Geotechnical Engineering Discussion 13724D

Authors' Reply to Written Discussion by Dr A K Goodwin, Associate, Mott MacDonald, Sheffield on "Assessing the contribution of vegetation to slope stability" by J R Greenwood, J E Norris & J Wint

Dr Goodwin has addressed a number of issues to which the Authors respond as follows:-

1. The Authors' methodology for assessing the contribution of vegetation to slope stability has been established for a number of years and is indeed included in the 1990 Coppin and Richards text book to which he refers (page 101).
2. The inclusion of water forces and effective interslice forces on the sides of slices of the analysis leads to the equilibrium of hydraulic forces on the slice and eliminates certain errors and inconsistencies in the stability analysis (Greenwood 1989, Morrison and Greenwood 1989, King 1989). It is the water forces which are considered rather than 'flows' as Dr Goodwin suggests.
3. It is accepted that vegetation may sometimes be associated with non-saturated zones of soil. Relevant suctions may be included in the 'Greenwood' stability equations both at the base and the sides of the slices of the analysis. This can considerably enhance the calculated factor of safety as Dr Goodwin has identified. However practical experience warns that suctions (whether relating to seasonal drying or the local effects of the vegetation) can soon be negated after a period of rain and we would not advocate relying on theoretical suctions for the on-going stability of a slope.
4. The Δu_v term is intended to reflect any changes in the water pressure at the base of the slice and we would agree with Dr Goodwin that changes in 'u' due to vegetation effects cannot be relied on for the same reasons of overriding rainfall as described above and general slope hydrology effects.
5. The problems of determining the spatial variability of hidden roots is a huge challenge and further interdisciplinary research work is needed to improve our knowledge of root networks in particular soils and growing conditions. The available tensile root force, T, directly affects the calculated factors of safety but as discussed in section 4.1 of our paper, the direction of the root in relation to the slip surface, θ, is shown to have little effect on the calculated values of shear resistance for normal values of ϕ'. This was demonstrated for Geosynthetic reinforcement (Greenwood, 1990).
6. The stability equations suggested by Goodwin attempt to incorporate the non-saturated, matric suction related parameters. The first equation appears to have dimension inconsistencies as part of the numerator is divided by ℓ. Many of the terms in the equations relate to non-saturated soil mechanics and are not found in the notation given by Coppin and Richards. Also the reason for using the terms $T\cos(90+\alpha-\theta)$ and $T\sin(90+\alpha-\theta)$ for the normal and tangential root reinforcement forces is unclear. They are at odds with the generally accepted use of $T\sin\theta$ and $T\cos\theta$ respectively.

As Goodwin notes and geotechnical engineers are aware, changes in the slope hydrology will tend to govern the stability of a particular slope. Suction forces are important and may provide temporary high factors of safety but the engineer needs to be confident of their sustainable nature. The 800% increase in factor of safety theoretically calculated by Goodwin due to suction effects could disappear if tension cracks open up or suctions are negated by prolonged wet periods. On the other hand a 10% increase in factor of safety from the observed presence of vegetation roots would seem rather more reliable. Vegetation will always have limited applications in general engineering terms but can be of considerable assistance for marginally stable slopes where life and property are not immediately at risk. It is right that all possible mechanisms by which vegetation can influence geotechnical conditions should be considered.

The authors thank Dr Goodwin for his discussion.

References

Greenwood, J.R. (1990). Inclusion of reinforcement forces in stability analysis (Communication). 4th Int. Conference on Geotextiles Geomembranes and Related products, the Hague, May 1990, pp114 and 997-999.

King. G.J.W. (1989). Revision of effective stress method of slices. Geotechnique 39, No 3, 497-502.