Journal of Zhejiang University-SCIENCE A

Upper bound analysis for estimation of the influence of seepage on tunnel face stability in layered soils

Cite this as: Wei LIU, Bettina ALBERS, Yu ZHAO, Xiao-wu TANG, 2016. Upper bound analysis for estimation of the influence of seepage on tunnel face stability in layered soils. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 17(11): 886-902.

http://dx.doi.org/10.1631/jzus.A1500233

Background

A case of ground surface collapse

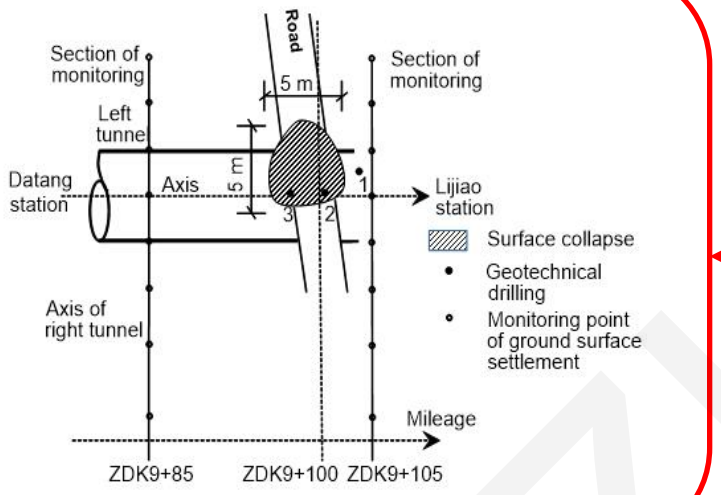


Fig. 1. Plan of the ground surface collapse

Information

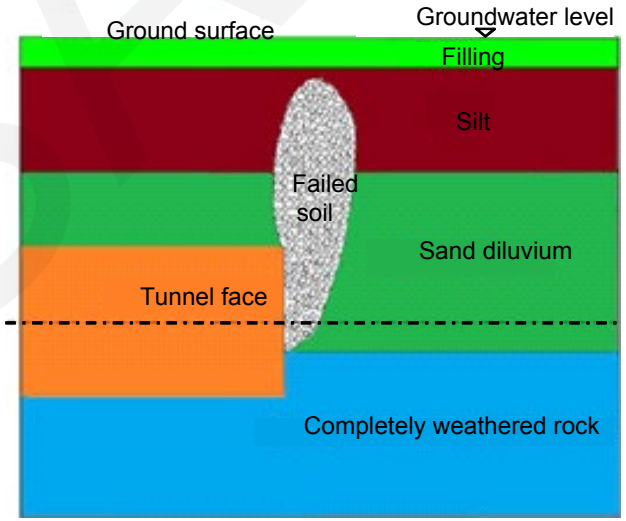
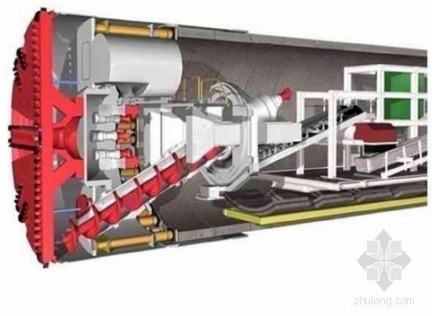
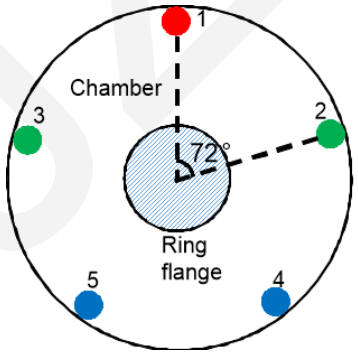


Fig. 2. The face collapse accident





Locations
- At the top
- In the middle
- At the bottom

Gauge No.	Location	Minimum support pressure (kPa)
1	●	38
2 and 3	●	65
4 and 5	●	97

Analysis model

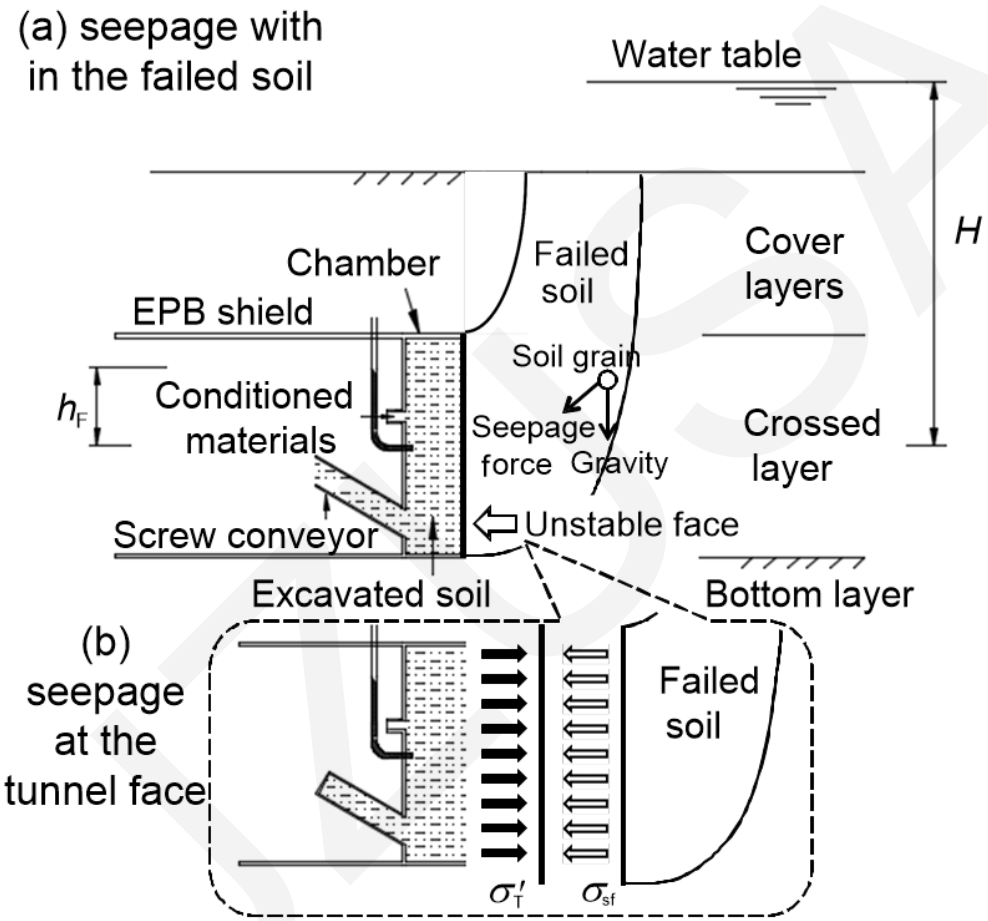


Fig. 3 seepage application in the face collapse in shield tunnel

Upper bound analysis

Upper bound solution

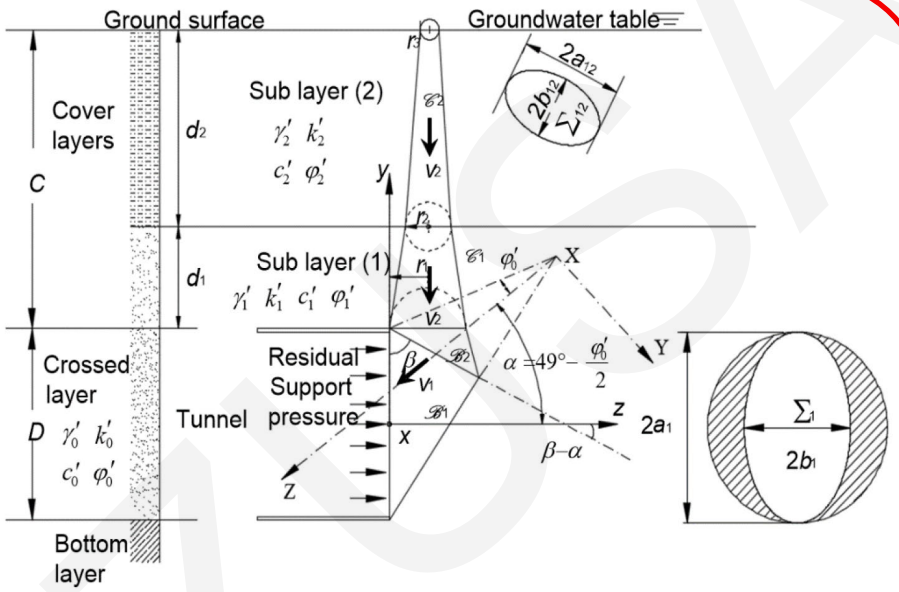


Fig. 4 Kinematically admissible mechanism for layered soil

$$P_e = P_v$$

$$\sigma_T' = \sigma_{soil} + \sigma_{seepage} \qquad \sigma_{soil} = \gamma' D N_{\gamma\mathscr{B}} - c' N_{c\mathscr{B}} + \frac{1}{D^2}\sum_{i=1}^{n} N_{\gamma_i\mathscr{E}},$$

$$\sigma_{seepage} = \gamma_w N_{sf} + \sigma_{sf}.$$

Seepage analysis

Numerical simulation

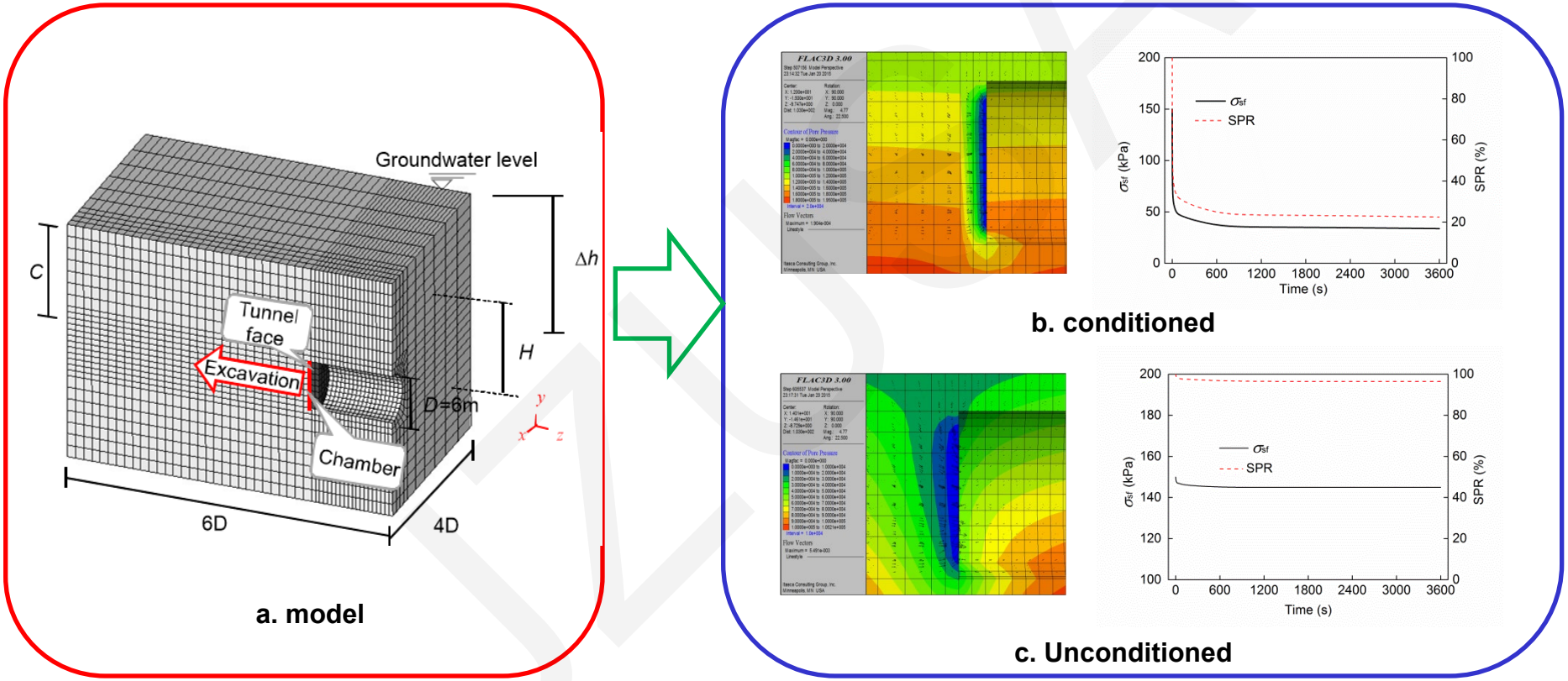
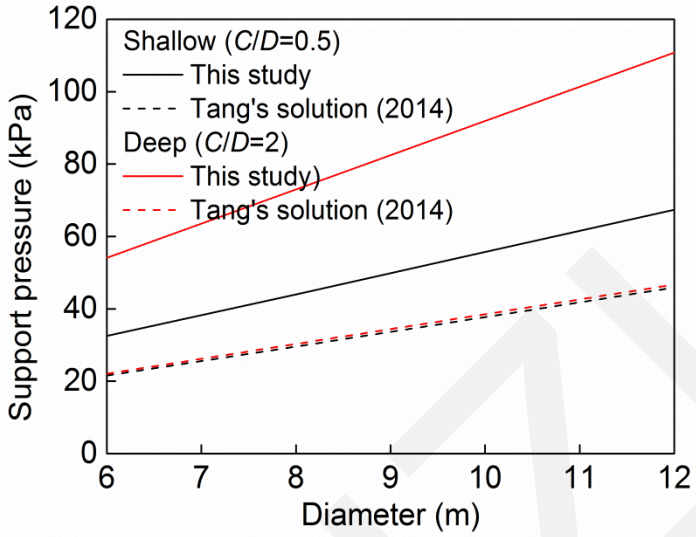


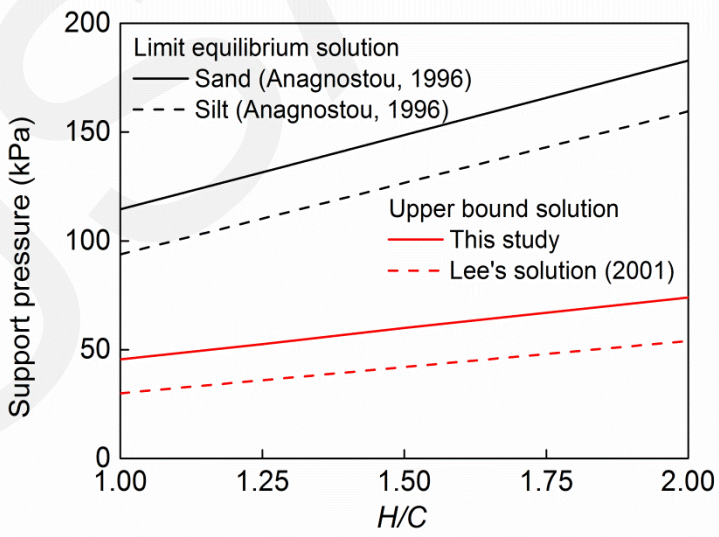
Fig. 5. Seepage analysis under the different conditions

Support pressure analysis

Ultimate support pressure for the face stability



a. Variation of the support pressure dependent on the diameter



b. Influence of groundwater level *H/C* on the support pressure

Fig. 6. Variations of support pressure

Conclusions

- In this paper, we study the face collapse accident in layered soil under groundwater seepage in the construction of Guangzhou metro line 3. This type of face collapse is investigated via upper bound analysis. Both the effects of the seepage forces acting on the tunnel face and seepage forces in the failed soil are considered in the analysis. The numerical simulation indicates that the groundwater seepage in the well-conditioned cases is not as significant as that in the unconditioned cases. The seepage forces acting on the tunnel face and those in the unstable soil increase linearly with increasing groundwater level, and both play an important role in the upper bound analysis of the face stability. Consequently, this upper bound solution of support pressure considers both the seepage forces acting on the tunnel face and the seepage within the soil and predicts a higher, and thus relatively safe, support pressure, which is needed for face stability under groundwater seepage.