AN IMPROVISED THREE-DIMENSIONAL SLOPE STABILITY ANALYSIS BASED ON LIMIT EQUILIBRIUM METHOD BY USING PARTICLE SWARM OPTIMIZATION

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I dedicated this thesis to my beloved father and mother for their support and encouragement.

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ABSTRACT

The stability of slopes is a major concern in the field of geotechnical engineering. Two-dimensional (2D) limit equilibrium methods are usually implemented in this field due to their simplicity. However, these methods ignore the features of the third dimension of slopes. Although three-dimensional (3D) methods tried to remove the previous limitation, most of them assumed the direction of sliding, simplified or ignored the intercolumn forces, and avoided to search for location and shape of three-dimensional critical slip surface. This study was performed to overcome the mentioned limitations. In the present study, a new slope stability method was established based on the force and moment equilibrium in two vertical directions that was able to find the unique direction of sliding. Moreover, a modified Particle Swarm Optimization was developed by replacing the worst particle of each swarm with the previous global best particle and using a dynamic inertia weight to determine the 3D critical slip surface. Then, a computer program was established to model 3D slopes and perform the required calculations. Several benchmark problems were re-analyzed to verify the results of the study and good agreements were achieved with the results of previous studies when different failure mechanisms as ellipsoid, cylindrical, and composite slip surfaces were successfully applied in the analysis. The results indicated that the 3D factor of safety of a slope is always greater than its corresponding 2D factor. Moreover, the end effect in 3D analysis was found to be more significance in the problems with lower ratio of length to the width of the sliding mass. It was also found that the presence of water and weak layer enlarged this effect. Through the verification study, it was observed that different sliding directions produce different factors of safety, while the lowest value of factor of safety and 3D critical slip surface is only reachable through the real direction of sliding. Finally, case studies of actual stability problems were analyzed to find their critical slip surfaces. Achieving the minimum factor of safety of 0.977 for the critical slip surface of a failed slope demonstrated the validity of performance of presented computer code. Based on the obtained results, this study successfully overcame the mentioned limitations of the previous methods. The results of this study provided a better understanding of the actual failure mechanism and helped to enhance the safety and reduced the economic and health costs due to slope failure by a more detailed analysis than before.

ABSTRAK

Kestabilan cerun kini menjadi kebimbangan utama dalam bidang kejuruteraan geoteknik. Penggunaan had dua dimensi (2D) yang merupakan kaedah keseimbangan biasanya dijalankan kerana penyerderhanaan pengaplikasian. Walau bagaimanapun, kaedah ini mengabaikan dimensi ciri ketiga cerun. Kaedah tiga dimensi (3D) dihasilkan bagi menghapuskan keterbatasan sistem aplikasi sebelumnya. Kebanyakan pengkaji menganggap arah gelongsor, dipermudah atau diabaikan daya intercolumn, menghalang untuk mencari lokasi dan bentuk tiga dimensi permukaan slip critical. Kajian ini telah dijalankan untuk mengatasi keterbatasan tersebut. Dalam kajian ini, satu kaedah baru telah diperolehi berdasarkan kestabilan cerun dalam mengimbangi tenaga dua arah menegak dapat mencari hala tuju unik gelongsor. Pengubahan zarah sekumpulan pengoptimuman dibangunkan bagi menggantikan kekurangan kumpulan zarah terdahulu, dengan penggunaan berat inersia dinamik untuk menentukan permukaan slip critical 3D. Program komputer telah diperolehi untuk model cerun 3D dalam melaksanakan pengiraan yang tepat. Beberapa masalah penanda aras dianalisis untuk mengesahkan keputusan kajian dan satu kesepakatan telah dipersetujui berkaitan dengan penemuan kajian terdahulu, akibat terdapat kegagalan mekanisma yang berbeza di permukaan slip ellips, silinder, dan kegagalan permukaan komposit telah berjaya digunakan dalam analisis kajian. Keputusan menunjukkan bahawa faktor keselamatan cerun 3D adalah sentiasa lebih besar berbanding faktor 2D. Hasil akhir dalam analisis kajian 3D didapati lebih penting dalam penyataan masalah dengan nisbah yang lebih rendah jisim panjang gelongsor. Kajian juga mendapati bahawa kehadiran air yang diperbesarkan akibat dari kesan lapisan yang lemah. Melalui kajian pengesahan, Dapat diperhatikan bahawa gelongsor arahan berbeza menghasilkan keselamatan faktor yang berbeza, manakala faktor keselamatan yang lebih rendah dan 3D kegagalan permukaan kritikal hanya dapat dicapai melalui gelongsor arah sebenar. Kajian kes masalah kestabilan sebenar telah dianalisis bagi mencari kegagalan permukaan kritikal. Faktor minimum keselamatan 0.977 di kegagalan permukaan kritikal kegagalan cerun menunjukkan kesahihan prestasi kod komputer dipaparkan. Berdasarkan keputusan yang diperolehi, kajian ini telah berjaya mengatasi keterbatasan aplikasi yang terdahulu. Hasil keputusan kajian memberikan pemahaman yang lebih baik terhadap mekanisme kegagalan sebenar dan dapat membantu untuk meningkatkan keselamatan bagi mengurangkan kos ekonomi dan kesihatan akibat kegagalan analisis cerun secara lebih terperinci berbanding sebelumnya.