

论文类成果

Extensions to the generalized method of slices for stability analysis

【创新性】

1983年，陈祖煜与知名国际土力学专家 Morgenstern 合作改进了在边坡稳定分析领域具有重要地位的 Morgenstern-Price 法，给出了力和力矩平衡方程式的解析解。该方法完全满足力和力矩平衡方程，引入的土条侧向力的假定函数在端点必须是确定值，以满足剪应力成对原理，并给出了相应的判据。经改进的以积分形式表达的 Morgenstern-Price 法的控制方程式为边坡稳定分析领域另一个著名的分析方法，即 Spencer 法，提供了更为简明的表达式（原方法同样包含庸长的差分推导）。

【影响力】

论文成果推广到主动土压力领域，克服了传统的库仑主动土压力理论不适用于柔性支挡结构（如锚拉、支撑、悬臂墙）的缺点，实现了土力学创始人 Terzaghi 教授提出的通过引入力矩平衡条件建立统一的主动土压力分析方法的构想，克服了目前深基坑设计沿用 Terzaghi 经验系数的局限性。对 Morgenstern-Price 法的改进计算公式已正式纳入“碾压式土石坝设计规范”（SL274-2001）、“碾压式土石坝设计”和“水利水电工程边坡设计规范”（SL386-2007）。国际知名岩土学者 Duncan 教授在为美国土木工程师学会岩土与环境学报所作的当代水平报告的长篇论文中 3 次介绍了相关的研究成果。

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EXTENSIONS TO THE GENERALIZED METHOD OF SLICES FOR STABILITY ANALYSIS

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EXTENSIONS TO THE GENERALIZED METHOD OF SLICES FOR STABILITY ANALYSIS

【Innovation】

In 1983, Chen Zuyu and the famous international soil mechanics expert N.R.Morgenstern together improved the Morgenstern-Price method, which takes an important position in the slope stability analysis field, and gave the analytical solution to the force and moment equilibrium equations. This method completely satisfies the force and moment equilibrium, in which the introduced assumed function of lateral force of slices must be a determined value on the endpoint; corresponding criteria are presented. The control equation of the improved Morgenstern-Price method expressed in the integral form is another well-known analytical method in the slope stability analysis field. It is exactly the Spencer method that provides a more concise expression (original method also contains the tedious derivation of difference).

【Influence】

Achievement of this paper is extended to the active earth pressure field, in which it removes the problem that the traditional Coulomb's earth pressure theory is inapplicable to flexible retaining structures (e.g. anchorage, support, cantilever wall), realizes Prof. Terzaghi's idea of establishing a uniform active earth pressure analysis method through bringing in moment equilibrium condition, and overcomes the limitation of the Terzaghi empirical coefficient that is still used in deep foundation design. The calculation formula for the improved Morgenstern-Price has been officially included in the Design Code for Rolled Earth-Rock Fill Dams (SL274-2001), Design of Rolled Earth-Rock-Fill Dams and Design Code for Engineered Slopes in Water Resources and Hydropower Projects (SL386-2007). The internationally famous geotechnical scholar Prof. Duncan introduces relevant research findings for three times in his state of art paper published in the Journal of Geotechnical and Geoenvironmental Engineering, ASCE.

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Extensions to the generalized method of slices for stability analysis

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Extensions are suggested to the generalized method of slices that is commonly used in slope stability analysis. It is shown that restrictions exist on the assumptions used to make the problem statically determinate. In addition, a numerical procedure has been developed to find the bounds to the factor of safety, subject to additional requirements of physical admissibility. As a result of these developments it has been possible to produce a revised computer program that appears to overcome the problems of convergence experienced by other programs in current use. Results obtained with this new analysis confirm the reliability of several methods of analysis used in practice.

On propose des développements à la méthode des tranches généralisée qui est couramment utilisée dans l'analyse de stabilité de pentes. On montre qu'il existe des restrictions aux hypothèses utilisées pour rendre le problème statiquement déterminé. De plus, une procédure numérique a été développée pour trouver les limites du facteur de sécurité compte tenu d'exigences supplémentaires d'admissibilité physique. Suite à ces développements il a été possible d'établir un programme d'ordinateur qui semble éliminer les problèmes de convergence rencontrés dans d'autres programmes actuellement en usage. Les résultats obtenus avec cette nouvelle analyse confirme la fiabilité de plusieurs méthodes de stabilité utilisées en pratique. [Traduit par la revue]

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Introduction
Generalized methods of slices are commonly used to investigate the stability of slopes, particularly when the section is nonhomogeneous. However, the problem is statically indeterminate and assumptions are necessary in order to obtain numerical results. Several methods have been advocated. For example, Janbu (1954, 1973) made assumptions regarding the location of the point of action of the interslice force and Morgenstern and Price (1965) and Spencer (1967, 1973) assumed the shape of the distribution of the inclination of the interslice force. Sarma (1973) adopted the distribution of the vertical component of the interslice forces.

A survey of the commonly used methods indicates the following.

1. The assumptions made for the different unknown variables involved in the equilibrium equations do not result in much difference in the final factor of safety. This is not surprising when considering that the various methods are based on the same equilibrium equations and the unknown variables are interrelated.
2. The assumptions regarding any unknown variable are not unique. A number of functions which lead to a group of solutions satisfying the equilibrium equations may be assumed. Some of the solutions should be rejected due to the requirement for physical admissibility (Morgenstern and Price 1965; Whitman and Bailey 1967; Janbu 1973). Since only the shape of the distribution of one of the unknown functions is assumed, the physical reasonableness cannot be checked until the final solution has been found. The selection of the assumed function depends to a large extent on intuition and experience but may be guided by stress analysis. Since we are basically confronted with an infinite number of possible choices for the assumed function, after performing several calculations we are still uncertain if some relevant solutions are missing or not.

The purpose of this paper is to overcome the disadvantages involved in the currently used methods by the following.

1. It will be shown that restrictions that have been ignored so far exist on the boundary values of the distributive assumption. The search for the solution to the equilibrium equations is then undertaken with a group of assumed functions that are fixed at both ends.
2. A method of sensitivity analysis to explore the influence of the assumed functions associated with physically reasonable solutions to the equilibrium equations will be developed. An efficient computer program for this method has been coded.

With the help of these two extensions, the bounds on the factor of safety caused by conditions of physical admissibility can be found. The effort required of the user is reduced considerably.

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