B5.1 DK NA General

(1) Inspection during execution of structures shall contribute to ensuring conformity between the design and the physical structure, including the fact that materials and products and their incorporation fulfil the assumptions.

(2) Inspection during execution includes checking of:

- basis of execution from design, e.g. design drawings and descriptions of building parts;
- basis of execution for work, e.g. work drawings and instructions
- documentation of products and materials, e.g. labels and product sheets
- production and assembly, e.g. geometry, tolerances and correct application of products and materials
- products and materials, e.g. the result of production and at receipt at the place of manufacture or at the construction site
- documentation of as-built, e.g. inspection records and photo documentation of the execution.

(3) Documentation of as-built for load-bearing structures shall explain conformity between the as-built and the design, both with respect to requirements laid down in norms and standards and to project specific requirements for the execution.

(4) General inspection during execution is carried out as stated in B5.2 DK NA.

(5) Special inspection during execution is carried out as stated in B5.3 DK NA.

(6) A distinction is made between 3 types of inspection during execution, depending on who performs the checking: self-checking, independent checking and third party checking; see Table B5a DK NA.

Table B5a DK NA Types of inspection during execution

Type of inspection during execution	**Definition**
Self-checking	Checking performed by the same person who has made the load-bearing structures
Independent checking	Checking performed by a person who has not been involved in the execution of the load-bearing structures Checking may be carried out by a person from the same organization.
Third party checking	Checking performed by a person who is neither directly nor indirectly linked financially or organizationally to the person(s) or organization(s) involved in the execution of the load-bearing structures.

(7) Self-checking shall always be carried out.

(8) Independent checking and third party checking shall be based on checking plans. Checking plans shall specify what is to be inspected, how inspection is carried out, when inspection is to take place, the party carrying out inspection, and who follows up on the result of inspection. The checking plan shall divide inspections into inspection sections.

NOTE 1 - Independent checking and third party checking of basis of execution for work, as well as documentation of products and materials may take place prior to, during, or after execution.

NOTE 2 – Third party checking does not replace independent checking.

NOTE 3 – Inspection sections can be any well-defined part of the inspection. When there are changes in the project or project schedule, temporary construction stoppage, or organizational changes during the execution, inspection sections can be changed.

(9) All independent checks within an inspection section shall be carried out by the same person.

(10) Independent checking and third party checking shall be documented. The documentation shall state the result of checking for each inspection section, and identify the parties in charge of the execution, the inspection during execution, and the follow up action on the result of checking, respectively.

(11) Inspection during execution shall be performed according to the quality management requirements as stated in Table B5b DK NA.

Table B5b DK NA Quality management requirements

Structural Class [1)]	**Quality management requirements**
KK1	Quality management system of the contractor
KK2	The contractor's documented quality management system, project-specific procedures and checking plan
KK3	As KK2
KK4	As KK2
[1)] For structures not covered by the structural classes of the Danish Building Regulations, the term “structural classes” are replaced by “consequences classes”, where CC1 replaces KK1, CC2 replaces KK2, CC3 replaces KK3, and "CC3 covered by B4 DK NA (4)" replaces KK4.	

B5.2 DK NA General inspection during execution

(1) General inspection during execution shall be carried out for all structures.

(2) The execution of all structures shall be checked according to DS 1140. Moreover, the execution of all structures shall be checked according to the rules given in the EN 1992 to EN 1999 series, including any associated National Annexes, and in conformity with the rules given in the associated execution standards, including any associated national application documents.

(3) Independent checking and third party checking are carried out as stated in Table B5c DK NA according to the type of inspection and the structural class of the relevant structure, structural section or structural member considered.

Table B5c DK NA Minimum requirements for general inspection during execution

Structural Class [1)]	**Independent checking**	**Third party checking**
KK1		
KK2	X[2) 3)]	
KK3	X	
KK4	X	X[4)]
[1)] For structures not covered by the structural classes of the Danish Building Regulations, the term “structural classes” are “replaced by consequences classes”, where CC1 replaces KK1, CC2 replaces KK2, CC3 replaces KK3, and "CC3 covered by B4 KN NA (4)" replaces KK4.		

[2] The independent checking of the basis of execution for work shall be carried out by a person who is not involved in the construction work at all, while other independent checking may be carried out by a person who has not been involved in the execution of the structures in the relevant inspection section.

[3] The "independent checking" of the execution may be replaced by "independent checking of the documentation of self-checking of the execution" of structures in buildings and building extensions:
- with an area not exceeding 300 sqm;
- with a maximum height to the top of the structure of 12 m measured from the terrain;
- with a maximum building width of 12 m;
which are included in:
- multi-storey buildings not exceeding 2 storeys above the terrain and not more than 1 storey below the terrain,
- buildings and building extensions not exceeding 1 storey above the terrain and one storey below the terrain, with rooms accommodating maximum 30 persons, who are all able to bring themselves into safety, and
- structures at the terrain or not more than 2 m above the terrain for retaining walls, ramps etc.

[4] Includes checking of the documentation of independent checking only.

(4) For structural members according to attestation levels AVCP 1+, 1 and 2+ for parameters related to resistance, only independent checking of the assembly of the structural member in the construction work is required according to Table B5c DK NA.

NOTE – Comprises structural members covered by a harmonised standard under the Construction Products Regulation or structural members with a certified inspection corresponding to the attestation level referred to.

(5) Execution classes indicate the importance of the execution to the structural reliability:
- EXC1: Execution is of limited importance to the structural reliability
- EXC2: Execution is of importance to the structural reliability
- EXC3: Execution is of great importance to the structural reliability.

NOTE1 – Execution classes result in a set of requirements for the execution, including requirements for inspection and documentation, specified in DS 1140 and in the EN 1992 to the EN 1999 series, including associated National Annexes, and in accordance with the associated execution standards, including associated national application documents. Requirements may be specified for the execution and inspection of structures as well as individual structural members.

NOTE 2 – The importance of the execution shall be determined on the basis of the associated structural class. The importance of the execution may in certain cases deviate from the associated structural class, e.g. for individual structural members or for special load actions, cf. EN 1993-1-1, Annex C including the associated National Annex.

NOTE 3 – The use of additional execution classes may be considered in special cases, see e.g. EN 1993-1-1, Annex C and the associated National Annex regarding EXC4.

(6) Execution classes specify the scope of inspection according to DS 1140. The execution class shall be specified for structures or structural members and shall be selected in accordance with Table B5d DK NA.

Table B5d DK NA Choice of execution class

Structural Class [1]	Execution class		
	EXC1	EXC2	EXC3
KK1	+	(+)	
KK2	(+)	+	(+)
KK3		(+)	+
KK4		(+)	+

+: Recommended choices
(+): Possible choices. Additional restrictions may have been specified in the EN 1992 to EN 1999 series, including any associated National Annexes, or in the associated execution standards, including any associated national application documents.

[1] For structures not covered by the Danish Building Regulations, “structural classes” are replaced by “consequences classes”, where CC1 replaces KK1, CC2 replaces KK2, CC3 replaces KK3, and "CC3 covered by B4 KDK NA (4)" replaces KK4.

B5.3 DK NA Special inspection during execution

(1) Special inspection during execution is carried out for structures, structural sections or structural members that are particularly complicated to construct, or are particularly essential for the serviceability, reliability and durability of the construction work.

(2) Items and scope of the special inspection during execution are prescribed by the designer.

NOTE 1 – Special inspection during execution may e.g. be relevant for

- particularly important structural members where correct execution is decisive for the assumed static mode of operation
- unconventional structures where the contractor has less experience with the execution
- structural members, the execution of which is particularly complicated, including interfaces between materials or contracts
- repeated large scale execution, e.g. series production
- structural members, the inspection of which is not possible in the finished construction work.

NOTE 2 – Special inspection during execution can e.g. consist in

- assigning selected structural members, including joints, to a higher consequences class than the class normally applying to the structures in question, cf. DS/INF 1990
- special inspections or special measuring methods
- inspection carried out to a particular extent and degree of detail or according to specified acceptance criteria
- performance of the inspection at specific times.

NOTE 3 – Special inspection during execution may include inspection during execution of all structural members, irrespective of their marking or certification.

(3) Special inspection during execution is carried out as a supplement to the general inspection during execution, depending on the type of inspection, see Table B5e DK NA.

Table B5e DK NA – Minimum requirements for special inspection during execution

Structural Class [1]	Independent checking	Third party checking
KK1		

KK2	X	
KK3	X	
KK4	X	X
[1] For structures not covered by the Danish Building Regulations, “structural classes” are replaced by “consequences classes”, where CC1 replaces KK1, CC2 replaces KK2, CC3 replaces KK3, and "CC3 covered by B4 KDK NA (4)" replaces KK4.		

(4) Special inspection during execution is carried out according to a checking plan specifying what the special inspection during execution covers and how it is performed.

B6 DK NA Partial factors for resistance

Comment:

This clause is not applied. Reference is made to Annex F (7) for complementary rules concerning the determination of partial factors for resistance.

Annex C Basis for partial factor design and reliability analysis

The Annex may be used with a changed Table C2 DK NA (target reliability indices).

Table C2 DK NA Target reliability index β for class RC2 structural members [1]

Limit state	Target reliability index	
	1 year	50 years
Ultimate	4,3	3,3
Fatigue		1,5 to 3,3 [2]
Serviceability (irreversible)	2,9	1,5
[1] See Annex B. [2] Depends on the degree of inspectability, repairability and damage tolerance.		

Annex D Design assisted by testing

The Annex may be used with the exception of D7.3 and D8.3; see comment.

Comment:

Annex D may be used to check characteristic values and to establish characteristic values and design values. Clauses D7.3 and D8.3 cannot be used, as they assume a reliability level corresponding to β = 3,8 and application of the design value method in Annex C. Reference is instead made to Annex F in which the determination of material partial factors and design values is described.

Annex E DK NA Robustness

This Annex may be used for the examination of robustness, see 2.1(4)(P) - 2.1(5)(P).

E1 DK NA Complementary rules for the verification of robustness

(1) A structure is robust:

– when the parts of the structure that are decisive for reliability are only slightly sensitive to unintended actions and defects; or

– when there is no extensive failure of the structure if a limited part of the structure fails.

(2) Examples of unintended actions and defects include:
- unforeseen load effects;
- unintended discrepancies between the structure's actual mode of operation and the analysis models used;
- unintended discrepancies between the executed project and the project material;
- unforeseen geometrical imperfections;
- unforeseen subsidence;
- unforeseen degradation.

Increased robustness may in certain cases also help to reduce the effects of any gross errors, although verification of robustness neither can nor must be regarded as designing against gross error.

(3) Robustness is addressed in more detail in DS/INF 146 Robustness - Background and principles (available in Danish only).

(4) The robustness of a structure shall be proportional to the consequences of a failure of the structure. Documentation of robustness is only required for structures in consequences class CC3. However, for structures in consequences class CC2, an assessment of the robustness has to be made. The amount of detail of the assessment is to be increased in the case of large spans, large, concentrated loads, few supports, and special (rare or new) types of structure.

(5) A robust structure is achieved by an appropriate choice of materials, overall static principle and construction and by appropriate design of key members. A key member is a restricted part of the structure that, despite its limited extent, is of central importance to the robustness of the structure such that any failure of this member would result in the failure of the whole structure or significant parts of the structure.

(6) Where documentation of robustness is required, an expert engineering report is to be drawn up verifying that at least one of the robustness criteria specified in (1) is met. This is achieved

- by verifying that the essential parts of the structure, i.e. key members, have low sensitivity to unintended actions and defects, cf. (2);
- by verifying that no extensive failure of the structure occurs if a limited part of the structure fails (loss of a member), see (7)-(8);
- by verifying adequate reliability of key members, such that the whole structure to which they belong attains at least the same level of system reliability as an equivalent structure for which the robustness is documented by verification of adequate reliability in the event of the “loss of a member”.

In addition to the verification itself, the expert engineering report is to contain a critical evaluation of the structure, including identification of key members and action scenarios.

Verification that the first criterion has been fulfilled is only possible in special cases, and therefore verification is usually performed by verifying one of the two latter criteria.

(7) If robustness is verified by "loss of a member" as defined in (8), the acceptable extent of collapse for multi-storey buildings with up to 15 storeys may be taken as: no more than two floors shall collapse, extending in this case to two vertically adjacent floors. At each of the two floors, the extent of collapse is not to affect more than 15 % of the floor area, and no more than 240 m^2 per floor, and no more than a total area of 360 m^2. Adequate resistance is verified in an accidental design limit state by using the equation (6.11 a/b), see Table A1.3 DK NA .

(8) Robustness verified in the event of "loss of a member" may for residential and grandstand structures be regarded as met, if it is verified that the damaged structure will continue to constitute a stable system even if one or more structural members are lost. It is assumed that failure may comprise the equivalent of the maximum permissible extent of collapse, cf. (7), including:

- either a floor structure and an arbitrary column;
- or a floor structure and an arbitrary 3 m piece of wall in longitudinal or transverse direction.

The ability of a structure to retain its integrity after a failure of the specified extent is primarily conditional upon the damaged structure continuing to constitute a stable system, which means that the structure or large parts of it are not transformed into a failure mechanism. If this condition is met, an approximate calculation will be sufficient.

(9) If robustness is verified by introducing additional reliability of key members, this can usually be achieved by applying a material partial factor, γ_M, which has been increased by the factor 1,2 compared to the value specified in 6.3.5. With respect to modelling this is equivalent to a system with key members in series having the same system reliability as a system of parallel members.

As a general rule, every effort should be made in the design to document the robustness of a structure as far as possible without the use of increased reliability factors on the key members. Where increased reliability factors are applied to the key members, it should however be ensured that the resistance of the structure to unintended actions and defects is actually increased.

NOTE – For example, the robustness of hinged columns in a residential building will not generally be sufficiently secured by applying a factor of 1,2, unless at the same time a structural connection is arranged through each building floor in the form of a continuous tensile and shear connection in the column.

(10) The structural Eurocodes may provide guidelines for adequately ensuring robustness.

E2 DK NA Complementary rules for robustness of high-rise buildings

(1) Design supervision and inspection during execution of high-rise buildings are carried out according to the rules for consequences class CC3 where consequences of failure are particularly severe, cf. Annex B4 DK NA (4). Requirements according to Annex E1 DK NA (1)-(5) (10) also apply to high-rise buildings.

(2) High-rise buildings shall be designed so that they have sufficient robustness against relevant design failure scenarios identified against the background of both known and unknown failure events.

NOTE 1 – High-rise buildings are defined as buildings with more than 15 storeys above the terrain used for accommodating people, e.g. residential, office, educational or hospital buildings.

NOTE 2 – Design failure scenarios include sequences of failure events for structural elements and joints based on known loading and accidental situations that may lead to loss of human life. Design failure scenarios also include failure events originated from unknown causes, e.g. human errors in design and/or execution.

(3) As a basis for verification and documentation of robustness, a screening process shall be carried out identifying any relevant design failure scenarios.

NOTE 1 – The screening process includes, but is not limited to, identification of relevant design failure scenarios, relevant load cases, relevant extent of damage, appropriate measures for improving robustness, and whether quantitative risk assessments are needed.

(4) The structure shall be divided into segments so that for a given design failure scenario the expected loss of human life is limited to:

- Design of high-rise buildings (consequences class CC3, where consequences of failure are particularly severe, cf. Annex B4 DK NA (4)): Max. 500
- Design of structural sections in consequences class CC3: Max. 50
- Design of structural sections in consequences class CC2: Max. 5

NOTE 1 – The expected loss of human life in high-rise buildings of imposed load categories A, B, C1 and D1 is 1 person per 15 m2. For imposed load categories C2, C3, C4, C5 and D2, the number is 1 person per 4 m2.

NOTE 2 – For the design of the horizontal structural segment, a vertical replacement load corresponding to the failure of upper storeys of 28 kN/m2 for 1-2 storeys, 34 kN/m2 for 3-4 storeys, and 41 kN/m2 for more than 4 storeys may be used.

NOTE 3 – Segmentation of the structure may also be used for the division of a high-rise building.

(5) For identified design failure scenarios related to failure events with known causes, the robustness of high-rise buildings shall be verified using the procedures described in (6), (7) and (8).
For identified design failure scenarios related to failure events with unknown causes, the robustness of high-rise buildings shall be verified using the procedures described in (6) and (9).

(6) For each of the identified design failure scenarios, it shall be established to which extent failure of the included structural members, including elements and joints, can lead to progressive collapse or extensive failure of the high-rise building, taking into consideration a documented redistribution of internal forces and moments to the remaining structure. Furthermore, it shall be identified how progressive collapse or extensive failure can be most effectively prevented using appropriate design and construction principles.

NOTE 1 – Appropriate design and construction principles may include combinations of:

- Incident control by reducing the frequency and magnitude of actions
- Increased resistances of critical central structural members and joints (key members)
- Safeguarding of alternative load paths and redistribution (redundancy)
- Enhanced ductility
- Reduction of consequences (segmentation, evacuation, etc.)
- Reduction of risk of errors in design
- Reduction of risk of errors in execution.

NOTE 2 – The choice of design and construction principles is to be justified and documented based on comparisons between various possible relevant options.

(7) In persistent and transient design situations, adequate robustness of the main structure against progressive collapse is verified according to the identified design failure scenarios by one of the two following methods:

A1) Design of the included structural members and joints as key members with partial factors for strength parameters and capacities is increased by a factor of 1,2. Adequate reliability is verified in persistent and transient design situations.

A2) Removal of structural members and joints in question (key members). Adequate reliability of the damaged structure is verified in the accidental design situation. In the case of removal of structural members to an extent corresponding to Annex E1 (8) DK NA, the extent of failure shall not be greater than stated in Annex E1 DK NA (7).

NOTE 1 – Identification of key members is carried out during the screening process.

(8) For identified design failure scenarios related to accidental and seismic design situations, adequate reliability shall be verified by one of the two following methods:

B1) Critical structural members and joints are designed as key members with partial factors for strength parameters and capacities increased by a factor of 1,2. Adequate reliability is verified in the accidental design situation.

B2) Introduction of limited damage related to the accidental event, e.g. in the form of removal of a structural member or a limited part of the structure. Adequate reliability of the damaged structure is verified in the accidental design situation.

NOTE 1 – The extent and magnitude of limited damage is determined during the screening process.

(9) For identified design failure scenarios related to failure events with unknown causes, the robustness of high-rise buildings shall be verified using one of the two following methods:

C1) Critical structural members and joints (key members) are designed for a replacement accidental action. Adequate reliability is verified in the accidental design situation.

C2) Removal of a critical structural member or joint, a limited part of the structure, or introduction of any other limited damage. Adequate reliability of the remaining damaged structure is verified in the accidental design situation.

NOTE 1 – Identification of key members and determination of the extent and magnitude of damage will take place during the screening process.

NOTE 2 – For vertical or inclined structural members and joints (key members) the most unfavourable of the following actions is chosen as replacement accidental action:

- A concentrated load of 160 kN perpendicular to the structural member, attacking at the centroidal axis of the key member, at any point and in any direction.
- A uniformly distributed load of 34 kN/m2 acting perpendicular to the face of the key member in any direction.

Permanent action is applied when it is unfavourable.

NOTE 3 – For horizontal structural members and joints (key members) the most unfavourable of the following downward and upward actions is chosen as vertical replacement accidental action on these:

- A concentrated load of 160 kN attacking at the centroidal axis of the key member, at any point;
- A uniformly distributed load of 15 kN/m2 acting on the catchment area of the key member.

Permanent action is applied when it is unfavourable.

NOTE 4 – If the removal of structural members or the application of replacement accidental actions is used to represent the effects of design and execution errors or other events that have persistent safety effects throughout the service life of the structure, the verifications according to C1) and C2) shall be carried out with design values for both strengths and actions. For strength parameters and capacities, values equal to the accidental load design situation are used, and for actions, values equal to the persistent design situation are used, with partial factors being equal to 1.0.

NOTE 5 – Persistent safety effects represent changes in the resistance of the structure and/or actions that are not transient and remain persistent during the service life of the structure.

Annex F DK NA (informative) Partial factors for resistance

Complementary rules for establishing partial factors for resistance.

(1) The design resistance value, R_d, should be determined either by equation (6.6a) if it is determined on the basis of design strength parameters and a calculation model, or by equation (6.6c) if it is determined on the basis of measured characteristic resistances.

(2) The partial factors for strength parameters and resistance should be determined using the following expressions:

$$R_d = R\left\{\eta_{\mathrm{i}} \frac{X_{\mathrm{k,i}}}{\gamma_{\mathrm{M},i}\gamma_0}\right\}; a_{\mathrm{d}}, \qquad (6.6a)$$

where

$$\gamma_M = \gamma_m \gamma_R$$

$$\gamma_m = \gamma_4$$

$$\gamma_R = \gamma_1 \gamma_2 \gamma_3$$

$$R_{\mathrm{d}} = \frac{R_{\mathrm{k}}}{\gamma_{\mathrm{M}}\gamma_0} \qquad (6.6c)$$

$$R_{\mathrm{d}} = \frac{1}{\gamma_{M,1}\gamma_0} R\left\{\eta_1 X_{\mathrm{k,1}}; \eta_{\mathrm{i}} X_{\mathrm{k,i(i>1)}} \frac{\gamma_{\mathrm{m,1}}}{\gamma_{\mathrm{m,i}}}; a_{\mathrm{d}}\right\}$$

The sub-partial factors take account of the following:

γ_1	failure mode, see Table F.2
γ_2	uncertainty related to the calculation model, see Table F.3
γ_3	scope of inspection, see Table F.4
γ_4	uncertainty of strength parameter or resistance, see Table F.1.

The factor γ_0 is applied to the partial factor γ_M for strength parameters and resistances (and γ_R for resistance according to EN 1997-1), depending on the combination of actions, see Table A1.2(B+C) DK NA.

(3) Division of the partial factors into sub-partial factors does not imply a probability theoretical consideration of the conditions associated with the individual sub-partial factor only.

(4) The sub-partial factor γ_4 depends on the coefficient of variation for the strength parameter or resistance. The coefficient of variation is to include the uncertainty associated with the transfer from laboratory conditions to conditions in a real structure. γ_4 is given in Table F.1 DK NA.

Table F.1 DK NA Sub-partial factor γ_4 for strength parameter or resistance

Coefficient of variation for strength parameter or resistance[1)]	≤5 %	10 %	15 %	20 %	25 %	30 %
γ_4	1,15	1,20	1,25	1,30	1,35	1,40
[1)] Strength parameter and resistance are assumed to have a lognormal distribution.						

(5) The sub-partial factor γ_1 depends on the type of failure of the structure. γ_1 is given in Table F.2 DK NA.

No warning refers to failure that occurs without prior warning (e.g. in the form of increased cracking or deformation) and significant reduction of resistance immediately after a failure (e.g. in the event of stability failure or brittle fracture).

Warning without residual resistance refers to failure where a warning is given of lost resistance (e.g. in the form of increased cracking or deformation) and the resistance is retained for some time after the warning.

Warning with residual resistance refers to failure where the resistance increases (e.g. as a result of strain hardening) after a formal failure has occurred (e.g. in the event of the permissible strain being exceeded). If the residual resistance is utilised in the calculation models, the failure type is to be taken as "Warning without residual resistance".

Table F2 DK NA Sub-partial factor γ_1 depending on type of failure

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

(6) The sub-partial factor γ_2 depends on the coefficient of variation for the calculation model. The coefficient of variation is established by comparing resistances determined by testing the structural members and by applying the calculation model, with the use of measured/given strength parameters and geometric dimensions. As an exception, the coefficient of variation may be determined as an estimate. γ_2 is given in Table F.3 DK NA.

Table F.3 DK NA Sub-partial factor γ_2 for uncertainty of the calculation model

Coefficient of variation of the calculation model[1)]	≤5 %	10 %	15 %	20 %	25 %
γ_2	1,05	1,10	1,15	1,20	1,25
[1)] Uncertainty of the calculation model is assumed to have a lognormal distribution.					

(7) For structures where inspection during execution is based on the use of inspection classes, the sub-partial factor is determined in accordance with Table F4 DK NA for the production of components and execution at the construction site. The choice of inspection class and requirements for inspection during execution may also be given in the EN 1992 to EN 1999 series of standards and Danish National Annexes to these and related material and execution standards.

NOTE – Comprises structures covered by sections 24 to 27 of the Danish Building Regulations BR18 and structures not covered by the Danish Building Regulations.

Table F4 DK NA Sub-partial factor γ_3 dependent on the scope of inspection for the production of components and execution at the construction site

Inspection class	**Extended[1)]**	**Normal**	**Reduced**
γ_3	0,95	1,00	1,10
[1)] The extended inspection class can be used on the condition that third party checking is conducted.			

(8) For structures where inspection during execution is performed in accordance with DS/EN 1990 DK NA and Annex B5 DK NA, the sub-partial factor γ_3 is 1,0 for the production of components and execution at the construction site. The basis for inspection during execution is given in Annex B5 DK NA and DS 1140. The choice of execution class and requirements for inspection during execution may also be given in the EN 1992 to EN 1999 series of standards and Danish National Annexes to these and related material and execution standards. For the production of components with attestation level AVCP 1+, 1 and 2+ and with certification for the scope of inspection at least corresponding to the extended inspection class according to (7), the sub-partial factor may be taken as 0,95.

NOTE – Comprises structures covered by section 16(1) of the Danish Building Regulations BR 18. When Using Annexes B5 DK NA and DS 1140, inspection classes are deleted and instead execution classes are used to indicate the scope of inspection and other requirements for the execution. Unless otherwise specified in the EN 1992 to EN 1999 series, including DK NA, the execution classes EXC1, EXC2 and EXC3 shall be applied.
1

(9) In (2), γ_4 covers the variation of the strength parameter. By checking the strength parameter, it will be possible to evaluate both the characteristic value and the coefficient of variation, which may differ from what was assumed when the partial factor was determined, see EN 1992 to EN 1999 series.

(10) When examining accidental design situations or seismic design situations, the partial factor γ_M = 1,0 is used unless otherwise stated in EN 1992 to EN 1999 series.