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GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL

of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Part two:

PLASTIC ANCHORS FOR USE IN NORMAL WEIGHT CONCRETE

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PART TWO:
PLASTIC ANCHORS
FOR USE IN NORMAL WEIGHT CONCRETE

FOREWORD

In this Part of ETAG "Plastic Anchors for Multiple Use in Concrete and Masonry for Non-Structural Applications" the methods of verification and the assessments required for the use of plastic anchors in normal weight concrete are given. For a general assessment of plastic anchors, on principle, Part 1 applies.

The same numbering of paragraphs as in Part 1 is used.

The plastic anchors for use in normal weight concrete shall be used for multiple fixings. By multiple anchor use it is assumed that in the case of excessive slip or failure of one anchor the load can be transmitted to neighbouring anchors without significantly violating the requirements on the fixture in the serviceability and ultimate limit state.

Therefore the design of the fixture shall specify the number n_1 of fixing points to fasten the fixture and the number n_2 of anchors per fixing point. Furthermore the design value of actions N_{Sd} on a fixing point to a value $\leq n_3$ (kN) is specified up to which the strength and stiffness of the fixture are fulfilled and the load transfer in the case of excessive slip or failure of one anchor need not be taken into account in the design of the fixture.

The following default values for n_1, n_2 and n_3 may be taken:

$n_1 \geq 4$; **$n_2 \geq 1$** and **$n_3 \leq$ 4,5 kN** or

$n_1 \geq 3$; **$n_2 \geq 1$** and **$n_3 \leq$ 3,0 kN**.

The required tests for suitability are given in Table 5.1 and the tests for admissible service conditions are given in Table 5.2. The determination of admissible service conditions and determination of characteristic resistances for plastic anchors to be used in concrete are completely given in this Part.

Section two:

GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

5. METHODS OF VERIFICATION

5.4. Safety in use

5.4.2. Tests for suitability

The types of suitability tests, test conditions, the number of required tests and the criteria applied to the results are given in Table 5.1. All the tests shall be performed with single plastic anchors without edge or spacing effects under tension loading.

The tests shall be carried out according to Annex A.

Table 5.1: Suitability tests for plastic anchors for use in concrete

	1	2	3	4	5	6	7			8	9
	Purpose of test	**Base material: Concrete**	**Crack width Δw [mm]**	**Drill bit**	**Ambient Temperature (1)**	**Condition of polymeric sleeve (6)**	**Minimum number of tests per anchor sizes (9), (10)**			**Criteria ultimate load req.α**	**Remarks to the test procedure described in Part 1**
							s	**m**	**l**		
1	Setting capacity for nailed-in anchors only	C20/25	0	$d_{cut,m}$	min T **(2)**	standard	5	5	5	$\geq 0,9$	5.4.2.2
2	Functioning, depending on the diameter of drill hole	C20/25	0	$d_{cut,min}$ **(12)**	normal	standard	5	5	5	$\geq 1,0$	5.4.2.3
				$d_{cut,max}$ **(11)**	normal	standard	5	5	5	$\geq 0,8$	
3	Functioning in cracks	C20/25	0,35	$d_{cut,max}$	normal	standard	5	5	5	$\geq 0,75$	5.4.2.4
4	Functioning under conditioning	C20/25	0	$d_{cut,m}$	normal	dry	-	5	-	$\geq 0,8$	5.4.2.5
				$d_{cut,m}$	normal	wet	-	5	-	$\geq 0,8$	
5	Functioning, Effect of temperature	C20/25	0	$d_{cut,m}$	min T **(3)**	standard	-	5	-	$\geq 1,0$	5.4.2.6
				$d_{cut,m}$	0 °C **(4)**	standard	-	5	-	$\geq 1,0$	
				$d_{cut,m}$	LT: +50 °C **(5)**	standard	-	5	-	$\geq 1,0$	
				$d_{cut,m}$	ST: +80 °C **(5)**	standard	-	5	-	$\geq 0,8$ **(8)**	
6	Functioning Sustained loads	C20/25	0	$d_{cut,m}$	normal	standard	5	5	5	$\geq 0,9$	5.4.2.7
				$d_{cut,m}$	LT: +50 °C **(5)**	standard	5	5	5	$\geq 0,9$	
7	Functioning 24 h Relaxation 500 h	C20/25	0	$d_{cut,m}$	normal	standard	-	5	-	$\geq 0,9$	5.4.2.8 **(7)**
				$d_{cut,m}$	normal	standard	-	5	-	$\geq 1,0$	
8	Maximum torque moment	C20/25	0	$d_{cut,m}$	normal	standard	5	5	5		5.4.2.9

(1) Normal ambient temperature: +21 $\pm$ 3 °C (plastic anchor and concrete),

(2) Minimum installation temperature as specified by the manufacturer; normally 0 °C to +5 °C.

(3) Tests with lowest service temperature (min T) as specified by the manufacturer

(4) Installation at minimum installation temperature as specified by the manufacturer; normally 0 °C to +5 °C.

(5) These values apply for temperature range b) according to Part 1, 4.4.2.6
(**LT** = maximum **long** term temperature +50 °C; **ST** = maximum **short** term temperature +80 °C). For temperature range a) and c) see Part 1, 4.4.2.6.

(6) Conditioning of polymeric sleeve according to Part 1, 5.4.2.5

(7) This test is not required for screwed-in plastic anchors of polyamide PA 6 based on current experience with this material.

(8) Reference values from the tests with maximum long term temperature +50 °C

(9) Anchor size: s = small; m = medium; l = large

[For footnotes (10), (11) and (12) see the following page]

(10) If more than 3 sizes shall be assessed, then all sizes (also intermediate sizes) shall be tested according to line 1, 2, 3, 6 and 8. If the tests from line 1 and 2 of Table 5.2 show regularity in failure mode and ultimate load the intermediate sizes shall not be tested.

If anchors with two embedment depths of any one size shall be assessed, the tests according to line 4, 5 and 7 shall be carried out either with both embedment depths or only with the minimum embedment depth in which case the results from those tests apply to both embedment depths.

(11) The test series with $d_{cut,max}$ may be omitted if the test series according to Table 5.2, line 2 are carried out with $d_{cut,max}$

(12) If two embedment depth of any one size shall be assessed, these tests shall be carried out with the maximum embedment depth.

5.4.3. Tests for admissible service conditions

For determination of the admissible service conditions the tests given in Table 5.2 shall be carried out.

If existing information is available from the manufacturer and the corresponding test report contains all relevant data, then the Approval Body may reduce the number of tests for admissible service conditions, making use of this existing information. However, it will be considered in the assessment only if the results are consistent with the Institute's test results or experience.

All tests for determination of admissible service conditions shall be carried out in concrete C20/25 at normal ambient temperature (+21°C ± 3°C) and standard conditioning of the polymeric sleeve. The drill holes shall be drilled using $d_{cut,m}$ drill bits. The anchor installation shall be carried out according to the manufacturer's published instructions.

Table 5.2: Tests for admissible service conditions for plastic anchors for use in concrete

	1	2	3	4	5	6	7			8
	Purpose of test	**Crack width Δw [mm]**	**Load direc-tion**	**Distances**	**Member thickness h**	**Remarks**	**Number of tests (2)**			**Test procedure described in Annex A**
							s	**m**	**l**	
1	Reference tension tests in non-cracked concrete	0	N	$s > s_{cr,N}$ $c > c_{cr,N}$	$\geq h_{min}$	test with single anchors	5	5	5	Annex A, 5.2
2	Characteristic resistance for tension loading not influenced by edge and spacing effects	0,2	N	$s > s_{cr,N}$ $c > c_{cr,N}$	$\geq h_{min}$	test with single anchors	5	5	5	Annex A, 5.2
3	Edge distance for characteristic tension resistance	0	N	$s > s_{cr,N}$ $c_1 = c_2 = c_{cr,N}$	$= h_{min}$	test with single anchor at the corner	4	4	4	Annex A, 5.2
4	Characteristic resistance for shear loading not influenced by edge and spacing effects	0	V	$s > s_{cr,N}$ $c > c_{cr,N}$	$\geq h_{min}$	test with single anchors	5	5	5	Annex A, 5.4
5	Minimum edge distance and spacing	0	**(1)**	$s = s_{min}$ $c = c_{min}$	$= h_{min}$	double anchor group at the edge at uncast side of test member	5	5	5	Annex A, 5.5.1

(1) Torque moment increased in steps of 0,2 T_{inst} for screwed-in plastic anchors

(2) Anchor size: s = small; m = medium; l = large; intermediate sizes need not be tested

Some plastic anchors can be set in a range of admissible setting depth (min t_{fix} … max t_{fix}). If these anchors are set in a thin skin 40 mm ≤ h < 80 mm (e.g. weather resistant skin of external wall panels according to ETAG 020, Part 1, 2.1.3.1), the anchor may extend beyond the thin member [see Figure 5.1b)] and, hence, this may negatively affect the load carrying capacity. In these cases the most adverse setting position [e.g. Figure 5.1b)] shall be considered in additional tests at least according to Table 5.2, line 1, 3 and line 4 (shear test with c = c_{min}) and, if required, by job site tests according to Annex B. Examples are given in Figure 5.1.

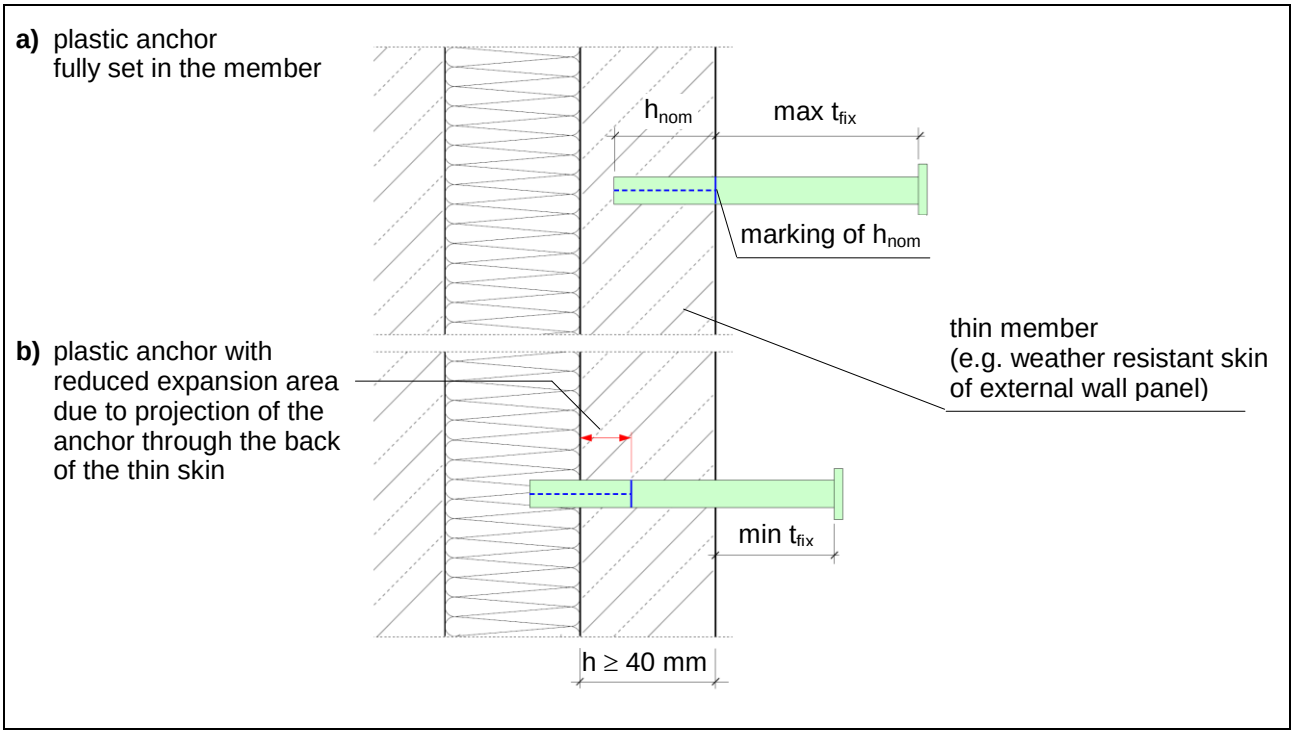

Figure 5.1: Example for different setting positions of plastic anchors in thin members

If plastic anchors are set in a precast prestressed hollow core slab, in most cases the anchors extend beyond the wall with h ≥ 17 mm [see Figure 5.2a)] and, hence, this may negatively affect the load carrying capacity. In these cases the most adverse setting position [Figure 5.2.b)] shall be considered in additional tests at least according to Table 5.2, line 1 and, if required, by job site tests according to Annex B. Examples are given in Figure 5.2.

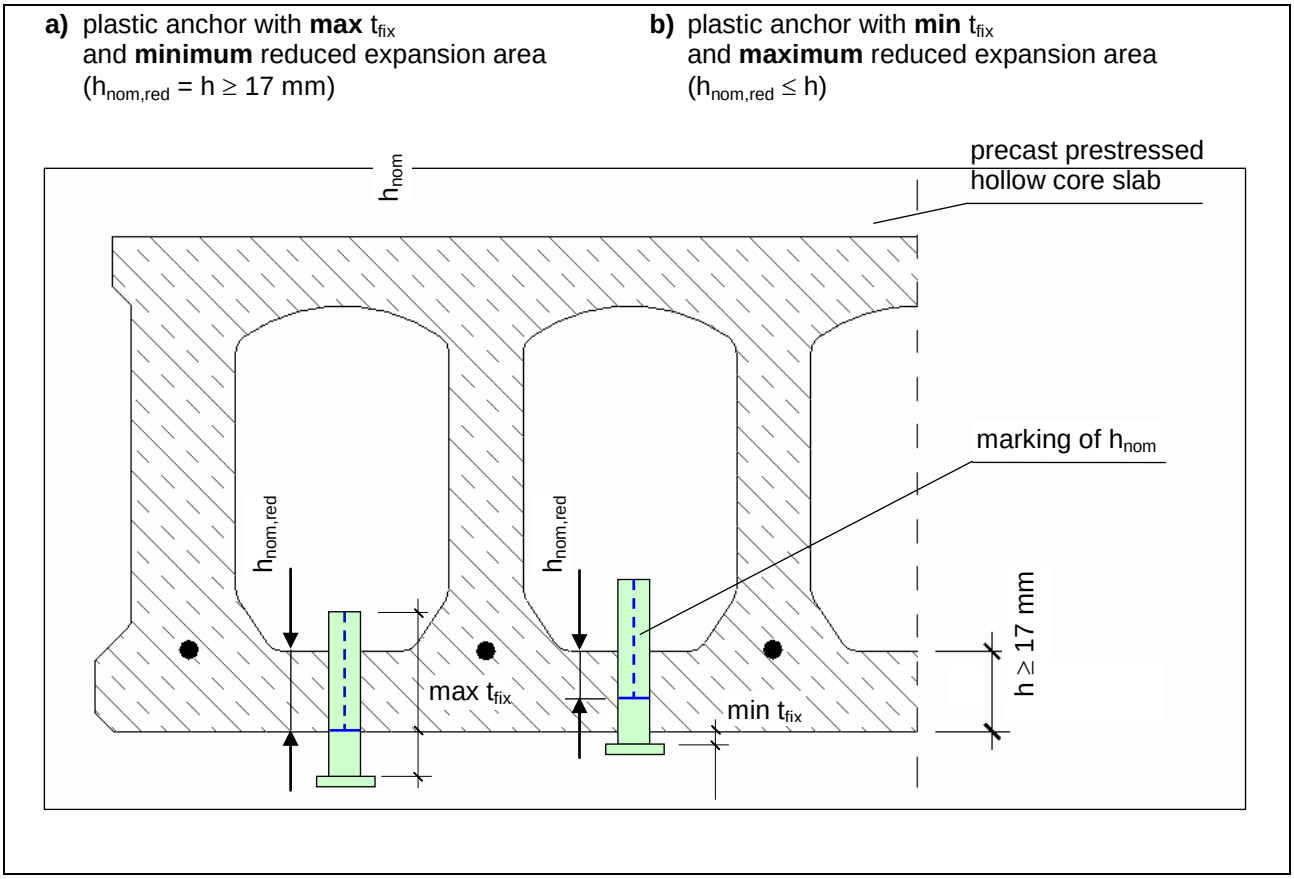

Figure 5.2: Example for different setting positions of plastic anchors in precast prestressed hollow core slabs

6. ASSESSING AND JUDGING THE FITNESS FOR USE

6.4. Safety in use

6.4.1.3. Criteria for all tests

In all tests the following criteria shall be met:

(2) In general, in each test series, the coefficient of variation of the ultimate load shall be smaller than v = 20 % in the **suitability tests** and v = 15 % in the **admissible service condition tests**.

If the coefficient of variation of the ultimate load in the **suitability test** is greater than 20 %, then the following α_v-value has to be taken into account:

$$\alpha_v = \frac{1}{1+0{,}03(\ v[\%]-20)} \leq 1{,}0 \qquad \textbf{(6.6a)}$$

If the coefficient of variation of the ultimate load in the **admissible service condition test** is greater than 15 %, then the following α_v-value has to be taken into account:

$$\alpha_v = \frac{1}{1+0{,}03(\ v[\%]-15)} \leq 1{,}0 \qquad \textbf{(6.6b)}$$

6.4.2. Criteria valid for suitability tests

In the suitability tests according to Table 5.1 the criteria described in Part 1, 6.4 shall be met. The values of the reference tests are taken from the tests according to Table 5.2, line 1 (for non-cracked concrete) and Table 5.2, line 2 (for cracked concrete) with the worst expansion direction.

6.4.3. Admissible service conditions

6.4.3.1. General

The criteria described in Part 1, 6.4.1 shall be met for all tests.

The characteristic resistance corresponds to the 5 %-fractile of the failure loads for concrete strength f_{ck} or steel strength f_{uk}. The requirements on the coefficient of variation of the ultimate loads are given in 6.4.1.3 (2) and Equation (6.6b).

6.4.3.2. Characteristic resistance of single anchor under tension loading

The characteristic resistances for single anchors without edge and spacing effects under tension loading are assessed from the test according to Table 5.2, line 2 with the most unfavourable expansion conditions. The values are valid for all concrete strengths ≥ C16/20, the effect of concrete strength being neglected. In special cases the characteristic resistances for concrete strength C12/15 can be taken at 0,7 times the characteristic resistances for concrete strength C20/25.

The characteristic resistances for single anchors under tension loading shall be calculated as follow:

$$\mathbf{N_{Rk} = N_{Rk,0} \cdot \min^{1)} (\min \alpha_1 ; \min \alpha_{2,\ line\ 1,2,3,6,7}) \cdot \min \alpha_{2,\ line\ 4,5} \cdot \min \alpha_V} \qquad \mathbf{(6.7)}$$

[1)] *The lowest value of min α_1 or min $\alpha_{2,\ line\ 1,2,3,6,7}$ is governing.*

with:

$\mathbf{N_{Rk}}$ = characteristic resistance as given in the ETA. These values shall be rounded to the following numbers: 0,3 / 0,4 / 0,5 / 0,6 / 0,75 / 0,9 / 1,2 / 1,5 / 2 / 2,5 / 3 / 3,5 / 4 / 4,5 /5 / 5,5 / 6 / 6,5 / 7 / 7,5 / 8 / 8,5 / … kN

≤ $\mathbf{N_{Sd} \cdot \gamma_{Mc}}$

$\mathbf{N_{Rk,0}}$ = characteristic resistance from the tests according to Table 5.2, line 2

For thin skins and precast prestressed hollow core slabs the minimum results from the tests according 5.4.3, Figure 5.1 and Figure 5.2 have to be considered.

$\mathbf{\min \alpha_1}$ = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests

≤ **1,0**

$\mathbf{\min \alpha_{2,\ line\ 4,5}}$ = minimum value α_2 (reduction factor from the ultimate load of the suitability tests) according to Part 1, Equation (6.5) of suitability tests. Table 5.1, line 4 and 5 (conditioning and temperature)

≤ **1,0**

$\mathbf{\min \alpha_{2,\ line\ 1,2,3,6,7}}$ = minimum value α_2 (reduction factor from the ultimate load of the suitability tests) according to Part 1, Equation (6.5) of suitability tests. Table 5.1, line 1, 2, 3, 6 and 7

≤ **1,0**

$\mathbf{\min \alpha_V}$ = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20 % and 15 %, respectively; see Equations (6.6a) and (6.6b).

6.4.3.3. Characteristic resistance of single anchor under shear loading

The characteristic resistances for single anchors without edge and spacing effects under shear loading are assessed from the test according to Table 5.2, line 4 using Equations (6.8a) and (6.8b).

$$V_{Rk,s} = V^{t}_{Rk,s} \cdot \frac{f_{uk}}{f_{u,test}} \quad \textbf{(6.8a)}$$

$$V_{Rk,s} \leq 0{,}5 \cdot A_s \cdot f_{uk} \quad \textbf{(6.8b)}$$

with:

$V^{t}_{Rk,s}$ = 5 % fractile of ultimate load from shear tests according to Table 5.2, line 4

$V_{Rk,s}$ = characteristic anchor resistance under shear force

f_{uk} = nominal characteristic steel ultimate strength

$f_{u,test}$ = steel ultimate tensile strength in the test

6.4.3.4. Spacing and edge distance for characteristic tension resistance

The edge distance $c_{cr,N}$ for maximum pull-out capacity of the plastic anchor is evaluated from the results of tension tests on single anchors at the corner ($c_1 = c_2 = c_{cr,N}$) according to Table 5.2, line 3. The mean failure load in the tests with plastic anchors at the corner shall be approximately equal with the values valid for anchors without edge and spacing effects. If this condition is not fulfilled, the tests have to be repeated with a larger edge distance. For plastic anchors in concrete strength C12/15 the evaluated values for the edge distance shall be increased by the factor 1,4.

The spacing $s_{cr,N}$ ensuring the transmission of the characteristic resistance $N_{Rk,p}$ of a single anchor shall be derived as follows:

$$s_{cr,N} = 3 \cdot h_{ef} \quad \textbf{(6.8c)}$$

with:

$$h_{ef} = \left[\frac{N_{Rk,p}}{7{,}2 \cdot \sqrt{f_{ck,cube}}} \right]^{\frac{2}{3}} \quad \textbf{(6.8d)}$$

and $N_{Rk,p}$ as given in the ETA (h_{ef} [mm], $N_{Rk,p}$ [N], $f_{ck,cube}$ [N/mm²])

6.4.3.5. Minimum spacing and minimum edge distance

The minimum spacing s_{min} and minimum edge distance c_{min} shall be evaluated from the results of installation tests with double anchor groups ($c = c_{min}$, $s = s_{min}$) according to Table 5.2, line 5. The 5 %-fractile of the torque moments, $T_{5\%}$ at which a hairline crack has been observed in the concrete at one anchor of the double anchor group, shall fulfil Equation (6.9).

$$T_{5\%} \geq 1{,}7 \cdot req.T_{inst,m} \cdot (f_{c,test} / f_{ck})^{0.5} \quad \textbf{(6.9)}$$

with:

$req.T_{inst,m}$ = mean value of installation torque moment according to Part 2, Table 5.1, line 8.

If no concrete failure occurs in any of the tests, Equation (6.9) is considered as fulfilled.

For plastic anchors in concrete strength C12/15 the evaluated values for minimum spacing and minimum edge distance in C20/25 shall be increased by the factor 1,4 ($s_{min,C12/15} = 1{,}4 \cdot s_{min,C20/25}$, $c_{min,C12/15} = 1{,}4 \cdot c_{min,C20/25}$).

6.4.3.6. Displacement behaviour

As a minimum, the displacements under short and long term tension and shear loading shall be given in the ETA for a load F which corresponds approximately to the value according to Equation (6.10)

$$\mathbf{F} = \frac{F_{Rk}}{\gamma_F \cdot \gamma_M} \qquad \textbf{(6.10)}$$

with:

F_{Rk} = characteristic resistance according to 6.4.3.2

γ_F = 1,4

γ_M = material partial safety factor according to Annex C for the corresponding failure mode

The displacements under short term tension and shear loading (δ_{NO} and δ_{VO}) are evaluated from the tests on single anchors without edge or spacing effects according to Table 5.2, lines 2 and 4. The value derived shall correspond approximately to the 95 %-fractile for a confidence level of 90 %.

Under shear loading the displacements might increase due to a gap between fixture and anchor. The influence of this gap is taken into account in design (see Annex C).

The long term displacements under tension loading, $\delta_{N\infty}$, shall be calculated from the results of the sustained load tests (Table 5.1, line 6) according to Equation (6.11).

$$\delta_{N\infty} = \frac{\delta_{m2}}{2,0} \qquad \textbf{(6.11)}$$

with:

δ_{m2} = mean extrapolated displacement in the sustained load tests for every temperature range (see Annex A)

The long term shear displacements $\delta_{V\infty}$ may be assumed to be approximately equal to 1,5-times the value δ_{VO}.