A new testing methodology for avalanche and rockfall barrier anchors.

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INTRODUCTION

The application of lightweight drilling rigs now permits the testing of anchors set in challenging high alpine terrain with working loads of up to 50 tonnes. Such tests are essential for the correct application of rockfall and avalanche barrier systems. In specific, anchor testing is applied to obtain the ground's working load limit for the anchor foundations and to correctly dimension a barrier's superstructure. The current practice for anchor dimensioning in Switzerland requires that pull-tests are performed (proof test and pull-out tests) on anchors according to the SIA 267/1 norm. Pull-out testing is performed on additional test anchors which deliver the characteristic pull-out resistance Ra,k of a specific ground material, where as proof testing is performed as quality control of existing anchors.

Recent years of experience in performing anchor pull-out and proof tests to 50 tonnes in high alpine terrain has reviled that such testing is highly time consuming and material intensive leading to great expense. Furthermore, for maintenance works in which remaining load strength of old anchors must be tested, it has been recognised that a suitable anchor test methodology does not exist. It is often the case during the examination of old barrier protection systems that one might ask „is this anchor still good?". The advantage of the new anchor testing method presented herein over the current pull-out test according to SIA 267/1, are the lower loads required for the test in addition to a more detailed measurement of the anchors remaining load strength.

METHODOLOGY AND FINDINGS

Addressing the inadequacies of the current anchor testing norm SIA 267/1, a new anchor testing methodology has been developed by the Swiss Federal Office for the Environment FOEN in collaboration with the Experts commission for Avalanches and Rockfall EKLS. The aim was to develop an anchor testing methodology that can be performed without compromising the existing anchor, in addition to minimising the required technical effort. The new testing methodology is called the extended-proof test. The idea for the extended-proof test was established during a research project in which 100 anchors were tested across the whole of Switzerland. During these tests it became evident from stress-strain diagrams that the pull-out load could be predicted with loads at 60 % of the characteristic anchor pull-out load. For example, it was found that instead of the standard 50 tonne pull test, a pull load of 30 tonnes is sufficient. The extended-proof test is based on reference curves from pull-out testing (compensation curves according to Gauss's principle).

The remaining load strength of an anchor can be obtained through a direct comparison of stress-strain diagrams from the extended-proof test with the reference diagrams (Fig. 1).

The following reference values for the anchor's remaining load strength η are recommended for anchor testing according to the extended-proof test:

Reference value 1: $\eta \geq 2.0$ fulfilled

Reference value 2: $1.35 \leq \eta < 2.0$ tolerated

Reference value 3: $\eta < 1.35$ exceeds tolerance

CONCLUSIONS

We are convinced that with this new anchor testing methodology that the quality of existing anchors can be fully examined, in addition to providing insights into the ground quality. The extended-proof test anchor testing methodology offers an invaluable tool for engineers concerned with assessing the quality of existing rockfall and avalanche protection systems. A detailed guide to the extended-proof test was published by the Swiss Federal Office for the Environment FOEN in 2014, and can be found at the following link: http://www.bafu.admin.ch/naturgefahren/14186/14809/15599/index.html?lang=de.

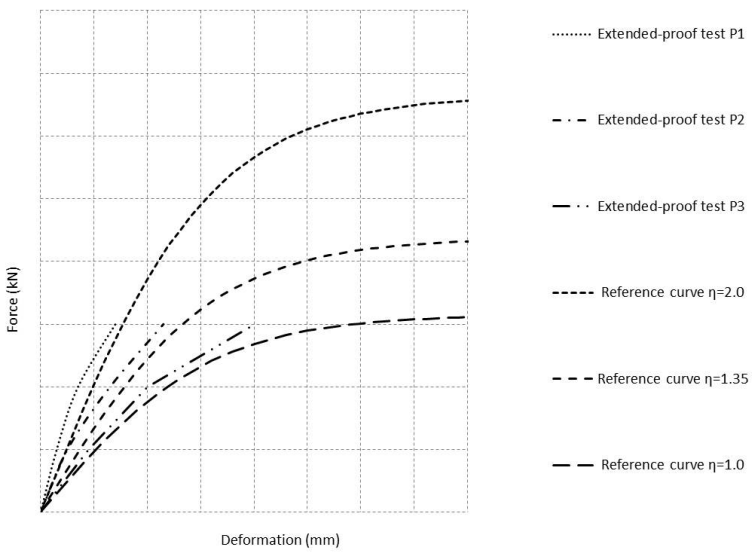

Figure 1. Stress-strain diagram comparing the reference curves to extended-proof test of three different remaining load strengths in tests P1, P2, and P3.

KEYWORDS

Anchor testing; Pull-out tes; Proof testing; Rockfall barrier; Avalanche barrier

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