KTA KERNTECHNISCHER AUSSCHUSS

Status Report

Recommendations Regarding the Application of KTA Safety Standards Considering Current Structural Engineering Standards

(Empfehlungen zur Berücksichtigung aktueller bautechnischer Normen bei Anwendung der KTA-Regeln)

KTA-GS-78

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Preface

The KTA subcommittee ‘Plant and Structural Engineering’ (UA-AB) discussed in their 91st and 92nd sessions in how far the safety standards KTA 2201, parts 1 through 6, KTA 2501 and KTA 2502 are still in conformance with modern structural engineering standards. In their 92nd session, UA-AB instituted a Working Group ‘Structural Engineering Standards’ with members representing all factions of the KTA and comprising additional experts from several technical institutes.

The Working Group ‘Structural Engineering Standards’ has ascertained that numerous structural engineering standards referenced in the above KTA safety standards have, meantime, been withdrawn with the intention of being replaced by new standards based on a modern design concept. Since 1991, the standards DIN 18800 Parts 1 through 4 (1990-11) for steel structures and, since 2002, the standard DIN 1045-1 (2001-03) for concrete, reinforced concrete and prestressed concrete structures have been introduced by the supreme building-authorities. These standards, together with DIN 1055-100 (2001-03) “Actions on structures - Part 100: Basis of design, safety concept and design rules”, build the foundation for the design verification in general structural engineering of structures designed in accordance with the so-called partial safety factor concept. Other standards are currently being revised and will be introduced by the supreme building-authorities on short order. They must, then, be applied to new building projects; however, the old standards will still be applicable but only until the conclusion of on-going projects. The design concepts of the old and the new generation of standards are not compatible to each other. Likewise, in comparison to the new structural engineering standards, the same must be said of the KTA safety standards that were based on the old design concept.

The Working Group ‘Structural Engineering Standards’ has discussed the extent to which the KTA safety standards and standards activities cited above require modifications and has now proposed that the UA-AB, initially, should issue a number of recommendations that would allow applying the existing KTA safety standards under consideration of the new design concept. The individual KTA safety standards will then be successively modified and adapted to the new standards generation.

The present progress report with its application recommendations was prepared by the Working Group ‘Structural Engineering Standards’. This work was closely coordinated with the ongoing modification efforts of standard DIN 25449. The following experts (institutions) have collaborated in preparing the present report:

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This progress report was discussed by, and received approval of, the UA-AB in its 96th session on September 8, 2005. In accordance with the resolution of UA-AB, this report was presented to the KTA in their 59th session on November 22, 2005, who, thus, took official notice of the present progress report.

Salzgitter, November 28th, 2005

KTA Status Report

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Contents

1 Introduction

1.1 Objective

A review of the KTA Safety Standards pertaining to civil engineering and to external events has uncovered a need for modification due to the ongoing development of new DIN standards and corresponding European technical standards. In the following, recommendations are presented that should be applied in the transition period until the corresponding KTA Safety Standards have been completely adapted to the applicable civil engineering standards; if taken into consideration, applying KTA Safety Standards in this interim period will fully meet the necessary structural design requirements. These recommendations are necessary in order to be able to apply the KTA Safety Standards together with the currently applicable civil engineering standards. A list of the relevant KTA Safety Standards with a correlation of the civil engineering standards referenced in these safety standards is presented in Section 2.5.

1.2 Background

Within the framework furthered by the European Commission of harmonizing technical standards, Germany is in the process of implementing Eurocodes into her Technical Civil Engineering Code. The Eurocodes create uniform design procedures that span all types of structural facilities in regard to verifying the limit states for load-bearing capacity and serviceability.

In the generation of standards applicable until now, the verification of structural stability is based on the global safety factor concept. Here, the loads resulting from the combination of equally ranked actions are correlated to the permissible structure-type-specific strain. The value of this permissible action effect is determined by a global safety factor which comprises, both, the uncertainties of the loading and structural bearing models as well as the variation of the material characteristics.

In contrast, the partial safety factor concept on which the new civil engineering standards are based introduces separate factors, one, for the uncertainties of the loading and structural bearing models and, two, for the variation of the material characteristics. Furthermore, combination coefficients are introduced to be applied when combining multiple actions that take the probability of a simultaneous occurrence of these actions into consideration.

In various KTA safety standards, civil engineering standards are referenced whose verification procedures are based on the global safety factor concept and that, meantime, have been withdrawn. The new generation of standards is already predominantly adjusted to the European verification concept and, thus, has been introduced as the German Technical Civil Engineering Code. Any KTA safety standards referencing these withdrawn civil engineering standards must, therefore, be revised.

1.3 Contents and procedure

Section 2 presents a summary account of the current development of civil engineering standards. This account contains a description of the essential differences to the older civil engineering standards that were withdrawn. It is limited to standards for civil structures made of concrete, reinforced concrete and prestressed concrete as well as for steel structures and composite structures of steel and concrete. Other building materials play only a subordinate role in nuclear facilities. Finally, Section 2 presents a list of KTA safety standards and of the design-relevant civil engineering standards from the older standards generation that are referenced in these safety standards.

Section 3 contains a compilation of the recommendations that should be applied when using the individual KTA safety standards. These recommendations fulfil the basics of the partial safety factor concept. They specify alternate provisions for the civil engineering requirements in KTA safety standards that are still based on the older standards generation.

Special emphasis is placed on the design situations from extreme internal and external impacts. Before, structural components were designed against these impacts exclusively in accordance with KTA safety standards and with several DIN standards that applied to specific structural components of nuclear power plants. The other, older civil engineering standards do not contain any requirements in this regard. The new civil engineering standards, on the other hand, present rules for the combination of permanent and temporary design situations and, also, of accidental design situations and those arising from earthquakes.

Furthermore, the new generation of standards discerns, in part, between the different design situations with regard to permissible action effects. Their correlation to the requirement categories of nuclear safety standards requires additional specifications. This also applies to the building structure interaction loads at the interface between the building structures and the plant-engineering components. Furthermore, the material and structure-type specific requirements are specified with special regard to the specific nuclear technological design situations.

2 Current Civil Engineering Standards

2.1 General

In regard to the ongoing European development of unifying the system of civil engineering standards, the attempt is being made to replace the national German civil engineering standards by the corresponding Eurocodes. These are, among others, Eurocode 1 “Actions on Structures”, Eurocode 2 “Design of Concrete Structures” and Eurocode 3 “Design of Steel Structures”.

Due to the many-years delay of introducing the Eurocodes, Germany has decided, nationally, to adapt her civil engineering DIN standards to the corresponding Eurocodes. Thus, in 2002 the technical standards DIN 1055-100 corresponding to EN 1990 and DIN 1045 Parts 1 through 4 corresponding to Eurocode 2 have been introduced by the supreme building-authorities. In regard to steel structures, this development had already started in 1990 with the revision of technical standards DIN 18800 Parts 1 through 4.

The mutual goal of revising these standards is to implement a partial safety factor concept that spans all types of structures and building materials and that replaces the global safety factor concept on which the former German standards were based. The basic assumptions for this safety factor concept spanning all types of structures and materials are specified in DIN 1055-100.

2.2 Actions on bearing structures

The previous standard DIN 1055 “Load assumptions for structural components” with its Parts 1 through 6 (issued in the years 1971 through 1987) was built around the global safety factor concept as usual in the material-type specific civil engineering standards. The transition to the partial safety factor concept has led to the development of Parts 1 through 10 of the revised DIN 1055 which have been ready to be introduced by the supreme building authorities since 2001, and has, furthermore, necessitated the development of DIN 1055 Part 100. This Part 100 contains the basic requirements spanning all types of structures and materials for the planning of bearing structures and includes descriptions of the safety factor concept and of the general design rules.

2.3 Structural members made of concrete, reinforced concrete and prestressed concrete

In the year 2002 the standards DIN 1045 Parts 1 through 4 together with DIN 1055-100 have been introduced by the supreme building-authorities. **Figure 2-1** shows the situation of the standards regarding reinforced and prestressed concrete bearing structures as well as regarding the actions on these structures.

The essential differences between the old and the new design concepts in the standards regarding reinforced and prestressed concrete are shown in **Figure 2-2**.

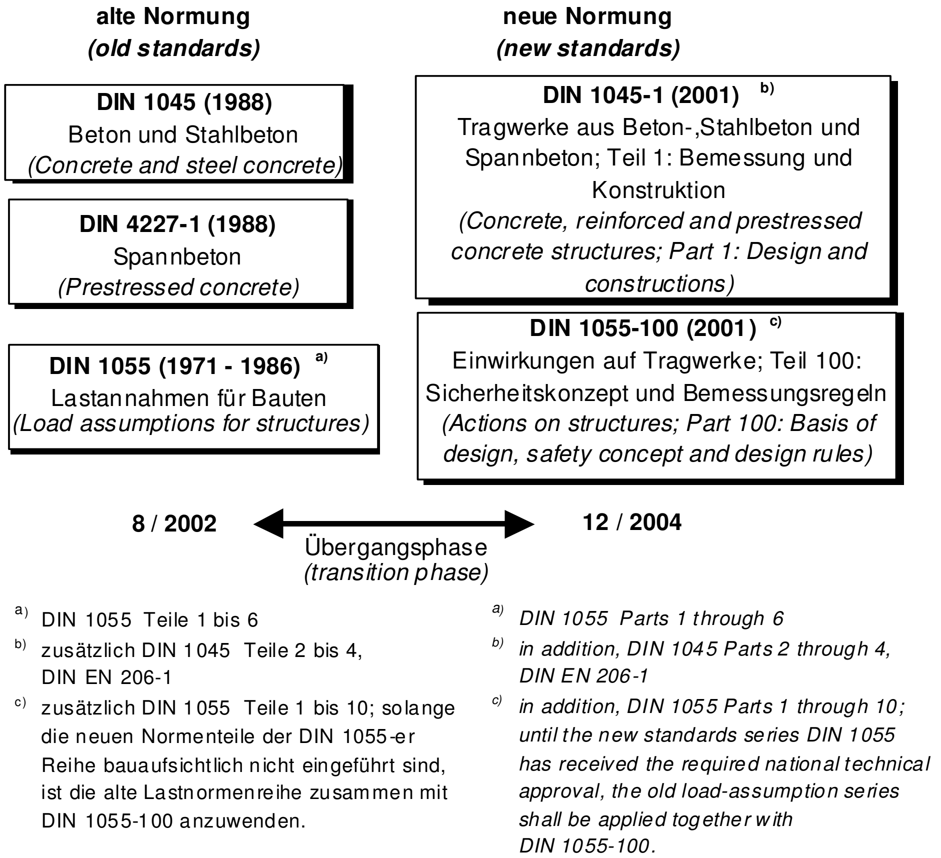

Figure 2-1: Development of the standards regarding reinforced and prestressed concrete as well as regarding actions influencing the bearing structures

alte Normung *(old standards)*	**neue Normung** *(new standards)*
DIN 1045 (1988) DIN 4227 (1988) DIN 1055 (1971 - 1986)	DIN 1045-1 (2001) DIN 1055-100 (2001)
globales Sicherheitskonzept ***(global safety factor concept)*** $\sum E_i \leq \sum R_k / \gamma$	**partielles Sicherheitskonzept** ***(partial safety factor concept)*** $\sum (\gamma_{F,i} \cdot E_i) \leq \sum (R_k / \gamma_{R,k})$
Nachweisverfahren ***(verification procedure)*** linear *(linear)*	**Nachweisverfahren** ***(verification procedure)*** linear / nichtlinear *(linear / non-linear)*
Zwangbeanspruchungen E_T ***(restraint forces E_T)*** - red. Steifigkeit ⇒ red E_T [a] *(- reduced stiffness)* - red. Sicherheit ⇒ red E_T / γ [b] *(- reduced safety)*	**Zwangbeanspruchungen E_T** ***(restraint forces E_T)*** - red. Steifigkeit ⇒ red E_T [a] *(- reduced stiffness)*
	Dauerhaftigkeit ***(durability)*** erhöhte Anforderungen *(increased requirements)* (u. a. Betondeckung) *(e.g., concrete cover)*

[a] Anwendung linearer Nachweisverfahren
(application of linear verification procedures)

[b] Voraussetzung, dass das Tragwerksversagen nicht durch E_T beeinflusst wird
(prerequisite: bearing structure failure must not be influenced by E_T

Figure 2-2: Comparison of the old and new generation of standards, DIN 1045 and DIN 1055, respectively

alte Normung *(old standards)*	**neue Normung** *(new standards)*
DIN 18800-1 (1981) Bemessung und Konstruktion *(Design and construction)*	**DIN 18800-1 (1990)** Bemessung und Konstruktion *(Design and construction)*
DASt Ri 008 (1973) Traglastverfahren *(Ultimate load method)*	
DIN 4114-1, -2 (1952, 1953) Stabilität (Knicken, Kippen, Beulen) *(Stability – folding, tilting, buckling)*	**DIN 18800-2 (1990)** Stabilität: Knicken von Stäben *(Stability: Buckling of rods)*
DASt Ri 012 (1978) Stabilität: Plattenbeulen *(Stability: Plate buckling)*	**DIN 18800-3 (1990)** Stabilität: Plattenbeulen *(Stability: Plate buckling)*
DASt Ri 013 (1980) Stabilität: Schalenbeulen *(Stability: Shell buckling)*	**DIN 18800-4 (1990)** Stabilität: Schalenbeulen *(Stability: Shell buckling)*

Figure 2-3: Development of standards series DIN 18800

alte Normung *(old standards)*	**neue Normung** *(new standards)*
DIN 18800-1 (1981) DIN 4114-1, -2 (1952, 1953) DASt Ri 008 (1973) DASt Ri 012 (1978) DASt Ri 013 (1980)	DIN 18800-1 bis *(through)* -4
globales Sicherheitskonzept ***(global safty factor concept)*** $\sum E_i \leq \sum R_k / \gamma$	**partielles Sicherheitskonzept** ***(partial safety factor concept)*** $\sum (\gamma_{F,i} E) \leq (R_k / \gamma_{Rk})$
Nachweisverfahren ***(verification procedure)*** zul σ - Verfahren, σ_ω - Nachweis *(perm. σ - procedure, σ_ω - verification)*	**Nachweisverfahren** ***(verification procedure)*** $S_d / R_d \leq 1$
Lastfallkombinationen ***(load case combinations)*** LF: H, HZ, HS LF: HS1, HS2, HS3	**Einwirkungskombinationen** ***(combinations of physical influences)*** Grenzzustand der Tragfähigkeit (GZT) *(serviceability limit state)* Grenzzustand der Gebrauchstauglichkeit (GZG) *(ultimate loading condition)*

Figure 2-4: Comparison of the old and new generation of standards DIN 18800

2.4 Steel structures

As shown in **Figure 2-3**, the new standards series DIN 18800 with its Parts 1 through 4 was established in the year 1990 replacing the technical standards DIN 18800-1 (1981-03), DIN 4114-1 (1952-07), DIN 4114-2 (1953-02), and the guidelines DASt Ri 012 (1978-10) and DASt Ri 013 (1980-07). Since January 1, 1996, the old standards cited here are valid only in connection with steel bridge structures and composite structures of steel and concrete. The essential differences between the old and the new structural steel engineering standards are presented in **Figure 2-4**.

The safety factor concept on which the new standards series DIN 18800 is based takes the awaited European standard EN 1990 into account. The DIBt Report, special edition 11/2, contains specifications in regard to individual elements of these standards as well as to those technical standards and DASt guidelines that are still based on the old safety factor concept.

It is also allowed, on a trial basis, to apply the pre-standard DIN V ENV 1993-1-1 (1993-04) (Eurocode 3) whose scope of specifications largely corresponds to DIN 18800 Part 1 and Part 2. In this regard the specifications contained in the national application document (presented in guideline DASt Ri 103) shall be observed.

Note:

The pre-standard DIN V ENV 1993-1-1 (1993-04) has been replaced by version DIN V ENV 1993-1-1 (2005-07) and a number of corresponding parts (this standards series has not yet been introduced by the supreme building-authorities).

Different to the standards series for structures made of concrete, reinforced concrete and prestressed concrete (DIN 1045), the standards series DIN 18800 is not directly based on DIN 1055-100.

2.5 Civil engineering standards referenced in KTA Safety Standards

The exemplary list of **Table 2-1** shows KTA safety standards relevant to civil engineering that reference standards regarding structures made of concrete, reinforced concrete and pre-stressed concrete as well as regarding structural steel engineering. When applying these KTA safety standards the application recommendations presented in Section 3 should be applied.

KTA Safety Standards		Concrete, Reinforced Concrete and Pre-stressed Concrete	Steel Structures, Composite Structures
KTA 2201.3 E	(1990-06)	DIN 1045 (1988-07) DIN 4227-1 (1988-07)	DASt Ri 008 (1973-03) DIN 4114-1 (1952-07) DIN 18800-1 (1981-03) DIN 18806-1 (1984-03)
KTA 2201.4	(1990-06)		DIN 4114-1 (1952-07) DIN 18800-1 (1981-03) DIN 18800-7 (1983-05)
KTA 2502	(1990-06)	DIN 1045 (1988-07) DIN 1048-1 (1978-12) DIN 1048-2 (1976-02) DIN 4227-1 (1988-07)	DIN 4114-1 (1952-07) DIN 4114-2 (1953-02) DIN 4133 (1973-08) DIN 18800-1 (1981-03) DIN 18800-7 (1983-05)
KTA 3205.2	(1990-06)		DASt Ri 008 (1973-03) DASt Ri 012 (1978-10) DASt Ri 013 (1980-07) DIN 4114-1 (1952-07) DIN 18800-1 (1981-03) DIN 18800-7 (1983-05)
KTA 3401.2	(1985-06)		DASt Ri 013 (1980-07) DIN 18800-1 (1981-03) DIN 18800-7 (1983-05)
KTA 3905	(1999-06)	DIN 1045 (1988-07)	DIN 1055-1 (1988-07) DIN 1055-3 (1971-06) DIN 18800-1 (1981-03) DIN 18800-7 (1983-05)

Table 2-1: Outdated KTA safety standards relevant to civil engineering (exemplary list; prepared August 2005)

3 Application Recommendations

3.1 General remarks

N o t e :

Unless noted otherwise, all standards referred to in the following sections are part of the revised standards series.

In general, the revised standards series DIN 1045 Parts 1 through 4 for structural members made of concrete, reinforced concrete and prestressed concrete as well as the series DIN 18800 Parts 1 through 4 for steel structures do not lead to any increased requirements regarding the load-bearing capacity (stability) of the components. However, the verification of the serviceability and durability is specified in much greater detail, in particular, with regard to structural members made of concrete, reinforced concrete and prestressed concrete, than in the older versions of these standards. Thus, in accordance with DIN 1045-1, each structural member is required to be assigned to an exposure class that depends on the individual environmental conditions. This assignment is the basis for specifying the minimum concrete strength class and also the concrete cover including allowance on the reinforcement which, in comparison to the previous version DIN 1045 (1988-07) and with the exception of Class XC1, was increased from 10 mm to 15 mm.

On account of the different design concepts of the old and the new standards series, it became necessary to prohibit intermixing of the two. Regulations from the new standards series (cf. DIBt Report 1/2002 "New standards for concrete") may not be combined with regulations from the old standards series with one exception: The design of prefabricated elements and comparable structural members in accordance with a different standards series is possible, provided, the individual components are not monolithically connected to the over-all bearing structure and, provided, neither the transmittal of internal forces within the overall structure nor the over-all stability are affected.

The following is a description of how a building structure designed in accordance with the old standards series can be structurally modified or enhanced to meet the requirements of the new standards concept.

In the case of steel structures, this is regulated by the guideline Adapting of Steel Structures (DIBt Report, Special Edition 11/2). Comparable regulations can also be established for steel-reinforced concrete structures and components that must meet the (partial-) safety factor concept presented in DIN 1055-100.

Following the method presented in the guideline 'Adapting of Steel Structures', the following procedure is recommended to be applied when connecting structural members designed under the new safety factor concept to components designed under the old safety factor concept:

The internal forces and support loadings calculated under the new safety factor concept for "permanent and temporary design situations" may be converted to verify the structural members designed under the old safety factor concept. The conversion is carried out by applying the ratio of internal forces due to the characteristic factors of the actions to the internal forces due to the design values calculated under DIN 1055-100. The internal forces and support loadings calculated for accidental design situations and those arising from earthquakes may be directly applied as verification of structural members designed under the old safety factor concept.

A modified and improved structural member shall basically be designed in accordance with the current civil engineering standards, i.e., standards prepared under the new safety factor concept. In addition to the modified and improved structural member, this design should also include the connecting structural members of the existing building structure where the additional loads were still transferred as concentrated stresses. It is recommended that the verification of load transfer after load distribution in the existing building structure is calculated with the characteristic factors of the action (in case of accidental design situations with the design load-bearing capacity) using the civil engineering standards applied in the original design.

The new standards contain specifications - like the older versions - regarding building materials that have been adapted to the current state of the development in building materials.

Note:

The reinforcing steels specified in DIN 1045-1 are restricted to those with a characteristic yield strength of f_{yk} = 500 N/mm^2 (BSt 500) and are differentiated not only by the product form (S or M) but also, for the first time, by the ductility (A: normal ductility, B: high ductility). The former reinforcing steels BSt 420 S and BSt 500 S specified in DIN 488-1 meet the requirements for a high-ductile steel. DIN 18800-1, for the first time, specifies fine grain structural steels and the bolt material of strength class 8.8.

3.2 New safety factor concept

3.2.1 Basic verification procedure

According to the new safety factor concept under DIN 1055-100, the verification procedure shall take the ultimate limit states and the serviceability limit states into account. These boundary conditions are separately calculated according to the following procedure:

- establishing structure and load models for the design situations that are decisive for the individual boundary conditions,
- verifying that the boundary conditions are not exceeded when the design values of the actions and of the bearing capacity are applied in the analytical models as dependent on the geometry of the structural member and on the properties of the building materials.

3.2.2 Actions

Following the method presented in DIN 1055-100, the following actions are discerned:

- independent permanent actions, G_k,
- independent actions due to prestressing, P_k,
- dominant independent temporary actions, Q_{k1},
- other independent varying actions, Q_{ki} (i > 1) ,
- accidental actions, A_d,
- actions due to earthquakes, $A_{Ed'.}$

Appendix B contains a correlation of these actions to the former terms (permanent normal loads, variable normal loads, etc.) used until now.

All actions, with the exception of the accidental actions, are described by characteristic factors. Accidental actions are specified in the form of design values and such that a partial safety factor of 1.0 is implicitly assumed for these actions.

Regarding the design-basis earthquake in accordance with safety standard KTA 2201.1, a value of 1.0 shall be assumed for, both, the weighting factor γ_1 in accordance with DIN 1055-100 and the importance factor γ_I in accordance with DIN 4149, such that the design value A_{Ed} is considered as nominal value.

Main emphasis of the following considerations will be the internal and external events listed in **Table 3-1** that must be considered as design-basis accidents in the design of nuclear power plants.

In accordance with DIN 1055-100, the load conditions from the internal and external events considered in the design of nuclear power plants can be correlated to the “accidental actions” or to the “actions due to earthquakes” with the additional requirement that, as defined by the requirement categories under Sections 3.2.1.1 and 3.3.2.1 below, the design requirements of the individual structure or structural member must be taken into consideration.

<table>
<tr><th colspan="3">Internal and External Events</th><th>Resulting Actions</th></tr>
<tr><td rowspan="6">Design Basis Accidents (Safety Level 3)</td><td rowspan="4">Internal Events</td><td>Leaks or ruptures of pressurized components</td><td>jet impingement forces, differential pressures,
load bearing and holding forces,
whipping pipe ends,
debris loads, temperature,
water pressure (static)</td></tr>
<tr><td>Malfunctions and accidents during handling of fuel assemblies</td><td>crashing down loads</td></tr>
<tr><td>Plant-internal fires and explosions</td><td>temperature gradients,
pressure gradients</td></tr>
<tr><td>Plant-internal flooding</td><td>water pressure (static)</td></tr>
<tr><td rowspan="2">External Events</td><td>Earthquake</td><td>mass-forces from the self-weight of structures and internals (components),
debris loads, displacements,
blast wave from bursting pressure vessels with a large energy content that were not designed against earthquakes</td></tr>
<tr><td>Flooding</td><td>water pressure (static)</td></tr>
<tr><td rowspan="2">Severe Accidents (Safety Level 4a)</td><td rowspan="2">External Events</td><td>Airplane crash</td><td>- direct impact to the surface area hit and induced vibrations
- secondary impacts from flying debris</td></tr>
<tr><td>Explosion blast wave</td><td>pressure loading of entire structure with a given time characteristic, and induced vibrations</td></tr>
</table>

Table 3-1: Accidental actions (internal and external events)

3.2.3 Combination rules

A loading design value must be determined for each critical load case by combining the independent, simultaneously occurring actions; regarding ultimate limit state and serviceability limit state, the combination rules presented below shall be investigated (definitions, cf. DIN 1055-100):

Ultimate limit state:

- permanent and temporary design situations
  E_d : $\gamma_G \bullet G_k + \gamma_P \bullet P_k + \gamma_{Q,1} \bullet Q_{k1} + \Sigma(\gamma_{Q,i} \bullet \psi_{0,i} \bullet Q_{ki})$
- accidental design situations
  E_{dA} : $G_k + P_k + A_d + \psi_{1,1} \bullet Q_{k1} + \Sigma(\psi_{2,i} \bullet Q_{ki})$
- design situation due to earthquakes
  E_{dAE} : $G_k + P_k + A_{Ed} + \Sigma(\psi_{2,i} \bullet Q_{ki})$

Serviceability limit state:

- rare (characteristic) combinations
  $E_{d,rare}$: $G_k + P_k + Q_{k1} + \Sigma(\psi_{0,i} \bullet Q_{ki})$
- frequent combinations
  $E_{d,frequ}$: $G_k + P_k + \psi_{1,1} \bullet Q_{k1} + \Sigma(\psi_{2,i} \bullet Q_{ki})$
- quasi-permanent combinations
  $E_{d,perm}$: $G_k + P_k + \Sigma(\psi_{2,i} \bullet Q_{ki})$

3.2.4 Partial safety factors and combination coefficients for actions

The partial safety factors in regard to the prestress, the permanent and the variable actions shall be assumed in accordance with DIN 1045-1. The partial safety factors and combination factors for general service loads, live loads, snow and ice loads, wind loads as well as temperature effects are specified in DIN 1055-100.

More detailed data regarding the partial safety factors as well as the reference values for the combination factors are listed in **Table 3-2** for typical actions.

Note:

The combination factors assumed by DIN 18800-1 are, different from **Table 3-2**, $\psi_0 = \psi_1 = \psi_2 = 0.9$ because at the time of the introduction of DIN 18800-1 the more differentiated handling of the combination factors according to DIN 1055-100 were not yet known.

Actions		**Partial Safety Factors** $\gamma_G, \gamma_Q, \gamma_P$	**Combination Factors**		
			ψ_0	ψ_1	ψ_2
G	Dead load	1.35 [1)]	-	-	-
P	Prestress	1.00	-	-	-
Q	Quasi-permanent service load	1.50 [2)]	1.0	1.0	1.0
	Variable service load	1.50 [2)]	0.7 - 0.9	0.5 - 0.8	0.3 - 0.8
	Crane loads	1.35	1.0	0.9 [4)]	0
	Indirect actions due to settlements	1.50 [3)]	1.0	1.0	1.0

1) 1.00 in case of favorable effects

2) 1.35 in case the action can be exactly determined

3) 1.00 in case a linear calculation is performed and the structure permits a reduction of stiffness, e.g., due to crack initiation or relaxation

4) In the case of requirement category A3 (cf. Section 3.3.1.1), the crane load need not be considered a variable action, i.e., $\psi_1 = 0$.

Table 3-2: Reference values for partial safety factors and combination factors

3.2.5 Partial safety factors of the bearing capacity

The partial safety factors to use in determining the load-bearing capacity in the ultimate limit state depend on the design situation (permanent and temporary, accidental), on the building material (concrete, reinforcing steel, prestressing steel, structural steel) as well as on the design requirements regarding the structure or structural member. The partial safety factors are specified in Sections 3.3.1 and 3.3.2 below.

3.3 Verification procedures

3.3.1 Structural members made of concrete, reinforced concrete and prestressed concrete

According to DIN 1045-1, the following procedures may be used to determine the internal forces:

- linear-elastic analysis,
- linear-elastic analysis with redistribution of moments,
- analytical procedures according to the theory of plasticity,
- non-linear analytical procedures (cf. Sec. 8.5 DIN 1045-1).

3.3.1.1 Requirement categories

Safety-related structural members of reinforced concrete must meet different requirements depending on the type of action they are subjected to. In this regard the following aspects shall be taken into consideration:

- occurrence probability during service life,
- reparability,
- limiting the extent of damage such that, e.g., the serviceability of the individual structural members or the stability and functional safety of plant components are maintained.

In the design of reinforced concrete structures the structural members are assigned to one of the three Requirement Categories A1, A2 or A3 depending on the aspects named above:

Requirement Category A1

Those combinations of actions corresponding to the permanent and temporary design situations in accordance with DIN 1055-100 shall be assigned to Requirement Category A1. The partial safety factors specified in DIN 1045-1 for the load-bearing capacity regarding permanent and temporary design situations shall be assigned to these combinations (cf. **Table 3-3**).

Requirement Category A2

Following the method described in DIN 1055-100, those combinations of actions that comprise accidental design situations which must be assumed to occur several times during service life are assigned to Requirement Category A2 (the partial safety factors for the load-bearing capacity are specified in **Table 3-3**). It must be ensured that the structural members designed accordingly are continuously useable after occurrence of these combinations.

In regard to the stability or functional safety of plant components, additional requirements may have to be specified for individual locations (e.g., limit values for deformations and crack widths).

Requirement Category A3

Combinations of actions comprising accidental design situations with a low probability of occurrence (internal or external events, $\leq 10^{-4}$ per year) which must be assumed to occur once during service life shall be assigned to Requirement Category A3 (the partial safety factors for the load-bearing capacity are specified in **Table 3-3**). The forming of large cracks and permanent deformations are permitted, provided, these are not prohibited for safety related reasons.

In regard to the stability or functional safety of plant components, additional requirements may have to be specified for individual locations (e.g., limit values for deformations and crack widths) that go beyond the minimum requirements with regard to the load-bearing capacity.

In context of the application of non-linear analytical procedures to determine internal forces, Sec. 8.5.1 DIN 1045-1 specifies an integral safety factor for the load-bearing capacity as γ_R =1 .1 (accidental design situations) and γ_R = 1.3 (permanent and temporary design situations), respectively. When this integral safety is maintained and the arithmetically averaged stress values for the structural material are applied, the partial safety factors specified in **Table 3-3** for concrete and reinforcing steel in Requirement Categories A1 and A2 are implicitly contained. In case of Requirement Category A3, **Table 3-3** recommends applying an integral safety coefficient $\gamma_R = 1.0$ as well as the theoretical stress values for the structural material $f_{cR} = 1.0\ \alpha\ f_{ck}$ (concrete) and $f_{yR} = 1.0\ f_{yk}$ (reinforcing steel), respectively.

3.3.1.2 Design recommendations

Characteristic stress values of reinforced concrete:

The design for the ultimate limit state starts out from the design value of the uniaxial compressive strength of concrete according to Equation 67, Sec. 9.1.6 DIN 1045-1 as follows:

$$f_{cd} = \alpha \bullet f_{ck} / \gamma_c \qquad (3\text{-}1)$$

The coefficient α accounts for the reduced long-term strength relative to the higher short-term strength as well as for the deterministically describable differences between the compressive strength determined for a test specimen and that of the structural member (cf. DAfStb Booklet 525, explanations regarding Sec. 5.2 DIN 1045-1). In the case of standard concrete, a value α = 0.85 is generally assumed for this coefficient. For combinations with short-term actions, the coefficient α may be increased to a value of 1.0.

Furthermore, values for design relevant properties of the building material concrete that deviate from those on which DIN 1045-1 is based may be applied, provided, this is well substantiated or verified. This applies, especially, in regard to the strength increase of concrete from the effect of long-term hardening in many-years old reinforced concrete structures, as well as in regard to the strength increase of concrete in case of multi-axial stress conditions or in case of high strain rates (e.g., in case of airplane crash).

Note:

Model Code 90, e.g., contains further details regarding strength increase.

Requirement Categories	A1	A2	A3
Building materials and Load-Bearing Capacities			
Partial safety factor for concrete	γ_c = 1.50	γ_c = 1.3	γ_c = 1.0
Partial safety factor for reinforcing steel and prestressing steel	γ_s = 1.15	γ_s = 1.0	γ_s = 1.0
Non-linear Analytical Procedures			
Load-bearing capacity [1)] in accordance with Sec. 8.5.1 DIN 1045-1	γ_R = 1.30	γ_R = 1.1	γ_R = 1.0
Calculated value for the compressive strength $f_{cR.}$ [2)] of concrete	0.85 α f_{ck}	0.85 α f_{ck}	1.0 α f_{ck}
Calculated value for the yield strength f_{yR} of reinforcing steel	1.1 f_{yk}	1.1 f_{yk}	1.0 f_{yk}
Calculated value for the 0,1%-tensile yield strength $f_{p0,1R}$ of prestressing steel	1.1 f_{pk}	1.1 f_{pk}	1.0 f_{pk}

1) Named ‘system resistance’ in Table 2 of DIN 1045-1

2) Reduction coefficient α in accordance with DIN 1045-1 (cf. Section 3.3.1.2)

Note: Requirement Categories A1, A2 and A3 correspond to the requirement categories C, B and A in accordance with DIN 25449 (1987-05)

Table 3-3: Partial safety factors for determining the load-bearing capacity for the ultimate limit state in Requirement Categories A1, A2 and A3 (reinforced and prestressed concrete structures)

The partial safety factor γ_c to be applied for the individual structure or structural member shall be chosen in accordance with Requirement Category A1, A2 or A3 (cf. **Table 3-3**).

The design value f_{yd} for the yield strength of reinforcing steel is determined by

$$f_{yd} = f_{yk} / \gamma_s \qquad (3\text{-}2)$$

with the partial safety factor γ_s chosen in accordance with Requirement Category A1, A2 or A3 (cf. **Table 3-3**). The strength increase in case of high strain rates may be taken into account.

In regard to earthquake analyses, when considering the dissipative effects of a non-linear behavior of the building materials, a possible strength reduction due to damages from cyclical deformations, as well as a reduction of the load-bearing capacity due to spalling of the concrete cover in critical areas of reinforced concrete components shall be taken into consideration.

Limiting strain of reinforcement and of concrete:

In general, the limiting strains specified in DIN 1045-1 apply. In well-substantiated cases increased limiting strains may be assumed, however, any strain reducing actions must be taken into account.

Shear force:

The bearing capacity regarding shear forces on a structural member made of reinforced or prestressed concrete shall be verified in accordance with DIN 1045-1 unless otherwise specified in the following. For each cross section it shall be checked whether or not the effective shear force V_{Ed} is larger than the design value of the supportable shear force on a structural member without transverse reinforcement $V_{Rd,ct}$, i.e., the following cases must be discerned:

$V_{Ed} \leq V_{Rd,ct}$ → no transverse reinforcement required

Note:

Beams, one-way slabs with b / h < 5: minimal reinforcement

$V_{Ed} > V_{Rd,ct}$ → transverse reinforcement necessary

Following the method presented in DIN 1045-1, the design value $V_{Rd,ct}$ for standard concrete is determined as

$$V_{Rd,ct} = [\, c_d \cdot 0.10 \cdot \kappa \cdot (100 \cdot \rho_l \cdot f_{ck})^{1/3} - 0.12 \cdot \sigma_{cd} \,] \cdot b_w \cdot d \qquad (3\text{-}3)$$

where

c_d is the coefficient specified in **Table 3-4** for the individual Requirement Category A1, A2 and A3.

All other input parameters shall be applied as specified in Equation 70 DIN 1045-1.

Coefficient	Requirement Categories		
	A1	**A2**	**A3**
c_d	1.00	1.15	1.50

Table 3-4: Coefficients c_d for Requirement Categories A1, A2 and A3

In the case of $V_{Ed} > V_{Rd,ct}$, a transverse reinforcement will be necessary. In accordance with DIN 1045-1, a shear force in bending-stressed structural members shall be dimensioned based on a truss model. In this context, the inclination of the compression struts of the truss shall be limited and the shear reinforcement verified as $V_{Ed} \leq V_{Rd,sy}$ and $V_{Ed} \leq V_{Rd,max}$. The inclination limitation of the compression struts as well as the design value of the bearable shear force $V_{Rd,sy}$ which is limited by the bearing capacity of the transverse reinforcements, and the design value of the maximum bearable shear force $V_{Rd,max}$ which is limited by the yield strength of the compression struts shall all be determined for the various Requirement Categories (cf. **Table 3-4**) in accordance with Sec. 10.3.4 DIN 1045-1.

Punching shear:

The punching shear verification must differentiate between the following actions:

- structural members subject to indirect actions that are treated, primarily, in Sec. 10.5 DIN 1045-1 (support pillars for slabs or foundations), and
- structural members with direct loading that, in nuclear engineering design, are considered as structural members subject to accidental actions in Requirement Categories A2 or A3 (e.g., aircraft crash or jet impingement forces).

The following recommendations pertain to structural members subject to indirect actions.

The punching shear verification shall additionally differentiate between structural members (i.e., slabs or foundations) without punching shear reinforcement and structural members with punching shear reinforcement:

- In the case of structural members without punching shear reinforcement, it shall be verified that the shearing force per unit length, v_{Ed}, to be assumed along the critical circular cut in accordance with Sec. 10.5.2 DIN 1045-1 does not exceed the shear resistance, $v_{Rd,ct}$, i.e. as follows:

  $$v_{Ed} \leq v_{Rd,ct} \quad (3\text{-}4)$$

  Following the method described in DIN 1045-1, the design value $v_{Rd,ct}$ for standard concrete is determined as

  $$v_{Rd,ct} = [c_d \cdot 0.14 \cdot \kappa \cdot (100 \cdot \rho_l \cdot f_{ck})^{1/3} - 0.12 \cdot \sigma_{cd}] \cdot d \quad (3\text{-}5)$$

  where

  c_d is the coefficient specified in **Table 3-4** for the individual Requirement Category A1, A2 and A3.

  All other input parameters shall be applied as specified in Equation 105 DIN 1045-1.

- In the case of structural members with punching shear reinforcement, the maximum shearing force bearing capability along the critical circular cut, $v_{Rd,max}$, is generally limited to

  $$v_{Rd,max} \leq 1.5 \cdot v_{Rd,ct} \quad (3\text{-}6)$$

  The punching shear reinforcement shall be determined as specified in DIN 1045-1.

In the case of structural members with direct loading, the punching shear verification as described above is only conditionally applicable. To verify the concentrated load introduction into slab or shell structures, a modified verification procedure for the shear force or punching force may be applied. Alternatively, more precise verifications may be performed by taking the dynamic effects and the non-linear behavior of the building materials into account.

Indirect actions

In a linear analysis accounting for indirect actions, stiffnesses may be reduced by established methods and the corresponding internal forces superposed on the design loads. In accordance with DIN 1045-1, a reduced partial safety factor of $\gamma_Q = 1.00$ may be applied in this case. This is equivalent to a stiffness reduction to 2/3 of the uncracked cross-section, i.e., $\gamma_Q = 2/3 \cdot 1.50 = 1.00$. Any further reduction must be well substantiated, e.g., by a comparative non-linear analysis.

3.3.2 Steel components

3.3.2.1 Requirement categories

In KTA safety standards the combination of actions has not yet been adapted to the new partial safety factor concept. Regarding the design of component support structures in accordance with safety standards KTA 3205.1 and KTA 3205.2, the correlation between the steel structure loading conditions and the Requirement Categories as shown in **Table 3-5** is recommended. The partial safety factors for the permissible action effects in the ultimate limit state are listed in **Table 3-6**. The partial safety factors in accordance with DIN 18800-1 and DIN EN 1993-1 shall be specified independent of a design situation to be considered for the ultimate limit state.

The design criteria for the individual load cases of the steel structure correspond, with certain overlaps, to the requirements for safety related components in accordance with Requirement Category A1, A2 and A3 under Section 3.3.1.1 of the present recommendations.

Steel Structure Loading Conditions	Design Requirements	Requirement Categories
H, HZ	Full serviceability, repeated loading possible, continued reusability	A 1
HS1		A 1, A 2 *)
HS2	Ensured stability, maintained required functions (e.g. bearing clearance), limited deformations, generally, continued reusability	A 2, A 3 *)
HS3	Large plastic deformation permitted, continued reusability not planned	A 3
*) Categories shall be specified depending on the individual case		

Table 3-5: Correlation between the steel structure loading conditions and Requirement Categories

Requirement Category		A1 / A2 / A3	Comments
DIN 18800-1	γ_M	1,0 / 1,1 *)	cf. Sec. 7.3.1 DIN 18800-1
DIN EN 1993-1-1	γ_{M0}	1,0	large yielding deformations are permissible
	γ_{M1}	1,0 / 1,1 *)	for permissible action effects that depend on the yield strength f_y (e.g., failure of stability)
	γ_{M2}	1,25	for permissible action effects that depend on the tensile strength f_t (e.g., regarding net cross-section failure from tensile loading or failure of bolts or weld seams)
*) Categories shall be specified depending on the individual case			

Table 3-6: Partial safety factors for the permissible action effects in the ultimate limit state for Requirement Categories A1, A2 and A3 (steel structures)

The actions to be superposed in the load cases of steel structures are specified in Table 7-1 of safety standard KTA 3205.1. The so-called “standard loads” in that safety standard correspond to the permanent and temporary actions in accordance with DIN 18800-1, and the so-called “special loads” correspond to the accidental actions and to the actions from earthquakes (cf. correlation presented in **Appendix B** of the present recommendations).

3.3.2.2 Design recommendations

In accordance with DIN 18800-1 the verification procedures listed in **Table 3-7** may be applied. In addition, limit values shall be maintained for the slenderness ratio in all cross-sections, or the buckling safety in accordance with DIN 18800-3 or DIN 18800-4 shall be verified.

Verification Procedures	Determining the	
	internal forces due to actions	**permissible action effects**
elastic – elastic	elastic analysis	elastic analysis
elastic – plastic	elastic analysis	plastic analysis
plastic – plastic	plastic hinge analysis	plastic analysis

Table 3-7: Verification procedures

The specified verification procedures that involve the theory of plasticity are based on the plastic hinge analysis. Verification procedures, such as the non-linear analysis, that extend beyond the simplified methods of the plastic hinge theory by, e.g., taking the more realistic elastic/plastic material behavior into account, are not dealt with in these standards, are, however, considered to be permissible.

The utilization of plastic reserves in cross-sections and systems for the loading conditions of steel structure (in particular, HS1, HS2 and HS3) is subject to the design requirements specified in **Table 3-5**.

Appendix A

Definitions

Ultimate limit state

Condition of the bearing structure which, when exceeded, will immediately lead to a calculational collapse or other forms of failure.

Serviceability limit state

Condition of the bearing structure which, when exceeded, precludes further use because the specified requirements are not anymore fulfilled.

Partial safety factors γ_G, γ_Q for the ultimate limit state

The partial safety factors γ_G, γ_Q are, generally, assumed to be equal to those of building construction design standards, i.e., $\gamma_G = 1.00$ and $\gamma_Q = 0$ for a favorable and $\gamma_G = 1.35$ and $\gamma_Q = 1.50$ for an unfavorable action.

In accordance with Sec. 6.1, para. 9 DIN 1055-100 and DAfStb Booklet 525, the partial safety factor γ_Q for temporary actions may be assumed to be $\gamma_Q = 1.35$ (instead of 1.50), provided, the action can be exactly determined.

Characteristic factor, Q_k

Q_k is specified such that, with a probability of 98 %, it will not be exceeded within the reference duration of one year or, respectively, it will not be reached or exceeded more often (in average) than once in 50 years.

Combination factor $\psi_0 \cdot Q_k$

ψ_0 is specified such that, when applying the combination factor $\psi_0 \cdot Q_k$ in the combinations of actions for the load-bearing limit state (and serviceability limit state), the reliability of the bearing structure will not be smaller than the target value.

Combination factor $\psi_1 \cdot Q_k$

ψ_1 is specified such that the probability of the frequent value $\psi_1 \cdot Q_k$ being exceeded is limited to 300 times a year or to a value of 5 %.

Combination factor $\psi_2 \cdot Q_k$

ψ_2 is specified such that the quasi-permanent value $\psi_2 \cdot Q_k$ is considered as temporal average value where 50 % of the actual values are lower and 50 % higher than this value.

Appendix B

Load Types in Loading Schedules and Pertinent KTA Safety Standards Correlated to the Actions Specified in DIN 1055-100

In the following table the terms used for loads in loading schedules and pertinent safety standards of the Nuclear Safety Standards Commission (KTA) are correlated to the actions specified under DIN 1055-100.

Standards Series / Title	Load Type	Correlation to independent actions specified in DIN 1055-100
Loading schedule	continuous standard loads	continuous
	non-continuous standard loads	variable
All KTA Safety Standards	dead load, continuous standard loads, soil pressure, water pressure (in vessels, pools)	continuous
	restraint in serviceable condition: e.g., forces and moments from temperature changes or support displacements	continuous, possibly variable
KTA 2201.1 Design of nuclear power plants against seismic events; Part 1: Principles	reaction to earthquakes as well as the resulting sequential effects including external loads from damages to plant components not designed against earthquakes (e.g., jet impingement forces)	earthquake
KTA 2207 Flood protection for nuclear power plants	actions from the static water pressure of the design basis water level, from flowing water, water waves, buoyancy, floating debris, ice pressure, and influences from possible sequential effects (e.g., erosion, water undermining)	accidental
KTA 2502 Mechanical design of fuel assembly storage pools in nuclear power plants with light water reactors	loads from spent fuel shipping cask (loaded) including transport equipment	variable
	loads from temperature effects (cooling medium temperature T1 and T2)	variable
	loads from temperature effects (cooling medium temperature T3)	accidental
	loads from operational load depositing procedures (impact factor)	variable
	forces, occurring upon activation of mechanical-equipment protection (e.g., frictional forces)	variable
	loads from plant-internal design basis accidents (e.g. jet impingement forces)	accidental
KTA 3205.1 Component support structures with non-integral connections; Part 1: Component support structures with non-integral connections for components of the reactor coolant pressure boundary of light water reactors	impeded expansions from operational temperatures of the support and the supported components	variable
	component load A specified under KTA 3201.2	continuous, possibly variable
	component loads B and C[1] specified under KTA 3201.2	variable
	component load D specified under KTA 3201.2	accidental
	impeded expansion due to design basis accident temperature	accidental
	pipe rupture loads, jet impingement loads, loads from external events (with the exception of earthquakes)	accidental
	earthquakes	earthquake
KTA 3205.2 Component support structures with non-integral connections; Part 2: Component support structures with non-integral connections for pressure and activity-retaining components in systems outside the primary circuit	component load A specified under KTA 3201.2	continuous, possibly variable
	component loads B and C[1] specified under KTA 3201.2	variable
	component load D specified under KTA 3201.2	accidental
	impeded expansion due to design basis accident temperature	accidental
	pipe rupture loads, jet impingement loads, loads from external events (with the exception of earthquakes)	accidental
	earthquakes	earthquake

[1] Component load C is, possibly, “accidental” (to be specified depending on the individual case)

Appendix C

Standards Referred to in this Progress Report

KTA 2201.1	1990-06	Auslegung von Kernkraftwerken gegen seismische Einwirkungen; Teil 1: Grundsätze	*Design of Nuclear Power Plants against Seismic Events; Part 1: Principles*
KTA 2201.3 (E)	1990-06	Auslegung von Kernkraftwerken gegen seismische Einwirkungen; Teil 3: Auslegung der baulichen Anlagen	*Design of Nuclear Power Plants against Seismic Events; Part 3: Design of Structural Components*
KTA 2201.4	1990-06	Auslegung von Kernkraftwerken gegen seismische Einwirkungen; Teil 4: Anforderungen an Verfahren zum Nachweis der Erdbebensicherheit für maschinen- und elektrotechnische Anlagenteile	*Design of Nuclear Power Plants against Seismic Events; Part 4: Requirements for Procedures for Verifying the Safety of Mechanical and Electrical Components against Earthquakes*
KTA 2207	2004-11	Schutz von Kernkraftwerken gegen Hochwasser	*Flood Protection for Nuclear Power Plants*
KTA 2502	1990-06	Mechanische Auslegung von Brennelementlagerbecken in Kernkraftwerken mit Leichtwasserreaktoren	*Mechanical Design of Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors*
KTA 3201.2	1996-06	Komponenten des Primärkreises von Leichtwasserreaktoren; Teil 2: Auslegung, Konstruktion und Berechnung	*Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis*
KTA 3205.1	2002-06	Komponentenstützkonstruktionen mit nichtintegralen Anschlüssen; Teil 1: Komponentenstützkonstruktionen mit nichtintegralen Anschlüssen für Primärkreiskomponenten in Leichtwasserreaktoren	*Component Support Structures with Non-integral Connections; Part 1: Component Support Structures with Non-integral Connections for Components of the Reactor Coolant Pressure Boundary of Light Water Reactors*
KTA 3205.2	1990-06	Komponentenstützkonstruktionen mit nichtintegralen Anschlüssen; Teil 2: Komponentenstützkonstruktionen mit nichtintegralen Anschlüssen für druck- und aktivitätsführende Komponenten in Systemen außerhalb des Primärkreises	*Component Support Structures with Non-integral Connections; Part 2: Component Support Structures with Non-Integral Connections for Pressure and Activity-Retaining Components in Systems Outside the Primary Circuit*
KTA 3401.2	1985-06	Reaktorsicherheitsbehälter aus Stahl; Teil 2: Auslegung, Konstruktion und Berechnung	*Steel Containment Vessels; Part 2: Analysis and Design*
KTA 3905	1999-06	Lastanschlagpunkte an Lasten in Kernkraftwerken	*Load Attaching Points on Loads in Nuclear Power Plants*
DIN 488-1	1984-09	Betonstahl; Sorten, Eigenschaften, Kennzeichen	*Reinforcing steels; grades, properties, marking*
DIN 1045-1	2001-07	Tragwerke aus Beton, Stahlbeton und Spannbeton; Teil 1: Bemessung und Konstruktion (Siehe auch Berichtigung 1)	*Concrete, reinforced and prestressed concrete structures - Part 1: Design and construction*

DIN 1045-2	2001-07	Tragwerke aus Beton, Stahlbeton und Spannbeton; Teil 2: Festlegung, Eigenschaften, Herstellung und Konformität; Anwendungsregeln zu DIN EN 206-1 (Siehe auch Berichtigung 1 und Änderung DIN 1045-2/A1)	*Concrete, reinforced and prestressed concrete structures - Part 2: Concrete - Specification, properties, production and conformity - Application rules for DIN EN 206-1*
DIN 1045-3	2001-07	Tragwerke aus Beton, Stahlbeton und Spannbeton; Teil 3: Bauausführung (Siehe auch Berichtigung 1 und Änderung DIN 1045-3/A1)	*Concrete, reinforced and prestressed concrete structures - Part 3: Execution of structures*
DIN 1045-4	2001-07	Tragwerke aus Beton, Stahlbeton und Spannbeton; Teil 4: Ergänzende Regeln für die Herstellung und die Konformität von Fertigteilen	*Concrete, reinforced and prestressed concrete structures - Part 4: Additional rules for the production and conformity control of prefabricated elements*
DIN 1055-1	2002-06	Einwirkungen auf Tragwerke - Teil 1: Wichten und Flächenlasten von Baustoffen, Bauteilen und Lagerstoffen	*Action on structures - Part 1: Densities and weights of building materials, structural elements and stored materials*
DIN 1055-2	1976-02	Einwirkungen auf Tragwerke - Teil 2: Bodenkenngrößen	*Actions on structures - Part 2: Soil properties*
DIN 1055-3	2002-10	Einwirkungen auf Tragwerke - Teil 3: Eigen- und Nutzlasten für Hochbauten:	*Action on structures - Part 3: Self-weight and imposed load in buildings*
DIN 1055-4	2005-03	Einwirkungen auf Tragwerke - Teil 4: Windlasten	*Action on structures - Part 4: Wind loads*
DIN 1055-5	2005-07	Einwirkungen auf Tragwerke - Teil 5: Schnee- und Eislasten	*Actions on structures - Part 5: Snow loads and ice loads*
DIN 1055-6	2005-03	Einwirkungen auf Tragwerke - Teil 6: Einwirkungen auf Silos und Flüssigkeitsbehälter	*Actions on structures - Part 6: Design loads for buildings and loads in silo bins*
DIN 1055-7	2002-11	Einwirkungen auf Tragwerke - Teil 7: Temperatureinwirkungen	*Actions on structures - Part 7: Thermal actions*
DIN 1055-8	2003-01	Einwirkungen auf Tragwerke - Teil 8: Einwirkungen während der Bauausführung	*Actions on structures - Part 8: Actions during execution*
DIN 1055-9	2003-08	Einwirkungen auf Tragwerke - Teil 9: Außergewöhnliche Einwirkungen	*Actions on structures - Part 9: Accidental actions*
DIN 1055-10	2004-07	Einwirkungen auf Tragwerke - Teil 10: Einwirkungen infolge Krane und Maschinen	*Actions on structures - Part 10: Actions induced by cranes and machinery*
DIN 1055-100	2001-03	Einwirkungen auf Tragwerke - Teil 100: Grundlagen der Tragwerksplanung - Sicherheitskonzept und Bemessungsregeln	*Actions on structures - Part 100: Basis of design, safety concept and design rules*
DIN 4149	2005-04	Bauten in deutschen Erdbebengebieten - Lastannahmen, Bemessung und Ausführung üblicher Hochbauten	*Buildings in German earthquake areas - Design loads, analysis and structural design of buildings*
DIN 18800-1	1990-11	Stahlbauten; Bemessung und Konstruktion	*Steel structures - Design and construction*

DIN 18800-2	1990-11	Stahlbauten; Stabilitätsfälle; Knicken von Stäben und Stabwerken	*Steel structures - Stability cases - Buckling of rods and rod structures*
DIN 18800-3	1990-11	Stahlbauten; Stabilitätsfälle; Plattenbeulen	*Steel structures - Stability cases - Buckling of plates*
DIN 18800-4	1990-11	Stahlbauten; Stabilitätsfälle; Schalenbeulen	*Steel structures - Stability cases - Buckling of shells*
DIN 25449	1987-05	Auslegung der Stahlbetonbauteile von Kernkraftwerken unter Belastungen aus inneren Störfällen (wird derzeit überarbeitet)	*Design and construction of reinforced concrete building elements in nuclear power plants regarding the loading from internal events* *(currently being revised)*
DIN EN 206-1	2001-07	Beton - Teil 1: Festlegung, Eigenschaften, Herstellung und Konformität; Deutsche Fassung EN 206-1:2000	*Concrete - Part 1: Specification, performance, production and conformity; German version EN 206-1:2000*
DIN EN 1993-1-1	2005-07	Eurocode 3: Bemessung und Konstruktion von Stahlbauteilen Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau; Deutsche Fassung EN 1993-1-1:2005 (Siehe auch die Änderungen A1 und A2)	*Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings;* *German version EN 1993-1-1:2005* *(cf. corrigendas A1 and A2 of the German version)*
DIN EN 1990	2002-10	Eurocode: Grundlagen der Tragwerksplanung	*Eurocode: Basis of structural design; German version EN 1990:2002*
DASt 103	1993-11	Richtlinie zur Anwendung von DIN V ENV 1993-1-1-Eurocode 3: Bemessung und Konstruktion von Stahlbauten; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau	*[DASt – German Commission for Steel Structures]* *Guideline regarding application of DIN V ENV 1993-1-1 Eurocode 3: Design and construction of steel structures;* *Part 1-1: General design rules, design rules for buildings*
DIBt-Mitteilung, Sonderheft 11/2	1998-12	Anpassungsrichtlinie zu DIN 18800 – Stahlbau – Teile 1 bis 4 (November 1990) – korrigierte Ausgabe Oktober 1998	*[DIBt - German Institute for Civil Engineering]* *Adaptation guideline for DIN 18800 – Steel structures – Parts 1 through 4 (November 1990)* *– ammended version October 19898*
DIBt Mitteilungen 1/2002	2002-02	Neues Normenwerk im Betonbau, Bauaufsichtliche Einführung beschlossen – Festlegungen und Konsequenzen	*DIBt Report: New standards for concrete buildings, Decision reached for national technical approval – Provisions and ramifications*
DAfStb, Heft 525	2003-09	Erläuterungen zu DIN 1045-1	*[DAfStb - German Commission for Steel Concrete]* *DAfStb Booklet: Comments regarding DIN 1045-12*
CEB-FIP, Model Code 1990		CEB-Comité Euro-International du Béton: CEB-FIP Model Code 1990, Final Draft, Bulletin d´information, No.	

203-205, Lausanne, Juni 1991

Zurückgezogenen Normen und Richtlinien / *Withdrawn Standards and Guidelines*

Hinweis:

Die Regelungen sind z.T. noch bauaufsichtlich relevant

Note:

Some of these regulations are still valid with regard to their national technical approval

DIN 1045	1988-07	Beton und Stahlbeton; Teil 1: Bemessung und Ausführung	*Concrete and reinforced concrete - Part 1: Design and construction*
DIN 1048-1	1978-12	Prüfverfahren für Beton; Frischbeton, Festbeton gesondert hergestellter Probekörper	*Testing concrete; Fresh concrete, hardened concrete of separately produced test specimens*
DIN 1048-2	1976-02	Prüfverfahren für Beton; Bestimmung der Druckfestigkeit von Festbeton in Bauwerken und Bauteilen, Allgemeines Verfahren	*Testing concrete; Determining of hardened concrete of structures and building elements, general procedures*
DIN 1055-1	1978-07	Lastannahmen für Bauten; Lagerstoffe, Baustoffe und Bauteile, Eigenlasten und Reibungswinkel	*Load assumptions for structures; Storage materials, building materials and components; Self weights and friction angles*
DIN 1055-3	1971-06	Lastannahmen für Bauten; Verkehrslasten	*Load assumptions for structures; Imposed loads*
DIN 1055-4	1988-08	Lastannahmen für Bauten; Verkehrslasten, Windlasten bei nicht schwingungsanfälligen Bauwerken	*Load assumptions for structures; Imposed loads*
DIN 1055-5	1975-06	Lastannahmen für Bauten; Schneelast und Eislast	*Load assumptions for structures; Snow loads and ice loads*
DIN 1055-6	1987-05	Lastannahmen für Bauten; Lasten in Silozellen	*Load assumptions for structures; Loads in silo structures*
DIN 4114-1	1952-07	Stahlbau; Stabilitätsfälle (Knickung, Kippung, Beulung) - Berechnungsgrundlagen, Vorschriften	*Steel structures; Stability load cases (folding, tilting, buckling) – Design fundamentals, regulations*
DIN 4114-2	1953-02	Stahlbau; Stabilitätsfälle (Knickung, Kippung, Beulung)	*Steel structures; Stability load cases (folding, tilting, buckling)*
DIN 4133	1973-08	Schornsteine aus Stahl; Statische Berechnung und Ausführung	*Steel stacks; Static design and construction*
DIN 4227-1	1988-07	Spannbeton – Bauteile aus Normalbeton mit beschränkter oder voller Vorspannung Berechnungsgrundlagen, Richtlinien	*Prestressed concrete – building elements made of standard concrete under limited or full prestress* *Design fundamentals, regulations*
DIN 18800-1	1981-03	Stahlbauten; Bemessung und Konstruktion	*Steel structures; Design and constructions*
DIN 18806-1	1984-03	Verbundkonstruktionen; Verbundstützen	*Composite structures; composite columns*
DIN 18800-7	1983-05	Stahlbauten - Herstellen, Eignungsnachweise zum Schweißen	*Steel structures - Manufacture, verification of suitability for welding*
DIN V ENV 1993-1-1	1993-04	Eurocode 3: Bemessung und Konstruktion von Stahlbauteilen Tei 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; Deutsche Fassung ENV 1993-1-1:1992	*Eurocode 3: Design and construction of steel building element* *Part 1-1: General design regulations, design regulations for buildings* *German version ENV 1993-1-1:1992* *(cf. amendments A1 and A2)*

		(Siehe auch die Änderungen A1 und A2)	
DASt 008	1973-03	Richtlinien zur Anwendung des Traglastverfahrens im Stahlbau	*[DASt – German Commission for Steel Construction]* *DASt Guideline, Applying the ultimate load method in steel structures*
DASt 012	1978-10	Beulsicherheitsnachweise für Platten (Diese Fassung ist noch gültig, aber nur in Verbindung mit DIN 18800-1, 1981-03)	*DASt Guideline, Verification of buckling safety for plates* *(This version is still applicable, however, only in conjunction with DIN 18800-1 (1981-03)*
DASt 013	1980-07	Beulsicherheitsnachweis für Schalen	*DASt Guideline, Verification of buckling safety for shells*