

# DIN 25449:2022-07 (E)

## Reinforced and prestressed concrete components in nuclear facilities - Safety concept, actions, design and construction

---

### Contents

Page

Foreword .....	5
1 Scope .....	6
2 Normative references .....	6
3 Terms and definitions, and symbols .....	7
3.1 Terms and definitions.....	7
3.2 Symbols .....	8
4 Materials .....	11
4.1 Concrete .....	11
4.1.1 General .....	11
4.1.2 Temperature dependence of characteristic values.....	11
4.1.3 Bound water content.....	11
4.1.4 Heat capacity .....	13
4.2 Reinforcing steel.....	13
4.3 Prestressing steel.....	13
5 Actions .....	13
5.1 General .....	13
5.2 Permanent actions.....	14
5.3 Variable actions .....	14
5.4 Accidental actions .....	14
5.4.1 General .....	14
5.4.2 Internal actions.....	15
5.4.3 External actions .....	17
6 Safety concept.....	19
6.1 General .....	19
6.2 Combination rules.....	19
6.3 Partial safety factors and combination factors for actions.....	21
6.4 Ultimate limit states .....	22
6.5 Serviceability limit states .....	24
7 Procedures for structural analysis and verification .....	24
7.1 General .....	24
7.2 Linear-elastic analysis.....	25
7.3 Non-linear analysis.....	25
7.4 Behaviour of structural elements subjected to dynamic actions .....	26
7.4.1 General .....	26
7.4.2 Structural element stiffness.....	26
7.4.3 Masses.....	26
7.4.4 Damping of structural elements.....	27
7.4.5 Soil and foundation .....	27
7.4.6 Simplified methods for individual structural elements.....	28
8 Design recommendations .....	29
8.1 Design strength of reinforced concrete.....	29
8.2 Ultimate limit strain of reinforcing steel and concrete.....	30
8.3 Shear forces.....	30
8.4 Punching shear.....	31

8.4.1	General.....	31
8.4.2	Structural elements without punching shear reinforcement .....	31
8.4.3	Structural elements with punching shear reinforcement.....	33
8.4.4	Structural members for wreckage loads .....	35
8.4.5	Structural detailing.....	35
Annex A (informative) Plant conditions and actions.....		36
Annex B (informative) Load assumptions due to blast waves from explosions for buildings as a whole and for slender structural elements.....		38
B.1	General.....	38
B.2	Rectangular buildings.....	39
B.2.1	Directly loaded individual structural elements .....	39
B.2.2	Overall structure, bracing structural elements, foundation .....	39
B.3	Cylindrical and spherical buildings.....	39
B.4	Slender structural elements .....	41
Annex C (normative) Modified partial safety factors for nuclear power plants in decommissioning .....		42
C.1	General.....	42
C.2	Modified partial safety factors .....	42
C.2.1	Partial safety factors without consideration of conditions specific to the facility and structure.....	42
C.2.2	Determination of partial safety factors with consideration of conditions specific to the facility and structure .....	43
Annex D (informative) Approaches for considering site-specific conditions for the determination of modified partial safety factors for nuclear power plants in decommissioning .....		44
D.1	General.....	44
D.2	Determination of partial safety factors via the reliability level .....	44
D.3	Direct determination of partial safety factors .....	45
D.3.1	Consideration of realistic scatter of the basic variables.....	45
D.3.2	Consideration of material samples.....	45
D.3.3	Possibilities for the precise determination of variable actions .....	46
Bibliography .....		48

## Figures

Figure 1	— Bound water content at low water vapour partial pressure (0,8 kPa) and at temperatures kept constant at progressive steps.....	12
Figure 2	— Idealized differential pressure $\Delta p$ as a function of time .....	15
Figure 3	— Idealized jet impingement force $F_S$ as a function of time.....	16
Figure 4	— Idealized form of an elastic ground response or floor response spectrum .....	17
Figure 5	— Load/time function for an aircraft crash according to the <i>BMU-Sicherheitsanforderungen</i> (Safety requirements issued by the German Federal Ministry for the Environment) .....	18
Figure 6	— Load/time function of pressure waves caused by chemical reactions, as defined in the <i>BMI-Richtlinie: 1976-09</i> (Guideline issued by the Federal Ministry of the Interior).....	19
Figure 7	— Dynamic load factor for an explosion pressure wave.....	29
Figure B.1	— Idealized overpressure, $p$ , as a function of time, of blast pressure waves acting on buildings.....	38

Figure B.2 — Pressure/time function of resulting overpressure $\Delta p$ for rectangular buildings.....	39
Figure B.3 — Overpressure $\bar{p}$ on cylindrical and spherical buildings, as a function of time .....	40
Figure B.4 — Overpressure distribution on the perimeter of cylindrical and spherical buildings .....	40

## Tables

Table 1 — Symbols .....	8
Table 2 — Reference values for the bound water content of dry (i.e. dried) hardened cement paste .....	12
Table 3 — Reference values for partial safety factors and combination factors.....	21
Table 4 — Partial safety factors and material properties for reinforced concrete and prestressed concrete members for determining the resistance in the ultimate limit state .....	23
Table 5 — Assignment of the various requirement categories.....	24
Table 6 — Values for the damping ratio $D$ as a percentage of critical damping for the design of structures and parts of structures .....	27
Table 7 — Maximum dynamic load factors .....	28
Table A.1 — Plant conditions and events given by way of example and the resultant possible consequences for the containment vessel.....	36
Table A.2 — Examples of internal and external events and the possible consequences of such events .....	37
Table B.1 — Pressure ordinates as a function of impact angle $\vartheta$ ( $\bar{p}$ as in Figure B.3).....	40
Table B.2 — Dynamic pressure $q$ as a function of $p_2$ .....	41
Table C.1 — Partial safety factors without consideration of conditions specific to the facility and structure.....	43