TECHNICAL NOTE

A comparative review of commercially-available software for soil slope stability analysis

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Summary

The main purpose of this paper is to carry out a comparative review of four commercial computer programs for the stability analysis of soil slopes. The review is carried out in two parts and should prove useful for potential users of the software. Part I reviews the facilities offered in terms of the range of limit equilibrium methods, the geotechnical modelling abilities, the operational features and the supporting documentation, and includes a general impression of 'friendliness'. Part II assesses the use, accuracy and validity of each program by presenting and discussing the results of a number of model tests. Also included is a brief discussion of slope stability analysis, in particular the limit equilibrium method. The requirements of a practical computer program for soil slope stability analysis are defined and then used as a means of assessing the effectiveness of each program.

Keywords: Slope stability analysis, limit equilibrium methods, geotechnical software.

Introduction

The limit equilibrium method is commonly used by engineers to assess the safety of man-made and natural soil slopes. This is often done through the use of computer programs to speed up calculations, and to allow the investigation of many trial slip surfaces, the use of more accurate methods, and the modelling of complicated problems.

The computer programs should be viewed as design aids and should not be seen to reduce the need for engineering judgement. Practising engineers know that they must take responsibility for the decisions they make and, hence, it is important that they are aware of the limitations of the methods and thus the programs, and of the relative accuracy and validity of the results.

The purpose of this note is to provide a brief discussion of slope stability analysis, to define the requirements of a practical computer program for soil slope stability analysis, and
then to review four commercially available slope stability computer programs, OASYS, GEOSOLVE, LAMP and CADS. The review should be of considerable interest to potential users of the software.

Slope stability analysis

Introduction

A comprehensive review of the methods of stability analysis for natural and man-made soil slopes has been carried out by Mostyn and Small (1987). The methods include:

1. Limit equilibrium methods; and
2. Methods based on the upper and lower bound theorems of plasticity theory.

Soils are not perfectly plastic. However, at failure under undrained conditions they behave as if they are perfectly plastic, so the bounding theorems of plastic theory apply. At failure under drained conditions their behaviour is not perfectly plastic, but the upper bound can be used and although the lower bound is not a ‘true’ safe bound it is likely to be close to it. However, the methods have suffered from restrictions in geometry, loading conditions, material behaviour and the requirement that the materials are homogeneous. Nash (1987) has argued that it is largely because of these factors that these methods have not become widely adopted in practical geotechnical design.

Limit equilibrium methods generally assume an arbitrary two dimensional failure mechanism (slip surface) and, without exceeding the appropriate failure criterion on the slip surface, ensure the static equilibrium of each component of the mechanism and of the complete mechanism. Then by examining a number of different mechanisms, the critical one is identified for which the load is taken to be the limit equilibrium collapse load. At no point is the equilibrium of the internal stresses in the soil considered (Atkinson, 1981). Significant changes in geometry and progressive failure cannot be modelled by the limit equilibrium method. The sensitivity of any slope to progressive failure can be examined by adjusting soil strength parameters in the manner suggested by Bishop (1971).

In most cases the limit equilibrium method gives neither a lower nor an upper bound of the collapse load, nor is the critical failure mechanism found from the analysis necessarily the actual mechanism at collapse. However, experience has shown that limit equilibrium calculations often give a good estimate of the collapse load and, hence, the safety of the soil slope.

Limit equilibrium methods

The methods offered by the individual programs OASYS, GEOSOLVE, LAMP and CADS are given in Table 1, and represent those commonly used by engineers. Discussion of these methods has been carried out in detail by numerous authors (e.g. Bromhead, 1986; Fredlund and Krahn, 1977; Nash, 1987; Williams, 1980) and hence only a brief discussion will be given here.

The methods have been classified in terms of the shape of failure surface, the overall equilibrium conditions satisfied, and the assumptions about inter-slice forces, in Table 2.

In any slope stability problem the most important consideration will be in modelling the