Lehrstuhl für Grundbau und Bodenmechanik Ruhr-Universität Bochum

Research report to the follow-up project

„Bearing behaviour of cement pressure-grouted anchors under aggressive carbonic acid exposure”

Summary

The bearing behaviour of pressure-grouted ground anchors is based on load transmission into the ground via cement surface of the anchor body. Due to the stress of the carbonic acid a layer of corroded cement is created on the surface of the anchor. This causes on the one hand a loss of bearing capacity by the reduction of the friction angle in the contact zone between anchor body and soil. On the other hand by means of mass loss and penetration of soil particles into the corroded zone a loss of restraint of the anchor arouses. The progression of the corroded layer is controlled by the process of diffusion of carbonic acid through the amorphous, gel-like layer consisting of hydrous silicon dioxides towards the surface of the cement body. The more the thickness of the corroded layer increases the slowlier the corrosion process proceeds. Furthermore the permeability of the surrounding soil affects the process of transport of carbonic acid to the surface of the corrosion zone. In the first part of this research project equations were developed to characterize the progression of corrosion depending on the surrounding soil and the concentration of carbonic acid. To quantify the loss of bearing capacity under carbonic acid exposure pull-out tests of corroded grouted anchors were performed in two different soils. For this purpose the experimental setup was percolated by water containing a determined concentration of carbonic acid for a defined time period of corrosion. After the expiration of the corrosion period a vertical load was applied to the system to achieve realistic stress conditions and the anchor was pulled out of the soil. Moreover pull-out tests on uncorroded anchors were carried out for comparison. By means of comparing the maximum bearing force measured in the tests with the period of corrosion and with the calculated values for the thickness of the corroded layer the following conclusions could be drawn. First of all in fine grained soils the effect of corrosion can be assumed as insignificant due to its low permeability. By applying the equations for the thickness of the corroded zone in comparison to the average grain diameter d_{50} it is possible to estimate the period of corrosion within which no loss of bearing capacity occurs. This is due to the fact that in none of the tests a significant decrease of pull-out force could be observed before the thickness of the corroded layer reached the range of average grain diameter. For coarse-grained soils with high average grain diameter this means that the corrosion process starts to affect the bearing capacity of the anchor only after a long corrosion process – and even then it proceeds only hesitantly because the thickness of the corroded layer increases very slowly in the advanced diffusion process (see above). In future this should be quantified via long-term tests. The maximum effect caused by corrosion was observed in the pull-out tests in the fine to medium grained sand material. After one year of corrosion the loss of bearing capacity was approximately 30 %. On the one hand the permeability of these types of soils is sufficient to allow transport of carbonic acid to the corrosion surface and on the other hand due to the relatively small average grain diameter there is no long process of corrosion required until a loss of bearing capacity by loss of restraint can be observed.

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