BUILDING SITE TESTS

3. Construction site tests

3.1. Test recommendations

These recommendations are valid for anchors with a European Technical Assessment (ETA). The job site tests are not considered to be a substitution of the Eurocode EN 1992-4 procedure for assessing the suitability of fixings in a particular base material. Tests in shear are not usually needed as shear performance is generally limited by the material strength of either the structure or the anchor. They may be needed when fixing to low strength masonry.

Tests for anchors on site may be required for two distinct purposes:

1.) To determine the suitability of a fixing and the Recommended Design Resistance of an anchor in the case where no manufacturer's data is available for the specific base material concerned, i.e. where the base material of the application is within the category of the ETA, but does not comply in terms of strength and/or dimensions.
2.) To validate the quality of installation of anchors used on the job, i.e. proof tests.

3.2. Pull-out tests for determining recommended design resistance

3.2.1. Number of tests

The characteristic resistance to be applied to an anchor should be determined by means of at least **15 pull-out tests** carried out on the construction work with a centric tension load acting on the anchor. Execution and evaluation of the tests as well as issue of the test report and determination of the characteristic resistance should be supervised by the person responsible for execution of works on site and be carried out by a competent person. Number and position of the anchors to be tested should be adapted to the relevant special conditions of the construction work in question and, for example, in the case of blind and larger areas be increased such that a reliable information about the characteristic resistance of the anchor embedded in the base material in question can be derived. The tests should take account of the unfavorable conditions of practical execution.

3.2.2. Installation of anchor

The anchor to be tested should be installed (e.g. preparation of drill hole, drilling tool to be used, drill bit, type of drilling hammer or rotation, thickness of fixture) and as far as spacing and edge distances are concerned be distributed in the same way as foreseen for the intended use.
Depending on the drilling tool, hard metal hammer-drill bits or hard metal percussion drill bits, respectively, according to ISO 5468 should be used. New drill bits should be used for one test series.
The cleaning process of the drill hole should follow the manufacturer's installation instruction using the corresponding tools.

3.2.3. Execution of test

The test rig used for the pull-out tests should allow a continuous slow increase of load recorded by a calibrated measuring equipment. The load should act perpendicular to the surface of the base material and be transmitted to the anchor via a hinge.
The reaction forces should be transmitted to the base material such that possible breakout of the concrete / masonry is not restricted. This condition is considered as fulfilled, if the support reaction forces are transmitted

a) Concrete: at a distance of at least 1.5 x h_{ef} from the anchors.
b) Masonry: either in adjacent masonry units or at a distance of at least 150 mm from the anchors.

The load should be progressively increased so that the load is achieved after not less than about 1 minute. Recording of load is carried out when the ultimate load is achieved.

3.2.4. Evaluation of results of pull-out tests

The characteristic resistance N_{Rk1} is obtained from the measured values of N1 as follows:

$$N_{Rk1} = \alpha \cdot N_1 \leq N_{Rk,ETA}$$

The characteristic resistance N_{Rk1} has to be equal or smaller than the characteristic resistance N_{Rk} which is given in the ETA for similar masonry (bricks or blocks).

N_1 = the mean value of the five smallest measured values at the ultimate load.
$N_{Rk,ETA}$ = characteristic resistance N_{Rk} given in the ETA for the same category of masonry.
a = 0.5 for plastic and bonded anchor acc. to TR 053.
a = 0.75 for mechanical and chemical anchor for use in concrete.

If in case of bonded anchors and mechanical anchors the number of pull-out tests is smaller than 15, the characteristic values are to be determined as a 5% fractile:

a) Mechanical and Bonded anchor for use in concrete:

$$N_{Rk1} = N_{Ru,m}(1 - k \cdot v) \cdot f_{b,N} \leq N_{Rk,ETA}^{C20/25}$$

$f_{b,N}$ is a factor for comparing the results with the same compressive concrete strength.

$$f_{b,N} = \sqrt{\frac{25}{f_{ck,cube}}} = \sqrt{\frac{20}{f_{ck,cyl}}}$$

b) Bonded anchor for use in masonry:

$$N_{Rk1} = N_{Ru,m}(1 - k \cdot v) \cdot \beta \leq N_{Rk,ETA}$$

$N_{Ru,m}$ = mean value of the ultimate load of the n tests.
v = coefficient of variation of the ultimate load.
β = is an influencing factor whose values are given in the approval document.
k = factor

Table 1: k factor for calculating 5% fractile

Number of tests n	5	6	7	8	9	10	11	12	13	14	15
k-factor for calclulating 5%-fractile	3.400	3.092	2.894	2.754	2.650	2.568	2.503	2.448	2.402	2.363	2.329

Note: coefficient of variation s unknown, one-sided confidence level p = 0.9

3.2.5. Determination of recommended design resistance

The Recommended Design Resistance: $N_{Rd} = \frac{N_{Rk1}}{\gamma_M}$

γ_M = material safety factor

The partial safety factors for the resistance of anchors with approval may be taken

a) Plastic and bonded anchors for use in masonry:
$\gamma_M = 2.5$
b) Anchors for use in concrete:
$\gamma_M = \gamma_{M,ETA}$ (1.25 x $\gamma_{M,ETA}$ in case concrete compressive strength is unknown)

In absence of national regulations the partial safety factors for the resistance of anchors without any approval may be taken

a) all base material $\gamma_M = 5$

3.3. Preliminary or proof tests for validating the quality of installation of anchors

3.3.1. Number of tests

The minimum number of fixings to be proof tested is 15. The minimum of 15 applies in any discrete area where different anchors may have been used, the base material is different, the condition of the base material has been affected by weather conditions e.g. on a different elevation or where anchors have been installed by different installation teams.
The tests are carried out on the construction work with a centric tension load acting on the anchor. Execution and evaluation of the tests as well as issue of the test report should be supervised by the person responsible for execution of works on site and be carried out by a competent person.

3.3.2. Installation of anchor

The anchor to be tested should be installed (e.g. preparation of drill hole, drilling tool to be used, drill bit, type of drilling hammer or rotation, thickness of fixture) and as far as spacing and edge distances are concerned be distributed in the same way as foreseen for the intended use.
Depending on the drilling tool, hard metal hammer-drill bits or hard metal percussion drill bits, respectively, according to ISO 5468 should be used. New drill bits should be used for one test series.
The cleaning process of the drill hole should follow the manufacturer's installation instruction using the corresponding tools.

3.3.3. Execution of test

The test rig used for the pull-out tests should allow a continuous slow increase of load recorded by a calibrated measuring equipment. The load should act perpendicular to the surface of the base material and be transmitted to the anchor via a hinge.
The reaction forces should be transmitted to the base material such that possible breakout of the concrete / masonry is not restricted. This condition is considered as fulfilled, if the support reaction forces are transmitted

a) Concrete: at a distance of at least 1.5 x h_{ef} from the anchors.
b) Masonry: either in adjacent masonry units or at a distance of at least 150 mm from the anchors.

The load should be progressively increased so that the load is achieved after not less than about 1 minute. Recording of load is carried out when the ultimate load is achieved.

3.3.4. Calculation of proof load

a) Bonded anchors for use in masonry:

$N_p = 0.8 \cdot N_{Ed} \cdot \gamma_{Mp}$

with $\gamma_{Mp} = \gamma_M \cdot \frac{1}{\beta}$

N_p = load Np for the proof load tests
N_{Ed} = design value of action ($N_{Ek} \cdot 8_F$)
8_M = partial safety factors for the resistance (= 2.5 for masonry units)
β = is an influencing factor whose values are given in the approval document

b) Anchors for use in concrete:

$N_p = 0.8 \cdot N_{Sd} \cdot \gamma_{M,p}$

$\gamma_{M,p}$ = material safety factor in case of pull-out failure

3.3.5. Acceptance criteria

Anchors can be said to have satisfied a proof test if the required load is held without movement or any damage or deformation occurring to either the fixing or the base material. Any anchor suffering movement or damage should be recorded as a failure. If, in any discreet area, 1 failure is encountered, the reason for failure should be investigated, the number of anchors tested in that area should be doubled to 5% and at least 6. If more than one fails, then 100% of the anchors should be tested, the reasons for failure determined and the specification reconsidered.

3.3.6. Determination of recommended design resistance

If the quality of installation is proven and the specification not reconsidered, the design resistances are calculated with the data given in the relevant approval.

In case of bonded anchors for use in masonry, where the base material of the application is within the category of the ETA but does not comply in terms of strength and/or dimensions, the Recommended Design Resistance is evaluated as follows:

The Recommended Design Resistance: $N_{Rd} = \frac{N_{Rk2}}{\gamma_M}$
with the characteristic resistance
a) Bonded anchors for use in masonry:

$N_{Rk2} = {}^1/_{0.8} \cdot N_p \cdot \beta \leq N_{Rk,ETA}$

$\gamma_M = 2.5.$

b) Anchors for use in concrete:

$N_{Rk2} = {}^1/_{0.8} \cdot N_p \leq N_{Rk,ETA}$

$\gamma_M = \gamma_{Mp}$ acc. to respective ETA
$\gamma_M = 1.25\ \gamma_{Mp}$ acc. to respective ETA.