Comparison of the Limit Equilibrium and the Limit Analysis methods in infinite slopes

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ABSTRACT

The infinite slope hypothesis is a very useful calculation scheme for analysing the sensitivity of the stability of many natural slopes subjected to climatic loads (Duncan and Wright, 1995). In this failure model, it is usual to quantify safety with a simple formulation, assuming plane strain and using the Limit Equilibrium method (Skempton and Deloy, 1957). This procedure, which is endorsed by experience (Nash, 1987; Graham, 1984), makes it possible to obtain estimations of the safety factor that, under undrained conditions, correspond to those obtained by means of the Upper Bound Theorem of Limit Analysis, a method with greater conceptual soundness.

Said correspondence does not occur under ideally drained conditions. In this case, both calculation strategies yield different results, and observed differences are inversely proportional to the depth of the failure mechanism. Consequently, both calculation methods cannot be considered equivalent at all (Collins, 1974; Chen, 1975). However, the existing functional dependence between them makes the sensitivity of both methods very similar, which provides conceptual consistency to the application of the Limit Equilibrium method.

It is interesting to test whether this consistency is also present when analysing partially saturated slopes, situation which best reflects the real conditions of the slopes (Kim et al., 2002). In order to study this question, an analysis is carried out under plane strain and flow conditions, assuming the approximation of the water pressure law of Rahardjo et al. (1995). The obtained results show that, like under drained conditions, the safety factor obtained through the application of the Limit Equilibrium is correlated with the one corresponding to the application of the Upper Bound Theorem of the Limit Analysis. Therefore, the application of Limit Equilibrium as a tool to characterize the sensitivity of stability of slopes subjected to climatic loads still has the conceptual support that Limit Analysis provides.

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