NUMERICAL MODELLING OF AN ANCHOR LOAD TEST - INFLUENCE OF THE GROUT

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1. Introduction

Although the bearing capacity of ground anchors mainly depends on the mechanical behaviour of the surrounding soil, details of construction of the anchor may also play a significant role. In this respect, two aspects are investigated in this study: the influence of the pressure grouted body at the fixed length and the behaviour of the so-called free length. Numerical simulations of pressure and gravity grouting were performed as well as simulations with and without the introduction of the grout at the free length. The results are compared against field measurements performed during an anchor pull-out test.

2. Description of the pull-out test and numerical simulations

The pull-out test was performed by Keller Grundbau in St. Kanzian, Austria, in December 2017. The free length was 12 m long and the fixed length 8 m. The anchor was pressure grouted at the fixed length and 6 strands were employed. The displacements of the head of the tendon were monitored, allowing the assessment of the load-displacement behaviour of the structure. The anchor was vertically installed and post-grouted. The soil, locally known as "Seeton", is a clayey silt of low plasticity. Laboratory and in-situ investigations, such as oedometer test, direct shear test and seismic dilatometer test, were performed in order to determine the soil properties. Due to the vertical anchor geometry, the model was axisymmetric. Three different numerical simulations were performed:

- With grout at the free length and fixed length pressure grouted (simulation 1 – S1);
- No grout at the free length and fixed length pressure grouted (simulation 2 – S2);
- With grout at the free length and fixed length gravity grouted (simulation 3 – S3).

The actual configuration employed in-situ was the first one. The other two enable the evaluation of the contribution from the pressuring procedure and from the grout application at the free length. The geometry is presented in Figure 1.

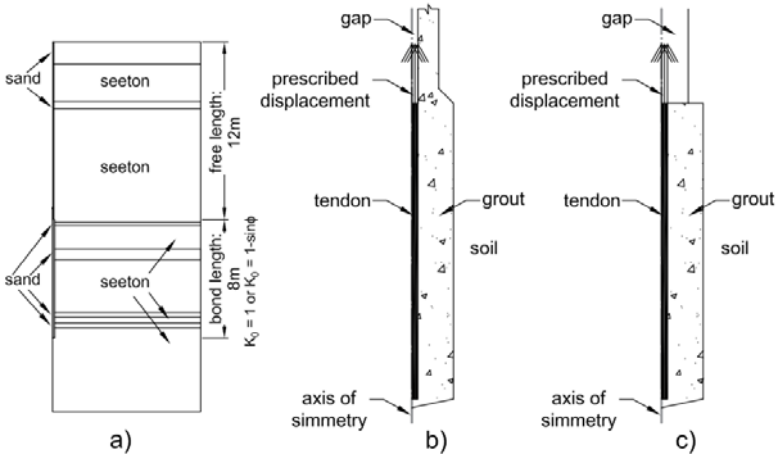

Figure 1. Model geometry: a) Full geometry; b) anchor detail (S1 and S3) and c) anchor detail (S2)

The pressure grouting effect was taken into account by an increase of the lateral stress in the ground, i.e. an increase of the coefficient of lateral earth pressure (K_0 = 1). The tendon was modelled only in the fixed length and a gap was introduced between the axis of symmetry and the grout in the free length. The tendon was simulated as a linear elastic material, the grout was modelled with a nonlinear constitutive model, originally developed for modelling the behaviour of shotcrete (Schädlich and Schweiger, 2014). This model allows post-peak softening in compression and tension and therefore the development of cracks in the grout can be captured. For the soil the Hardening Soil model with small strain stiffness as implemented in the finite element code Plaxis 2D (Brinkgreve et al., 2016) was employed.

3. Results and conclusions

The load-displacement curves obtained numerically and in-situ are shown in Figure 2. The displacements considered are on top of the tendon, at the fixed length.

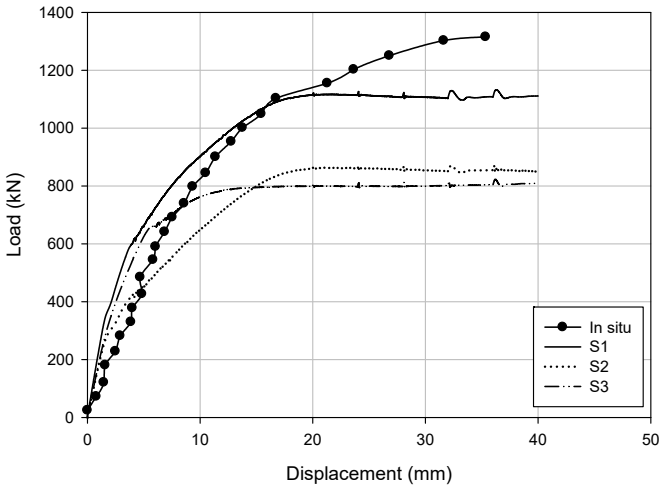

Figure 2. Load-displacement curves

As expected, the best agreement was achieved with simulation S1. Although the in-situ measurement showed higher load values at the end of the test, at about 1100 kN the "creep", conventionally taken as a measure for ultimate capacity, was larger than 2 mm. If no grout was considered in the free length (S2), the ultimate load decreased substantially and the load-displacement behaviour was softer. This configuration reflects conventional design, where it is assumed that there is no load transfer into the soil in the free length although it is very often also grouted in order to provide protection against corrosion. However, the numerical results clearly showed that significant load may be transferred into the ground in the free length. If the anchor is gravity grouted in the fixed length (S3), i.e. no increase of K_0 is assumed in the numerical model, the behaviour at the beginning is similar to "S1" but the ultimate capacity is close to "S2". For this reason, in this particular case the grout in the free length would compensate roughly for not pressure grouting the fixed length.

4. References

[1] Brinkgreve, R.B.J., Kumarswamy, S. & Swolfs, W.M. (2016). *PLAXIS 2016. Finite element code for soil and rock analyses, User Manual*. Plaxis bv, Delft, The Netherlands.

[2] Schädlich, B. & Schweiger, H.F. (2014). A new constitutive model for shotcrete. *Proc. Numerical Methods in Geotechnical Engineering (Hicks, Brinkgreve & Rohe, eds).* Taylor & Francis Group, London, 103-108.