TECHNICAL NOTE: SITE TESTING GUIDELINES – VOL 2: PROOF TESTS

VERSION 1.1

1 SCOPE

This Technical Note is Volume 2 of a suite of AEFAC Technical Notes which provides recommendations for proof testing. The purpose of proof tests is to validate correct installation of an anchor. The recommendations are intended to assist design engineers formulate appropriate site testing procedures, and to assist field testers conducting tests on site.

The scope of Volume 2 is to provide recommendations specific to proof tests that are supplementary to the recommendations provided in Volume 1. It is a requirement that Volume 2 be used in conjunction with Volume 1.

2 TERMINOLOGY

A full list of terminology is listed in Section 2 of Volume 1.

3 NOTATION

A full list of notation is provided in Section 3 of Volume 1.

4 GENERAL

The purpose of undertaking proof tests is to demonstrate that an anchor has been correctly installed. It is imperative that the proof test does not damage the anchor as a result of the test. The magnitude of the proof load is at the discretion of the responsible engineer and will be project dependent.

For sampling and testing purposes each discrete population of anchors shall be considered as a separate group and tested separately.

Note: *An upper limit on the test load may be established by considering the expected strength of the fastening.*

$$S^* \leq \phi N_{Rk}$$

where

S^* = design load

ϕ = capacity reduction factor (0.67 for concrete)

N_{Rk} = characteristic resistance of anchor

The maximum proof load for test, $N_{p,\,max}$ should not exceed the design characteristic strength of the fastening ϕN_{Rk} to avoid damage to the anchor.

For anchors with working load capacities, the maximum proof load for test, $N_{p,\,max}$ should not exceed 1.5 × allowable working load of anchor.

However, the anchor should also not yield after the proof load test.

Yield load of anchor = $f_y A_s$

where

f_y = characteristic yield strength of steel

A_s = cross sectional area of steel in tension

Hence the maximum proof load for test, $N_{p,\,max}$ for anchors with ultimate limit state capacities is described in Equation (1):

$$N_{p,max} = \emptyset N_{Rk} \leq \lambda f_y A_s \qquad (1)$$

For anchors with working load capacities, the maximum proof load for test, $N_{p,\,max}$ is described in Equation (2):

$$N_{p,max} = Allowable\ Working\ Load\ \times 1.5 \leq \lambda f_y A_s \qquad (2)$$

NOTE:

λ = factor for limiting maximum applied test load to avoid yield of the anchor. Value of λ varies with international practice, however it is recommended for λ to be limited to 0.7 to avoid onset of yield especially for high-strength anchors

5 TYPE OF TEST

Clause 5.1 of Volume 1 summarises the purpose of performing a proof test.

6 TEST SETUP

6.1 Test equipment

The requirements for the test equipment to be used for a proof test are provided in Cl. 6.1 of Volume 1.

6.2 Configuration of test rig

Details of the test rig configuration for a proof test are provided in Cl. 6.2 of Volume 1. The position of the fixings for proof tests is predetermined by the project.

Displacement measurements for proof tests are generally not required, however Clause 6.2.4 of Volume 1 should be consulted if displacement measurements are required.

7 TEST REGIME

7.1 Application of load

The application of load should be in accordance with the recommendations of Cl. 7.1 of Volume 1.

Load regime for proof test is as follows:

- For anchors with ultimate limit state capacities, proof test load (N_p) should not exceed the ***lesser*** of the ultimate limit state design capacity of the anchor OR 0.7x yield capacity of the anchor to prevent damage to the anchor as per Equation (1).
- For anchors with allowable working load capacities, proof test load (N_p) should not exceed 1.5 × allowable working load of the anchor OR 0.7x yield capacity of the anchor as per Equation (2).
- The proof load shall be maintained for a minimum of 30 seconds. The load should not drop more than 10% in that duration.

The proof load test requires the following procedure to be undertaken:

1. Apply load slowly until the proof load is reached, visually monitoring the specimen for sudden changes in deformation.
2. Record the load achieved and note the maximum load drop 30 seconds after peak load is achieved to check if it is within 10% of the peak load. Note if visible deformation has occurred.
3. Depending on the type of anchor, at the proof test load, there could be visible displacement. For some anchors, this could constitute a failure whereas for others (such as torque controlled anchor), this may not be considered to be a failure but would exceed the allowable serviceability limit. If visible deformation has occurred, client should be consulted to determine if detailed deformation measurement is required.

Note:

1. For applications where serviceability function is critical for the anchor, displacement measurements should be taken and the displacement acceptance criteria should be assessed by the responsible design engineer.
2. A confined test setup is generally suitable for checking installation quality for chemical anchors. However, such setup may not detect gross errors related to incorrect embedment depth of anchors installed. An unconfined test setup would be more appropriate for checking potential gross errors in embedment depth during installation.

7.2 Number of tests

Proof testing should be conducted as best as possible in a random manner. The number of required tests must be assessed on a case-by-case basis by the engineer requesting the tests. However, the following serves as a guide for the minimum requirements:

- A minimum test sample population shall be three specimens or 2.5% of the total relevant anchor population, whichever is greater.
- The 'test sample population' is defined as a group of anchors representative of the relevant anchor population, having the same type of anchor, the same base material (that has not experienced different environmental exposure), same installation method and same installation personnel. Where any of these variables change, this group of anchors shall be considered a separate anchor population.

In specific cases such as fall arrest systems, industry standards and codes of practice may require 100% of anchors to be proof tested.

7.3 Failure cases

Failure of any anchor up to the proof load indicates a serious flaw in the installed product, the substrate, or the quality of installation. It is imperative that the cause of the failure is properly investigated and identified, and the necessary action taken. Failure to address shortcomings in the specification or installation of safety-critical anchors may pose a serious risk to human life.

If a single failure is recorded, the minimum test sample population shall be increased to six test specimens or 5% of the total relevant anchor population, whichever is greater. If two or more test samples fail, all anchors in the relevant anchor population shall be tested. In the event that a failure is observed the responsible engineer must be alerted.

Note: *Under certain circumstances it may be acceptable to replace the failed anchor(s) with replacement anchors. This procedure must only be followed under the direction of the responsible engineer through consultation with product supplier's technical support. If the fasteners cannot be replaced and installed in the same holes the project specification will require modification by the responsible engineer to accommodate different sized anchors and/or different anchor locations.*

8 ADDITIONAL REQUIREMENTS FOR TESTS

Additional considerations for proof tests – particularly regarding the suitability of site tests –are provided in Cl. 8.1 of Volume 1.

9 REPORT OF RESULTS

A list of the information to be included in the proof test report is provided in the Appendix A of Volume 1.

10 SUMMARY

This Technical Note provides recommendations specific to site testing for proof tests. Proof tests are conducted with the intention of demonstrating correct installation of a fastener. Proof tests are not suitable for the investigation of fastener strength.

The information provided in this Technical Note is supplementary to the recommendations provided in Volume 1 of this series. A procedure is presented to identify a suitable proof load as well as key requirements for the sample population for testing.

11 REFERENCES

A list of references is provided in Cl. 11 of Volume 1.