Imperial College London

UK RAILWAY CUT SLOPES; EFFECT OF SOIL-ATMOSPHERE INTERACTION ON THE FACTOR OF SAFETY AGAINST FAILURE

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INTRODUCTION

The UK Railway was the world's first infrastructure of its kind. According to the literature, the slopes that were cut more than a hundred years ago are currently at their most critical stage: the so-called long-term conditions. However, it is not the literature that triggers this investigation, but the actual failures that keep taking place every year.

Implementing complex boundary conditions in the Imperial College Finite Element Program (ICFEP), the effect of precipitation and vegetation on the cutting is assessed. The analyses that have been carried out are a contribution to a better understanding of the behaviour of cut slopes in clay.

FINITE ELEMENT MODELLING

SCENARIO	PRECIPITATION	INFILTRATION THRESHOLD VALUE	VEGETATION	VEGETATION TYPE	VEGETATION CLEARANCE	DESICCATION
Scenario 0	No	-	No	-	-	-
Scenario 1	Yes	0.0kPa	Yes	Moderate	No	No
Scenario 2	Yes	10.0kPa	Yes	Moderate	No	No
Scenario 3	Yes	10.0kPa	Yes	Dense	Yes (50%)	No
Scenario 4	Yes	10.0kPa	Yes	Dense	Yes (50%)	Yes

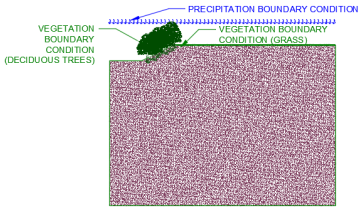

Figure 1: Scenarios 1 and 2 boundary conditions

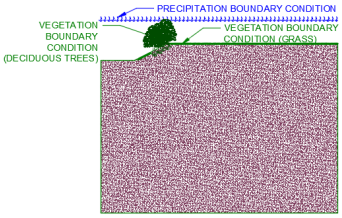

Figure 2: Scenarios 3 and 4 boundary conditions. Before vegetation clearance.

PORE PRESSURE CONTOURS

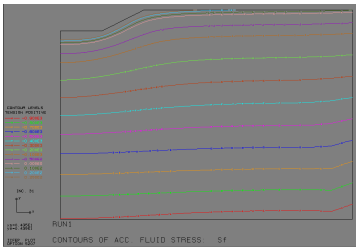

Figure 3: Pore pressure contours just after excavation.

The excavation sequence initially drops the water table. After this, the consolidation is governed by infiltration and evapotranspiration. The pore pressure contour plots show high local suctions in summer that can stay up in winter although with a lower intensity.

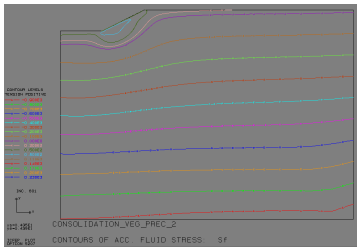

Figure 4: Pore pressure contours in March 2010. Scenario 4.

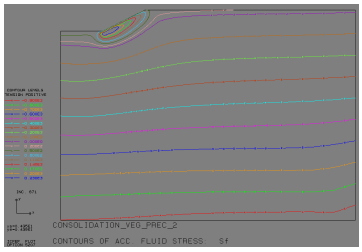

Figure 5: Pore pressure contours in August 2010. Scenario 4.

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FAILURE MECHANISMS

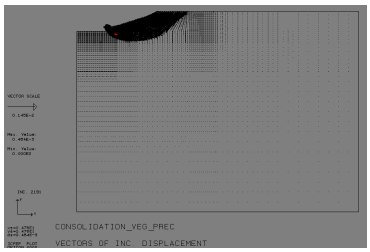


Figure 6: Failing slope in March 2010. Scenario 4.

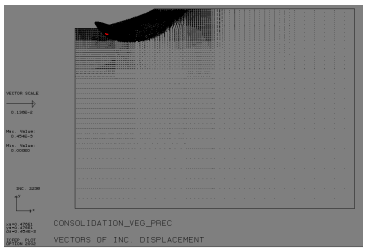
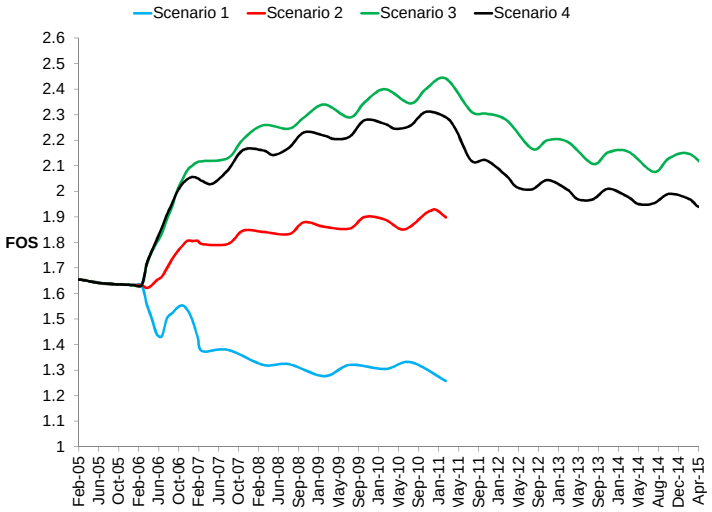


Figure 7: Failing slope in August 2010. Scenario 4.

The depth of the slip surface is dominated by the local suctions on the slope. In summer, when tensile pore pressures reach their maximum below the trees, the failure mechanisms are deeper-seated than in winter.

FACTOR OF SAFETY (FOS)



When the precipitation and vegetation boundary conditions are applied -14 months after excavation- the evolution of the FOS differs from one scenario to another. Seasonal fluctuations are present in all of them although they become more remarkable with dense vegetation cover (Scenarios 3 and 4). When the water table stays below the surface, the scenario is dominated by transpiration and there is an overall increase on the FOS. In addition, the local maximums are obtained in late autumn, when the water table is at its deepest position after 6 months of water being extracted through transpiration (Scenarios 2,3 and 4). Tree removal reduces significantly the stability of the slope (Scenarios 3 and 4).

CONCLUSIONS

- The presence of vegetation clearly improves the stability of cut slopes.
- Vegetation clearance reduces the FOS of the cutting significantly. A grass cover is unable to substitute the effect of large trees.
- Seasonal fluctuations of FOS are governed by the depth of the groundwater table.
- Failure mechanisms are related to peak local suctions.

REFERENCES

Potts, D.M. & Zdravkovic, L. 1999. Finite Element Analysis in Geotechnical Engineering: Theory. Thomas Telford.