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Probabilistic analysis of a pressurized tunnel face against collapse and blow out

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This paper presents a probabilistic analysis for the face stability of a pressurized tunnel face. In a first stage, a finite element formulation of the statical approach of the limit analysis theory (FELA), which can be expressed as a second-order cone programming (SOCP) problem, is briefly described. This method is then applied to the problem of the face stability of a pressurized tunnel to compute the values of the critical pressures of collapse and blowout in both cases of frictional and non-frictional soils. The present lower bound analyses are validated by comparison with the results reported in literature using (i) an analytical upper bound limit analysis approach and (ii) numerical simulations based on FLAC3D software. In a second stage, the computation of the failure probability of the tunnel face against both collapse and blowout considering the soil spatial variability is performed using subset simulation (SS) approach in conjunction with FELA. The subset simulation approach has the great advantage of a low computational cost, compared with the crude Monte Carlo simulation methodology, especially for computing a small failure probability. Furthermore, the FELA approach has the advantages of properly dealing with a spatially varying soil with a low computational cost compared with the existing deterministic approaches. The obtained results have shown that the collapse is the only probable failure mode for a frictional soil, while both failure modes should be considered in the analysis for a purely cohesive soil. Finally, a practical framework for the reliability-based design of a pressurized tunnel face is proposed according to the present results.