EFFECT OF APPLIED LOAD ON THE STABILITY OF UNREINFORCED AND REINFORCED SLOPES

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A project report submitted in partial fulfillment of the
requirement for the award of the degree of
Master of Engineering (Civil – Geotechnics)

Faculty of Civil Engineering
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JANUARY 2012

I dedicated this study to my beloved parent, Loke Yoke Hung and Yeoh Kim Lin for their everlasting love, care and support, which keep my spirit burning in achieving my goals.

ACKNOWLEDGEMENT

With a fully sincere and faithful heart, I would like to express my deepest gratefulness to the Almighty God for giving me the strength throughout this period in completing my project. Even though this project was hard but I gain a lot of knowledge and also experience went doing this research.

First of all, my heartiest gratitude goes to my supervisor, Associate Professor Dr. Nurly Gofar for continuous guidance and support as well as patient in advices, instructions, constant motivation and invaluable knowledge given to me along the process to complete the project. Without her continuous support and interest, this project report would have not been the same as presented here.

I would also like to express my sincere gratitude to my beloved family for their continuous faith and support to me. I would also like to thank all the UTM lecturers have contributed whether directly or indirectly to this project.

Appreciation also expressed to geotechnic lab technicians, they have been giving me a helping hand during my project. Lastly once again, all the kindness, patience, contribution, support and everything, I will not forget in my life.

ABSTRACT

Recent development in hilly area has highlighted issues related to instability in engineered as well as natural slopes, hence; it is a challenge to both professionals and researches in Malaysia to address the problem related to landslides and slope failures. Several occurrences during the past few years include Highland Tower collapse in December 1993, Bungalow collapse at Taman Hillview in November 2002, the massive landslide occurred at Bukit Antarabangsa in December 2008, and the recent landslide at Hulu Langat in May 2011. Therefore, uncontrolled development which place structural foundation too near to the slope crest on hilly area may lead to slope failure. Thus, it is essential to consider the safe distance between the foundation and the slope crest. The aim of this study is to determine the safe distance of foundation on slope crest using a commercial software Slope/W (Geostudio, 2007). Morgenstern-Price and bishop method are selected for slope stability analysis due to the flexibility in selecting the critical slip surface. A case study at PT 4697, Seksyen7, Shah Alam, Selangor was selected for the analysis. Applied loading of 10kPa, 15kPa, 20kPa, 30kPa and 50kPa will be placed at various distances from the crest of the slope. The result from the slope stability analysis had indicated that the construction of reinforced earth wall improved the stability of slope but the loading on slope crest decreases the factor of safety of both unreinforced slope and reinforced slope. Therefore the load within unstable area will results in the depressions at the point of applied load, however once the load is moved beyond the unstable area, its effect become significantly minimized and the pattern of safety factor is constant start from a stable distance where the increasing of loading will remain constant for the factor of safety.

ABSTRAK

Pembangunan semasa di kawasan berbukit telah menekankan isu-isu yang berkaitan dengan ketidakstabilan dalam kejuruteraan seperti cerun semula jadi, justeru itu, ia adalah satu cabaran kepada kedua-dua profesional and penyelidikan di Malaysia untuk menangani masalah yang berkaitan dengan tanah runtuh dan kegagalan cerun. Beberapa kejadian dalam tempoh tahun yang lepas termasuk Highland Tower runtuh pada Disember 1993, Bangalow runtuh di Taman Hillview pada November 2002, kejadian tanah runtuh besar-besaran berlaku di Bukit Antarabangsa pada Disember 2008, dan tanah runtuh di Hulu Langat baru-baru ini pada Mei 2011. Oleh itu, pembangunan yang tidak terkawal yang menempatkan asas struktur yang terlalu dekat dengan puncak cerun di kawasan berbukit boleh membawa kepada kegagalan cerun. Sehubungan dengan itu, ia adalah penting untuk mempertimbangkan jarak yang selamat di antara asas bangunan dan puncak cerun. Kajian ini bertujuan untuk menentukan jarak yang selamat di puncak cerun dengan menggunakan perisian komersial Slope/W (Geostudio 2007). Kaedah “Morgenstern-Price” dan “Bishop” dipilih untuk analisis kestabilan cerun disebabkan oleh fleksibiliti dalam memilih permukaan slip kritikal. Satu kajian kes di PT 4697, Seksyen 7, Shah Alam, Selangor telah dipilih untuk analisis. Beban kenaan 10kPa, 15kPa, 20kPa, 30kPa dan 50kPa akan diletakkan pada jarak yang pelbagai dari puncak cerun. Hasil dari analisis kestabilan cerun telah menunjukkan bahawa pembinaan “Reinforced Earth Wall” meningkatkan kestabilan cerun tetapi pembebanan pada puncak cerun mengurangkan faktor keselamatan cerun pada kedua-dua cerun tanpa bertetulang dan cerun bertetulang. Oleh itu, beban di dalam kawasan yang tidak stabil akan membawa kepada keputusan dalam lekukan pada titik beban kenaan, apabila beban dipindahkan ke luar kawasan yang tidak stabil, kesannya adalah ketara dikurangkan dan corak faktor keselamatan adalah malar bermula dari jarak yang stabil di mana peningkatan pembebanan akan kekal malar untuk faktor keselamatan.

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CHAPTER 1

INTRODUCTION

1.1 Background

Recent development in hilly area has highlighted issues related to instability in engineered as well as natural slopes, hence; it is a challenge to both professionals and researches in Malaysia to address the problem related to landslides and slope failures. The increasing demand for engineered cut and sill slopes on construction projects has only increased the need to understand analytical methods, investigative tools and stabilization methods to solve slope stability problems (Moayedi et al., 2009). Several occurrences during the past few years include Highland Tower collapse in December 1993, Bungalow collapse at Taman Hillview in November 2002, the massive landslide occurred at Bukit Antarabangsa in December 2008, and the recent landslide at Hulu Langat in May 2011.

Construction on hilly area need to consider the safe angle of cut slope as well as the safe distance between the building foundation and slope crest. According to Lee and Manjunath (2000), for both reinforced and unreinforced slopes, the bearing capacity decrease with an increase in slope angle and a decrease in the edge distance. At an edge distance of less than five times the width of the footing, bearing capacity becomes independent of the slope angle and the less effective of slope reinforcement which can lead to failure mechanisms. Hence, as summarized by Huang *et al.* (1994), the failure mechanisms found in the reinforced model sand slopes have several types of failure patterns such as triangular wedge surrounded by two intensively sheared

bands develops directly under the footing and the punching failure and also zonal failure can best describe the failure types. Furthermore, it had been found that placing stiff reinforcement in the sand slope directly under the footing can improve significantly the bearing capacity of a footing placed on a slope.

The availability of strong polymer reinforcement materials which are resistant to corrosion provides attractive possibilities for the improvement of both bearing capacity of foundation soil and slope. However, study Chen and Lim (2005) on the a 9 m high segmental retaining wall indicated that the failure was due to reservoir placed on the top of the slope. Further investigation indicated that the collapsed of the segmental retaining wall was mainly due to loss of internal instability in which insufficient resistance was provided by reinforcement length.

The aim of design of reinforced slope is to determine the number and position of reinforcements to provide overall equilibrium in the slope and to avoid any local overstressing. The presence of reinforcement intersecting the failure surface provides additional resistance force to failure. This position of failure plane is strongly related to the position of external loading on crest. Meanwhile, the anchored length must also be sufficient to prevent the occurrence of bodily outward sliding of the reinforced zone over an underlying layer of reinforcements (Jewell *et al.*, 1985). Care is needed to ensure that the assumed reinforcement forces and soil shear resistance are compatible with the expected strains in the reinforced soil.

Therefore effect of edge distance and foundation loading on slope stability needs to be studied because of the foundation loading too near to the edge of slope will cause slope failure occur in both unreinforced and reinforced slopes.

1.2 Problem Statement

The lessons from the Taman Hillview and Highland Towers collapsed tragedy and the recent landslides at Hulu Langat have indicated that improper

development and design on hilly area can put users at the risk of landslide. Case studies have shown that the presence of external loads on crest have been the cause of failures of both unreinforced and reinforced slopes. The presence of external load initiates failure planes and the load itself increases the driving force. In reinforced slope, the failure plane is usually intersected by the reinforcement. However, internal instability can take place if the force generated by external load is excessive resulting in tensile failure of the reinforcement itself. Thus, designer should consider the safe distance between the foundation and crest even on stabilized or reinforced slope.

1.3 Aim and Objective of Study

The aim of this study is to determine the safe distance of foundation and the crest reinforced slope. Thus the objectives of this study are:

1. To investigate the effect of reinforcement on the stability of slope using analytical method and Slope/W.

2. To investigate the effect of the location of footing on the stability of reinforced slope.

1.4 Scope of Study

The project will use a Case study at Lot PT 4697, Section 7, Shah Alam, Selangor. Geometry of the slope and soil data will be obtained from G&P Geotechnics Sdn Bhd (2010). Reinforced Earth will be used as slope reinforcement. The analysis will be performed for various values of loading safe distance from the edge of slope crest. Calculation and simulation utilizes Slope/W software for slope stability analysis.

1.5 Significance of Study

The study provides understanding on the effect of improper position of the construction on slope crest will lead to failure of the slope. It is important to ensure the safety conditions of the slopes are attained to prevent slope failure. Therefore, from the study, the safety of the slopes can be determined in term of safety factor and safe distance of foundation on slope crest.

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