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Influence of Matric Suction on Pullout Resistance of Soil Nails

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Soil nailing is a widely used slope stabilization technique which uses passive elements-soil nails (reinforcement bar within a grouted body). When the soil mass attempts to move down, the tensile force mobilized in the nail will increase the shear resistance by increasing the normal stress along the potential failure surface and reducing the shear stress that had to be mobilized by the soil to maintain equilibrium. The two key engineering features that should be considered in the design of soil nails are the pullout capacity of the nails generated by interface friction developed during various stages of loading and tensile capacity of the nails.

Pullout resistance is affected by matric suction, overburden pressure, dilatancy, method of installation, angle of internal friction of soil, and grouting pressure. Many researchers revealed that the matric suction is the major parameter that contributes to the uncertainties in the estimation of the pullout capacity of soil nails (Zhang et al., 2009, Su et al., 2008). Most of the pullout formulae do not account for the presence of matric suction and nature of shear strength parameter variation with saturation (matric suction). But formula proposed by Gurpersaud (2010) has accounted for the matric suction. The main objective of this study is to understand how the matric suction influences the development of pullout resistance of grouted soil nails under controlled laboratory conditions.

The characteristics of the soil used to make the compacted fill was determined by Laboratory tests and according to USCS the soil is silt with high plasticity (MH). To ensure uniform conditions, soil at optimum moisture content was compacted in layers of 125 mm in a box and two soil nails were installed in

the fill. Dimension of the Perspex box is 1.3 m x 1.08 m x 0.96 m. A clear distance of more than 200 mm was allowed in all sides to avoid the influence of boundary effects. The grouted nail used in the present study was with diameter 100 mm and length 914 mm with an inclination of 10^0 downward to horizontal. The hole for the nailing was done by manual auguring with augers of diameter 75 mm and 100 mm and the grouting was done using manual syringe made of PVC pipe with a diameter of 50 mm. Water cement ratio of grout was 0.45.

The overburden pressure of 40 kPa was applied to the fill by timber planks and hydraulic jacks. The force applied and displacement of the nail during the pullout test were recorded by hollow jack and the dial gauge fixed at the end of the nail. The matric suction was measured at two locations along the nail continuously by tensiometers.

The laboratory study was numerically simulated in plaxis 2D software using the plane strain model. Standard fixity was used for the boundary condition. Grouted soil nail was modeled as plate with reference to Babu and Singh (2009). An overburden pressure of 40 kPa was applied on the top of the soil mass. Mohr coulomb failure criteria was used for soil analysis and a prescribed displacement of 13.1 mm was given to the nail. This was the actual displacement observed in the test. Therefore, the actual process of model construction and testing was closely simulated.

The average matric suction was obtained by linear consideration of matric suction profile. The nail was pulled out at a matric suction of 39.88 kPa. The pullout force was increased up to a peak of 11.72 kN and the displacement was stayed at 13.10 mm in the actual test.

The results obtained from experimental and numerical results are very close. Conventional design formula which employs the saturated parameters gave a low value. But the modified beta formula by Gurpersaud (2010) with k=1 over estimated the result. In order to estimate the effects, interpret the results and estimate the modification to the current design formula, this research needs to be done for different matric suctions and overburden loadings.