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Efficiency and limits of Stability Charts in the analysis of limit equilibrium state of slopes of geological interest

Maria Ausilia Paparo and Stefano Tinti
Sector of Geophysics, Department of Physics and Astronomy (DIFA), University of Bologna, Bologna, Italy

The stability charts are one of the most common tools used in engineering and applied geology to derive the value of the Safety Factor, say F, of slopes of engineering and geological interest. Its importance is due to the easiness of finding the solution for F without falling into complex numerical calculations.

These charts propose a graphical method to derive F=F(Ns), where Ns is the Stability Number, obtained by a combination of geotechnical (cohesion, friction angle, weight) and geometrical parameters (angle of incline and slope height): for each value of Ns it is possible to find one single value of F. Taylor (1948) was the first to introduce the stability charts method and later until recently many others proposed different improved versions of them (Michalowski, 1997; 2002; Baker, 1999; 2003; Baker et al. 2006; Easa and Vatankhah, 2011).

The aim of this work is to show that there is no univocal relationship between F and Ns like it is erroneously assumed by the stability charts method. Indeed, the comparison of the stability charts with new charts obtained with the Minimum Lithostatic Deviation (MLD) method (Tinti and Manucci, 2006; 2008) reveals that F depends separately on all the parameters that concur to form the stability number, though the dependence on some of them, especially the soil weight, is more relevant. The work has been conducted not only on soil parameter configurations typical of embankments and dykes, but also on configurations typical of homogeneous slopes of geophysical interest. It is found that the values of F usually fall below the ones predicted by the stability charts though the general trend of the stability curves is confirmed. This discrepancy is particularly crucial when the value of F is close to the critical value of 1, since in this case classical methods could indicate that a slope is stable, even though it is not. One can therefore state that the classical stability single-valued curves F(Ns) can provide an acceptable first approximation to the stability problem when the slopes are found to be far from critical conditions (very stable or very unstable slopes). On the other hand, for slopes close to instability, the relationship F(Ns) cannot be considered single-valued anymore and the full dependence of F on all the slope parameters must be investigated in order to evaluate if the slope is stable or unstable.