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Use of anchors in nuclear power stations and nuclear facilities

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1 Preliminaries

In nuclear power stations and nuclear facilities anchors are often used as fixing devices for the additional fixing of parts of works. These anchors shall, in general, be suitable for anchorages in cracked and non-cracked concrete. Proof of suitability can be delivered by means of a national technical approval.

The following specifications apply to anchors used as fixing devices for new constructions, reconstructions as well as in the case of retrofitting.

One of the decisive criteria of use of these anchors is the question whether their failure in the special load cases (see clause 2.2) may directly or indirectly affect the nuclear safety of the nuclear power station or nuclear facility. Consequently, difference is made - from the point of view of nuclear design - between the fixing of safety relevant components and the fixing of not safety relevant components. They are called in the following „safety relevant anchorages“ and „not safety relevant anchorages“.

Safety relevant anchorages shall ensure a sufficient load resistance also in the assumed special load cases (see clause 2.2). These special load cases are outside the field of application of technical approvals. They take account of
a) impact loads
b) crack widths of $w > 0{,}4$ mm in reinforced concrete constructions.
This is the reason why for these anchorages additional tests are required which are listed up in clause 5. The tests described in this paper only take account of the required additional tests to be carried out on safety relevant anchorages.

This paper includes specifications for the determination of load resistance and design of safety relevant anchorages made with anchors in nuclear power stations and other nuclear facilities..

Anchorages which are not safety relevant shall be planned and designed in accordance with the relevant national technical approval.

This paper was elaborated by a Project Team of the experts committee „Anchorages and fastenings“ at the Deutsches Institut für Bautechnik.

2 Particularities for anchorages in nuclear power stations

2.1 General

As already mentioned in clause 1 difference shall be made for construction works of nuclear power stations between safety relevant and not safety relevant anchorages.

The adequate load resistance and serviceability of safety relevant and not safety relevant anchorages made with anchors in parts of works shall be verified under service conditions.

The term „safety relevant“ in this paper only refers to the nuclear aspects of the nuclear facility. Safety relevant anchorages in the sense of nuclear design are only used in safety relevant construction works or parts of construction works because the integrity of the structural member in the special load case is the condition for the integrity of a part of the construction work or its fastening, respectively. To these anchorages of safety relevance also anchorages carried out in not safety relevant parts of construction works are belonging, the failure of which may lead to the risk of collapse of safety relevant parts of the works. Both types of fixings are summarized in this paper under the term „**safety relevant anchorages**“. For these anchorages, the special exposures and larger crack widths in the special load cases have to be taken into account.

Note:
Safety relevant anchorages shall be designed as ductile fastenings because of the fact that the safety of the fixtures (fixed constructions) will be increased by rearrangement of load transmission. The required ductility may be ensured by the fixture, the anchor plate or the anchors themselves. In general, for the calculated mode of failure of the structure consisting of fixture, anchor plate and anchor, concrete cone failure should not govern.

2.2 Loads acting on anchors and requirement categories for safety relevant anchorages

2.2.1 Loads

Safety relevant anchorages shall be designed such that they resist not only to loads resulting from the load cases under service conditions but also to loads caused by external actions (earthquake, aircraft crash, explosion) and/or internal accidents.
According to DIN 25449 /1/ for anchorages made with anchors difference is made between three categories of requirements the loads and load combinations of which can be considered for requirement categories A and B in the sense of DIN 1045 /2/ as predominantly static loads (number of load cycles $N \leq 10^4$).

2.2 Requirement categories:

a) **<u>Requirement category A</u>**

Load cases (accidents) with a frequency of occurrence of one accident during the whole working life of a construction work. These load cases are:

External actions (Einwirkungen von außen - EVA) = external accidents

- Reference (design) earthquake (safety earthquake)
- Induced vibrations (impact) caused by aircraft crash[1)]
- External explosion (direct pressure load or induced vibrations, respectively)

Internal actions (Einwirkungen von innen - EVI) = internal accidents

- Differential pressures
- Intensity (forces) of radiation
- Supporting and securing forces
- Impact loads
- Increased temperatures

b) **<u>Requirement category B</u>**

Accidents with a frequency of occurrence of $\leq$ 10 accidents during the working life of a structural member.

c) **<u>Requirement category C</u>**

- Normal service loads, predominantly static loads in the sense of DIN 1055
  The load assumptions according to DIN 1055 /3/ apply.
- Accidents with a frequency of occurrence of > 10 during the working life of a structural member.

2.2.3 Crack widths

In the suitability tests to be carried out on anchors for requirement category A crack widths of $w > 0{,}4$ mm shall be considered. The crack widths to be used are given in clauses 5.2.

These crack widths represent an upper envelope and take account of all extreme cases to be covered so that a separate verification of crack widths to be expected in the area of anchorage will not be necessary.

If detailed proof of the characteristic crack width w_k to be expected at the place of use is delivered, the tests for verification of suitability of anchors as well as for determination of the admissible service conditions may be carried out using the crack widths given in or to be calculated according to clause 5.2.1.

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1) In the immediate area of impact of an aircraft anchorages made with anchors are not allowed because of the important deformation and crack widths to be expected in the structural member hit by the aircraft.

2.3 Base material concrete

Normal concrete of strength class B 25 to B 55 according to DIN 1045 /2/ or C 20/25 to C 50/60 according to ENV 206 /4/.

For anchorages made in concrete of higher strength than B 55 or C 50/60 or made in high density (heavy) concrete further tests and assessments will be required for the anchors which have to be specified in each individual case.

The temperature in the base material under service conditions shall at long term not exceed a value of 80°C because at higher temperatures the tensile strength of concrete may decrease. In case of temperatures exceeding 80°C further considerations will be required.

2.4 Splitting forces resulting from anchorage

The transmission of tensile splitting forces caused by anchors shall be verified; in general, a reinforcement will be required in this case. The ratio that tensile force bears to the load acting on the anchorage shall be taken from the relevant national technical approval.

3 Requirements for anchors

3.1 General

For safety relevant anchorages only anchors may be used the suitability of which for anchorage in cracked and non-cracked concrete has been verified. This verification may be based on a national technical approval.

Anchor systems with sufficient mechanical interlock (e.g. undercut anchors) shall be used because these anchors are in general much less sensitive to changes of crack widths than other anchor systems.

For safety relevant anchorages anchors shall be used satisfying also the requirements of the additional tests described in the following clause 5.

3.2 Minimum anchorage depth

For safety relevant anchorages the minimum anchorage depth of anchors shall in general be equal to 80 mm. The anchorage depth may be reduced to 40 mm if only very small loads have to be transmitted ($R_k \leq 0,4$ kN for all load directions).

3.3 Corrosion protection

For the protection of anchors against corrosion the provisions laid down in the relevant technical approvals have to be considered; if necessary, higher exposures to corrosion have in addition to be taken into account.

3.4 Safety in case of fire

For the safety of anchors in case of fire the requirements laid down in the relevant technical approvals are valid.

3.5 Safety in case of radiation

The effect of radiation exposure on the load capacity of anchors may be neglected in the case of metal anchors.

4 Installation conditions for anchors

4.1 Assumptions

This paper is applicable to anchors provided that they are installed by trained personnel and that it is ensured by corresponding measures of supervision that the anchors are correctly installed.

Note:
The above assumption allows in the case of safety relevant anchorages to omit tests for verification of the effect of imperfections during installation on the load resistance of anchors and is the condition for safety factors.

4.2 Conditions

The rules for installation of the anchors laid down in the relevant national technical approval have to be considered. The following conditions for the installation of anchors shall be observed:

- In order to avoid aborted drill holes or damages to the reinforcement, respectively, the exact position of the reinforcement shall be determined by means of a corresponding reinforcement detector.

- The concrete in the area of the steel member to be fixed shall be smooth in order to ensure that the steel fixture after installation of anchors will fit close to the concrete over its entire surface. In case of an uneven concrete surface a levelling layer of mortar may be applied in order to achieve a smooth surface.

- The required distances to edges of structural members, openings, change of elevation of slabs (floors) or installed facilities shall be observed in the same way as the spacings between anchors (e.g. anchor plates with headed bolts).

- Anchors which are not correctly installed shall be removed as far as possible.

- Aborted drill holes of a depth of $t > h_{ef} / 4$ shall be completely filled with high strength mortar. It is also the question of an aborted hole if an anchor which is not correctly installed is removed again. An anchor may be installed with a spacing corresponding to three times the diameter of the aborted drill hole. Prestressing or loading of the anchor after filling the aborted drill hole with high strength mortar will be admissible at the earliest when the strength of the mortar is at least equal to the strength of the concrete. If the evolution of strength of the mortar is not known, the anchor is allowed to be prestressed or loaded after 24 hours at the earliest.

- The anchors shall always be torqued with the maximum torque moment given in the technical approval.

  Note:
  In order to improve the load-bearing and deformation behaviour of the anchors it is recommended after application of the prescribed torque moment to torque the anchors again after about 2 to 3 hours (at the earliest).

- In the area of supports, brackets, the bottom sides of beams, near chases and free edges of structural members as well as in areas with dense reinforcement (spacing of reinforcement bars $\leq 3\ d_s$) anchorages of only small anchorage depth ($h_{ef} < 80$ mm) are not admissible because of the risk of splitting of concrete.

5 Additional tests

5.1 General

This chapter summarizes the additional tests to be carried out on safety relevant anchorages.

The additional tests shall be carried out by testing laboratories who dispose of the necessary equipment and are experienced with the testing of fastenings in the framework of approval procedures.

If not otherwise stated the tests shall be carried out on all anchor sizes foreseen.

5.2 Testing and evaluation of tests

5.2.1 Crack widths

The tests shall be carried out with crack widths of w_1 = 1.0 mm and w_2 = 1.5 mm.
If a detailed verification of the characteristic crack width w_k to be expected at the point of application is foreseen, the tests shall be carried out with $w_1 = 0.7 \cdot w_k$ and $w_2 = \max w_k$, where w_k corresponds to the 95 %-fractiles of the crack widths to be expected.

Note:
The above crack widths have been determined on the basis of comparative calculations carried out on different nuclear power stations, (the effect of the concrete between the cracks has been taken into account) w_1 is the crack width for requirement category A and w_2 is the crack width occurring only in extreme cases.

5.2.2 Test conditions and requirements

The tests are carried out in unidirectional cracks on correctly installed single anchors. As test members expansion elements ($d \geq 2\ h_{ef}$) are used ensuring an approximately constant width of crack over the entire height of the test member during load application. The concrete strength shall correspond to B 25 (25 N/mm^2 $\leq \beta_{WN} \leq$ 35 N/mm^2). The anchors shall be torqued with the maximumn torque moment given in the approval.

Installation of anchors shall be in accordance with ETAG /5/, Annex A.

5.2.2.1 Suitability tests

If a general proof cannot be delivered that the behaviour of anchors located in intersecting cracks of crack width $w = w_1$ is at least equivalent to the behaviour of anchors located in unidirectional cracks of crack width $w = w_2$, the following tests shall in addition be carried out in intersecting cracks of $w = w_1$.

Note:
It is assumed that for requirement category A the number of load cycles with high loads and important load variations acting on the anchorage is equal to N_L = 10. The number of load cycles acting on the structural member with large crack widths and crack movements is assumed to be equal to N_R = 5.
In the tests a higher number of load cycles is applied in order to ensure that the anchors will not fail by pull-out if some further load cycles are applied and in order to take account of the effect of a great number of load cycles with smaller loads and load variations on the displacement behaviour of the anchors.

5.2.2.1 a) Monotonic tensile loading of anchors until failure during opening of crack

Test conditions
- Install anchor in hair crack. Open crack up to w_2 with the anchor remaining unloaded.
- Carry out tensile test according to ETAG, Annex A /5/ with opened crack
- Number of tests $n \geq 5$

Requirements
- Uniform rate of increase of load/displacement curve (see ETAG, Parts 1 and 3 /5/)
- Coefficient of variation of the displacements at $F = 0.5\ F_{Ru,m}$ smaller than 50 %[2)]
- Coefficient of variation of the ultimate loads smaller than 20 %
- Ultimate load $\geq$ 80 % of the value of $w = w_1$ (see also clause 5.2.2.2 a)

If the requirement for the ultimate load is not satisfied, then the characteristic tensile load resistance $N_{Rk,p}$ shall be reduced (see clause 5.2.3.2 c).

5.2.2.1 b) Load cycles (tensile loading) applied to anchors during opening of crack

Test conditions
- Install anchor in hair crack. Open crack up to w_2 with the anchor remaining unloaded.
- Load cycles in the range of pulsating tensile stresses:
  $N_{max} = N_{Rk} / \gamma_{Mc}$
  N_{min} = After every tensile loading the anchor shall be pushed back in its initial position
  Number of load cycles $N_L = 15$
  Frequency $\leq$ 1 Hz

  N_{RK} = characteristic tension resistance of anchors for requirement category A, determined from tests with $w = w_1$ according to clause 5.2.3.2 (the smallest value according to clauses a) to c) will govern)
  γ_{Mc} = partial safety factor for material resistance for requirement category A (see 5.2.3.6)

- tensile test according to ETAG, Annex A /5/ with opened crack ($w = w_2$)
- number of tests $n \geq 5$

Requirements
- During application of load cycles failure of the anchor is not allowed to occur.
- In the following pull-out test the load/displacement curves shall satisfy the requirements according to clause 5.2.2.1 a) without taking account of the residual displacements after the load cycles. The residual load resistance in the pull-out test shall at least correspond to 90 % of the load resistance of anchors without prior application of load cycles (see clause 5.2.2.1 a)), but at least be equal to 70 % of the load resistance for crack width w_1 (compare clause 5.2.2.2 a)).

If an anchor fails by pull-out during application of the load cycles or if the displacements are too important (see clause 5.2.3.7) then the tests shall be repeated with application of a smaller maximum load N_{max}. The characteristic tension resistance $N_{Rk,p}$ shall in this case be reduced (compare clause 5.2.3.2 c), Equation 5.6).

If the requirement for the ultimate load is not satisfied, then, too, the characteristic tension resistance $N_{Rk,p}$ shall be reduced (see clause 5.2.3.2 c), Equation 5.5).

5.2.2.1 c) Tests carried out with constant tensile loading in opening and closing cracks

Test conditions
- Install anchors in hair crack. Open crack to w_2.
- Load anchors by applying a tensile force N_p
  $N_p = N_{RK} / \gamma_M$
  N_{RK} / γ_M: see clause 5.2.2.1 b)

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2) If the above coefficient of variation of the displacements is $v > 30$ % or if the coefficient of variation of the ultimate loads is $v > 10$ % the number of tests shall be increased to $n = 10$.

- crack movements at constant tensile loading of anchor with N_p
  $w_{max} = w_2$
  $w_{min} = w_2 - 0.5$ mm
  number of crack movement cycles $N_R = 10$
  frequency $\approx$ 0.2 Hz
- After the crack movement cycles a tensile test is carried out with opened crack ($w = w_2$) according to ETAG, Annex A /5/
- number of tests $n \geq 5$

Requirements
- During application of crack movements the anchor is not allowed to fail.
- In the following pull-out test the load/displacement curves shall satisfy the requirements according to 5.3.2.1 a). The residual load resistance shall at least be equal to 90 % of the load resistance of anchors without prior crack movements (see clause 5.2.2.1 a)), but at least be equal to 70 % of the load resistance for crack width w_1 (compare clause 5.2.2.2 a)).

If an anchor fails by pull-out during application of the load cycles or if the displacements are too important (see clause 5.2.3.7), then the tests shall be repeated with application of a smaller maximum load N_p. The characteristic tension resistance $N_{Rk,p}$ shall in this case be reduced (compare also clause 5.2.3.2 c), Equation 5.6).

If the requirement for the ultimate load is not satisfied, then, too, the characteristic load $N_{Rk,p}$ shall be reduced (see clause 5.2.3.2 c), Equation 5.5).

5.2.2.2 Tests for determination of characteristic loads

5.2.2.2 a) Characteristic pull-out load under tensile loading

Test conditions
- Install anchors in hair crack. Open crack to w_1.
- Carry out tensile test according to ETAG, Annex A /5/ with opened crack
- Number of tests $n \geq 5$

Requirements
- Uniform rate of increase of load/displacement curves (see ETAG, Parts 1 and 3 /5/)
- Scatter of displacements at $F = 0.5\ F_{Ru,m}$ $v \leq 40$ %
- Scatter of ultimate loads $v \leq 15$ %

5.2.2.2 b) Alternating shear loading on anchors

Test conditions
- Install anchors in hair crack. Open crack to w_1 with anchor remaining unloaded.
- Loading of anchor by an alternating shear load acting in the direction of crack
  $V_{max} = V_{Rk} / \gamma_{Mc}$
  Number of load cycles $N_L = 15$

  V_{Rk} = characteristic shear resistance of anchors for requirement category A according to 5.2.3.3 a)
  γ_{Mc} = partial safety factor for material resistance for requirement category A according to 5.2.3.6

- After load cycles carry out shear test until failure with opened crack ($w = w_1$) according to ETAG, Annex A /5/.
- Number of tests $n \geq 5$

Requirements
- No failure of anchor during application of load cycles
- Residual load resistance of anchor > 90 % of the value obtained for $w = w_1$ and monotonic loading

If an anchor fails during application of the load cycles, the tests shall be repeated by applying a smaller maximum load V_{max}. The characteristic shear resistance $V_{Rk,s}$ shall in this case be reduced (compare clause 5.2.3.3 a), Equation 5.8).

If the requirement for the ultimate load is not satisfied, then, too, the characteristic shear resistance $V_{Rk,s}$ shall be reduced (see clause 5.2.3.3 a), Equation 5.7).

5.2.3 Admissible service conditions

5.2.3.1 General

The following applies to the design of safety relevant anchorages, requirement categories A and B. The design is based on design method A (ETAG, Annex C /6/). For the design of anchorages corresponding to requirement category C the relevant national technical approval will be applicable.

5.2.3.2 Tensile loading

a) <u>Steel failure</u>
$N_{Rk,s}$ according to national technical approval

b) <u>Concrete cone failure</u>
$N_{Rk,c}$ according to design method /6/ assuming cracked concrete. In this case, the following modifications have to be taken into account:

$$N^{\circ}_{Rk,c} = k_1{}^{3)} \cdot \sqrt{\beta_{WN}} \cdot h_{ef}^{1,5} \qquad \text{with } k_1 = 6.0 \tag{5.1}$$

$$\psi_{ec,N} = 1.0^{4)} \text{ (in all cases)} \tag{5.2}$$

$$s_{cr,N} = 3\, h_{ef} \tag{5.3}$$

$$c_{cr,N} = 1.5\, h_{ef} \tag{5.4}$$

Note:

3) *The factor k_1 is smaller than the value given in /6/. Account is being taken here of the fact that in the case of large crack widths more important displacements may occur which may reduce concrete cone failure load.*

4) *For the large crack widths to be expected the scatter of the load/displacement curves will be more important than in the case of normal crack widths. The anchor forces may therefore considerably deviate from the values calculated according to the theory of elasticity, the load resistance of a group of anchors thus being possibly reduced. For this reason, the factor $\psi_{ec,N}$ is neglected and a uniform loading of all anchors is assumed. This is on the safe side.*

If in the area of high stresses a splitting of the concrete cover cannot be excluded, the design shall be based on an effective anchorage depth reduced by the concrete cover.

c) <u>Pull-out failure</u>

The characteristic tension resistance $N_{Rk,p}$ for failure mode „pull-out“ corresponds to the 5 %-fractiles of the results of axial tension tests carried out in unidirectional cracks with $w = w_1$ (see clause 5.2.2.2 a)) for a confidence level of $P = 90$ %.

If in the suitability tests the requirements for the ultimate load are not satisfied, then the characteristic tension resistance shall be reduced according to Equation (5.5).

$$N_{Rk,p} = N_{Rk,p0} \cdot N_u / \text{req } N_u \tag{5.5}$$

with

$N_{Rk,p}$ = characteristic tension resistance to be used for the design
$N_{Rk,p0}$ = calculated value of characteristic tension resistance deduced from the results of tests carried out in unidirectional cracks with $w = w_1$
N_u = ultimate load achieved in the suitability test
req N_u = ultimate load required in the suitability test

For the ratio N_u / req N_u the smallest value shall be used for the tests according to clauses 5.2.2.1 b) and 5.2.2.1 c).

The ratio N_u / req N_u shall not exceed the value of 0.7.

The characteristic tension resistance $N_{Rk,p}$ according to Equation (5.5) shall not exceed the value obtained with Equation (5.6).

$N_{Rk,p} \leq \min(\gamma_M \cdot N_{max} ; \gamma_M \cdot N_p)$ (5.6)

with

N_{max} = maximum load in the tests according to clause 5.2.2.1 b)
N_p = constant load in the tests according to clause 5.2.2.1 c)
γ_M = Partial safety factor for material resistance according to clause 5.2.3.6

d) Splitting failure

Verification of failure mode „splitting“ may be omitted because according to clause 2.4 there must be a sufficient reinforcement for taking account of splitting forces.

5.2.3.3 Shear loading

a) Steel failure

$V_{Rk,s}$ corresponds to the 5 %-fractile of the ultimate loads of tests carried out in unidirectional cracks with $w = w_1$ and load applied in the direction of crack for a confidence level of P = 90 % (see clause 5.2.2.2 b)).

If in the tests according to clause 5.2.2.2 b) the requirement for the ultimate load is not satisfied, then a reduction according to Equation (5.7) shall be foreseen. The characteristic shear resistance shall not exceed the value obtained with Equation (5.8).

$V_{Rk,s} = V_{Rk,s0} \cdot V_u / \text{req } V_u$ (5.7)
$\leq \gamma_M \cdot V_{max}$ (5.8)

with
$V_{Rk,s}$ = characteristic shear resistance to be used for the design
$V_{Rk,s0}$ = calculated value of characteristic shear resistance deduced from the results of tests carried out in unidirectional cracks with $w = w_1$
V_u = ultimate load achieved in the suitability tests according to clause 5.2.2.2. b)
req V_u = ultimate load required in the suitability tests according to clause 5.2.2.2 b)
V_{max} = maximum load in the suitability tests according to clause 5.2.2.2 b)
γ_M = Partial safety factor for material resistance according to clause 5.2.3.6

b) Concrete edge failure

– without reinforcement at edges or with structural reinforcement at edges, respectively:
  The design is be based on design method A /6/. The following modifications shall be taken into account:

$V^{\circ}_{Rk,c} = 0.40\ (l/d_{nom})^{0.2} \cdot (d_{nom})^{0.5} \cdot \beta_{WN}^{\ 0.5} \cdot c_1^{\ 1.5}$ [N] (5.9)

$\psi_{ec,V}$ = 1.0 (in all cases) as far as justification for factor 1.0 is concerned see clause 5.2.3.2 b), Note 4)

– with special rear reinforcement:
  Note:
  A generally accepted design method is not available at the moment.

c) Concrete pryout failure

Design based on design method A /6/ with $N_{Rk,c}$ according to 5.2.3.2 b). The corresponding factor shall be taken from the relevant national technical approval.

5.2.3.4 Combined tension and shear loading

For requirement categories A and B the interaction equations according to design method A /6/ shall be used.

5.2.3.5 Bending moments

For the characteristic bending moment in the case of requirement category A the value given in the national technical approval shall be used. For determination of the lever arm the point of restraint in the concrete shall be assumed to be situated at a distance of 0.5 d (d = diameter of bolt) behind the concrete surface. In addition the displacement fraction possibly occurring in the direction of the tension component shall be taken into account.

A partial or full restraint of the anchor in the anchor plate may be assumed if the restraint moment can be transmitted by the fixture.
A verification of resistance to bending may be omitted if for the design of the fixtures the maximum displacements measured after 10 load cycles between $\pm V_{max}$ according to clause 5.2.2.2 b) are taken into account and if the conditions given in the design method /6/, clause 4.2.2.2, are observed.

For requirement categories B and C anchorages shall be designed such that an exposure to bending of the anchor has not to be taken into account; the conditions to be observed in this case are given in the design method /6/, clause 4.2.2.2.

5.2.3.6 Safety factors

The concept of partial safety factors is used.

a) Loads

$\gamma_G = \gamma_Q$	=	1.0	requirement category A
	=	1.2	requirement category B
	=	1.4	requirement category C

b) Material

concrete:

$\gamma_{Mc} = \gamma_{Mp}$	=	1.7	requirement category A
	=	1.9	requirement category B
	=	2.1	requirement category C

steel:

γ_{Ms} according to clause 3.2.3 of design method /6/ for all requirement categories.

5.2.3.7 Displacements

The displacements measured in the tests according to clauses 5.2.2.1 b) and 5.2.2.1 c) after load cycles or crack movements, respectively, under the action of a load $N_{Rk,c} / \gamma_{Mc}$ shall be taken into account in the design of the parts of works to be fixed.

Proof shall be delivered that the stability and serviceability of the safety relevant parts of works will be ensured also in the case of the most unfavourable displacement of anchors.

6 Reference documents

/1/ DIN 25449: 1987-05: Design of reinforced concrete members of nuclear power stations exposed to loads resulting from internal accidents

/2/ DIN 1045: 1988-07: Concrete and reinforced concrete, design and execution

/3/ DIN 1055-1: 1978-07 and DIN 1055-3: 1971-06: Load assumptions for structures

/4/ ENV 106: 1990-10: Concrete; performance, production, placing and compliance criteria

/5/ „ETAG“
Guideline for European Technical Approval of Metal Anchors for Use in Concrete; Part 1 and Part 3 as well as Annexes A and B; issue of June 1997

/6/ „Design method“
Guideline for European Technical Approval of Metal Anchors for Use in Concrete; Annex C; issue of June 1997