USM NEW HOSTEL (DESASISWA TEKUN) SLOPE STABILITY STUDIES

By

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ABSTRAK

Dewasa ini, kita boleh dapati kebanyakan lembah-lembah bukit telahpun menjadi tumpuan peneroka. Berlalunya masa membawa kepada perubahan cita rasa disamping keperluan yang lebih selesa. Kini, pembangunan bukan sekadar di kawasan lembah atau landai sahaja, malah pembangunan infastruktur mula menjalar ke kawasan tanah tinggi. Namun adakah ia selamat? Untuk mencapai tujuan ini, analisis kestabilan cerun adalah penting dan mesti dilakukan dengan sempurna untuk mengelakkan berlakunya kegagalan cerun daripada berlaku. Walaupun terdapat banyak kaedah-kaedah analisis yang digunakan dalam bidang Geoteknik, namun keputusan analisis tersebut tidak dapat menghasilkan gambaran keputusan yang menyeluruh untuk suatu kawasan yang besar. Dalam projek ini, prinsip Geographical Information System (GIS) digunakan bersama dengan teori kaedah analisis cerun tidak terhingga dalam membuat analisis kestabilan cerun. Penggunaan prinsip ini dapat menghasilkan satu imej peta yang dapat memaparkan factor keselamatan cerun bagi seluruh tempat kajian kepada para pengguna. Justeru itu, kawasan yang merbahaya di kawsan bukit dapat dikenalpasti dan pembinaan tidak dijalankan di kawasan berkenaan. Walaupun banyak perisian computer diperkenalkan di pasaran namun dalam projek ini, hanya dua perisian yang digunakan iaitu perisian ERDAS Imagine Ver. 8.3 dan perisian SLOPE/W. Methodologi yang terdapat dalam laporan ini diharapkan akan memberi manfaat kepada orang yang ingin menggunakan kedua-dua perisian ini dalam membuat analisis kestabilan cerun dan ahli penyelidik lain.

ABSTRACT

The aim of this study is to utilize the GIS techniques for slope instability assessment and prediction in the University Sains Malaysia main campus new hostel area, in the Penang State, peninsular Malaysia. GIS, can assist in terms of speeding up processing and moreover in the hazard zonation and prediction assessment.

Nowadays, the problems of slope failure have become more serious. High speed development without hesitation and doubt to build a structure on hill due to the shortage of lands for certain countries contributed to the increasing of slope failure case. By this reason, the work of maintenance for reduce the slope failure become more important nowadays, so the system are needed for some person such as consultant, contractor, developer and government to prevent the slope from fail effectively.

The research of project has a purpose to produce a system which can help to reduce the risk to slope failure by using ERDAS Imagine Version 8.3. Few steps already be recognize in this research such as data collection, confirm type of data which used to analysis the slope stability and system monitoring. The results are produced in images and these images should show the factor of safety for the entire area of a hill. From these maps, we can know and define the danger zones on a hill.

The result of analysis would be check by using Slope/W for determined the effectiveness of system. These software are user friendly and they can be used to do so many spatial analysis and others. Hopefully in this project, the methodology of analyzing slope stability using these two programs can be beneficial to those who are interested in doing slope stability analysis.

ACKNOWLEDGEMENT

First of all I would like to thank Allah S.W.T for giving me the strength and good health enough to survive for completing the report. Special thanks to my extraordinary supervisor, Dr. Fauziah Ahmad. She has sacrificed most of her precious time to help me with my report writing and thought me a lot of new things especially the software applications. Without her guidance, it is merely impossible for me to prepare a creditable study report.

I would also extend my appreciation to En. Sabri Lebai Din. He had been extremely helpful in explaining the process of digitizing and mapping in this study. Not forgetting the dedicated technicians in Computer Laboratory for helping me a lot during the testing process. Thank you very much.

Last but not least, I would like to thank all my friends and the others who directly or indirectly helped me but their names have not been mentioned here. May success will always be with all of you.

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INTRODUCTION

1.1 INTRODUCTION

Slope failure is one of the normal phenomenal that occurred in mountainous areas. They become a problem when they interfere with human activity in which their disasters normally result in damage to properties and loss of life. Although most slope failures are small and individually cause few fatalities, the cumulative losses are small worldwide account for around 25 percent of annual deaths from natural hazards (Hansens 1994).

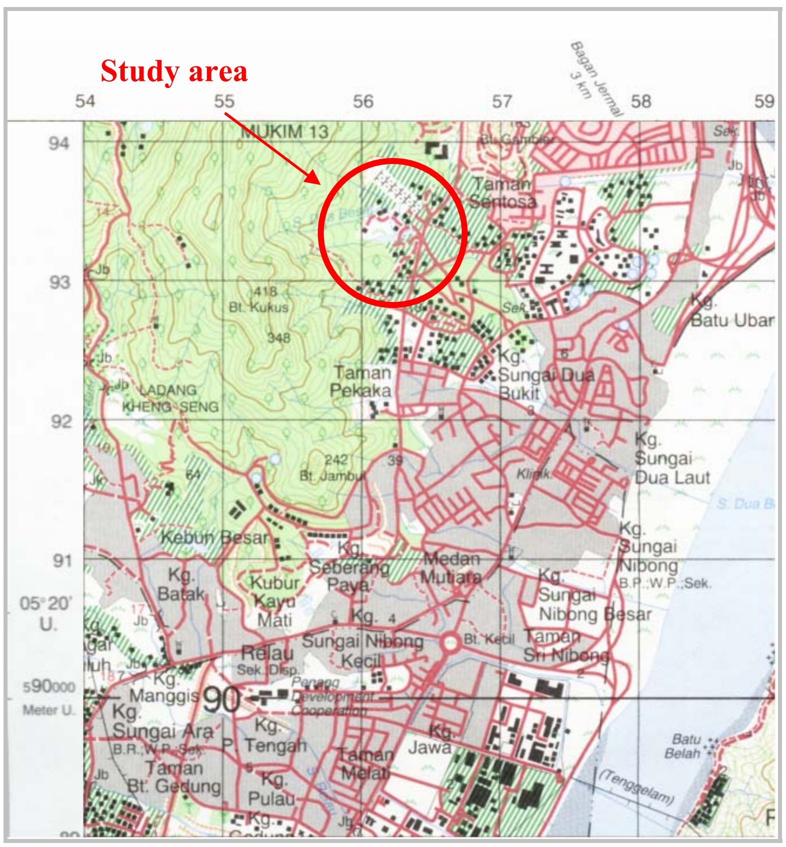
Lot of studies have been carried out to find the impact potential of various natural and artificially induced variables over the landslide. Though it is impossible to completely avoid such problems, yet a lot of human lives and resources can be saved by suitably employing landslide theories to avoid such landslide prone patches at initial stage of planning.

In tropical mountainous areas, slope failures either initiated by natural processes or by human activities are a major cause of natural disasters. Although a small percentage of the individual slope failures are catastrophic, it is especially the high number of slope failure which makes that the total economic loss due to slope failures (eg. Direct damage to agricultural land and infrastructure and indirect damage to economic activity). Since slope failure is considered as a fairly well predictable geological hazard, the economic loss due to slope failures.

One of the significant products that have been developed was ERDAS Imagine. The impact of ERDAS has been widely felt in all fields that use geographic information, in resources management, land use planning and others. The ERDAS advanced method used to analysis and monitoring the changing of slope effectively.

1.2 STUDY AREA

The study area is the University Science of Malaysia main campus new hostel, Penang which is located nearby Taman Pekaka as shown in the map below:



Map 1.1 : Area of case study

1.3 OBJECTIVE

The main objective of this study is to analyze the slope stability in the particular area by using Geographical Information System (GIS). In GIS, all the parameters of analysis can be represented by maps. Map products can then be created centered on any location, at any scale, and showing selected information symbolized effectively to highlight specific characteristics. When all of the maps combined together, new images appeared which can show the value of factor of safety for the area.

BAB 2

Literature Review

2.0 GENERAL

Slope failures are major natural hazards in many areas throughout the world. Thinking about the stability of either new slopes formed by earthworks, or of naturally occurring slopes, is of great and obvious importance in the field of civil and geotechnical engineering. The slope stability study is to measure stability of different types of slope under certain type conditions such as before construction works and after of construction works. Such studies enable safety measure stability to be employed during and after construction.

2.1 SLOPE STABILITY

Slope stability known as ground surface that stands at an angle with the horizontal is called an unrestrained slope. The slope can be natural or artificial. If the ground surface is not horizontal, a component of gravity will tend to move the soil downward. If the component of gravity is large enough and the soils internal shear strength is small enough, a slope failure can occur.

2.2 TYPE OF SLOPE

There is 2 types of slope:-

• Natural Slope

The natural (not man made) slope can be split into two main categories:-

i) the slope that are made up of a series of long term processes

ii) the slope that are made up of process which act for a short duration

This second category of slope takes much more investigation to discern the original cause of slope formation, and an understanding of these processes is essential for a successful engineering investigation, and to know how to deal with problems of instability which may arise.

(Connolly H, 1997. MEng final year project report, School of Engineering: University of Durham, pp 43.)

• Man-made Slopes

Man-made slope can be considered in two main categories:-

a) Cut slope:-

Shallow and deep cuts are of major interest in many civil and mining engineering operations. Such design is influenced by geological conditions, material properties, seepage pressures, the possibility of flooding and erosion, the method of construction as well as the purpose of a particular cutting.

In some situations the stability at the end of construction of a cutting may be critical. On other hand many cut slope are stable in the short-term but may fail without warning many years later (Skempton 1964, 1970).

(R.N. Chowdhury,1982 – Slope Analysis, Developments in Geotechnical Engineering Vol22)

b) Embankments and earth dams

The analysis of embankments does not involve the same difficulties and uncertainties as does the stability of natural slopes and cuts. However, independent analysis is required for a following critical condition:-

i. end-of-construction
ii. long-term condition
iii. rapid draw-down (for water retaining structures like earth dams)
iv. seismic disturbance

(Peck, 1969, Casagrande, 1965)

It is important to know when analyzing a slope whether its most critical state occurs at the end of its construction period, ie. short term, or in a more long term situation. This depends on the type of slopes in question and on the type of soil

	EXCAVATION	EMBANKMENT
MOST STABLE CONDITION	End of Construction (short term).	Long Term
MOST CRITICAL CONDITION	Long Term	End of Construction (short term).

Table 2.1: (Connolly H, 1997. MEng final year project report, School of Engineering: University of Durham, pp 43.)

2.3 SLOPE FAILURE

"Slides may occur in almost every conceivable manner, slowly and suddenly, and with or without any apparent provocation. Usually, slides are due to excavation or to undercutting the foot of an existing slope. However, in some instances, they are caused by a gradual disintegration of the structure of the soil, starting at hair cracks which subdivide the soil into angular fragments. In others, they are caused by an increase of the pore water pressure in a few exceptionally permeable layers, or by a shock that liquefies the soil beneath the slope. Because of the extraordinary variety of factors and processes that may lead to slides, the conditions for the stability of slopes usually defy theoretical analysis." - [Source: Terzaghi, K., and Peck, R.B., 1967, *Soil mechanics in engineering practice* (2nd edition), New York, John Wiley & Sons, Inc., p. 729]

Natural slope which have been stable for many years may suddenly fail due to one or more causes such as:

a. External disturbance in the form of cutting or filling of parts of a slope or of adjacent to it.
b. External disturbance in the form of seismic activity. (earth tremors or earthquake)

c. Increase of pore water pressure within a slope. (e.g rise in water table)

d. Progressive decrease in shear strength of slope materials.

e. Progressive change in the stress field within a slope.

f. Weathering of soils and rock destroys bond and reduces shear strength.

(R.N. Chowdhury, 1982 – Slope Analysis, Developments in Geotechnical Engineering Vol22)

Several major types of slope failures have been identified:-

• Falls

Falls are confined by the surface zones in soil (soil falls) or rock (rock falls) and are precede by the formation and enlargement of cracks and removal of base support of individual blocks or masses. These can occur in either soil or rock masses, and usually occur on extremely steep slopes. A fall is characterized by the moving material being completely separated from the ground over which it travels.

• Sliding

Many classifications of landslides have been given e.g. Eckel (1958), Hutchinson (1968), Skempton and Hutchinson (1969) and many else according to R.N. Chowdhury in his Slope Analysis, Development In Geotechnical Engineering vol22.

Slides involve shear failure and may be translational or rotational or a combination of rotational and translational.

• <u>Rotational</u>

This type of failure surface may be either circular or non-circular.

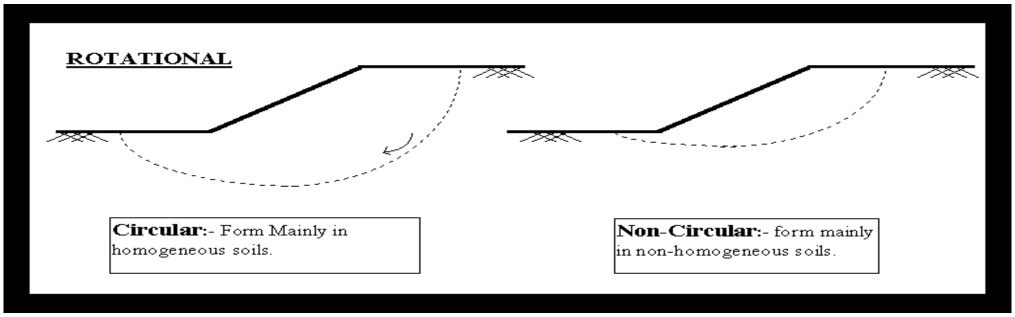


Figure 2.1 Rotational type of failure

• <u>Translational</u>

Translational slides often involve movement along marked discontinuities or planes of weakness.

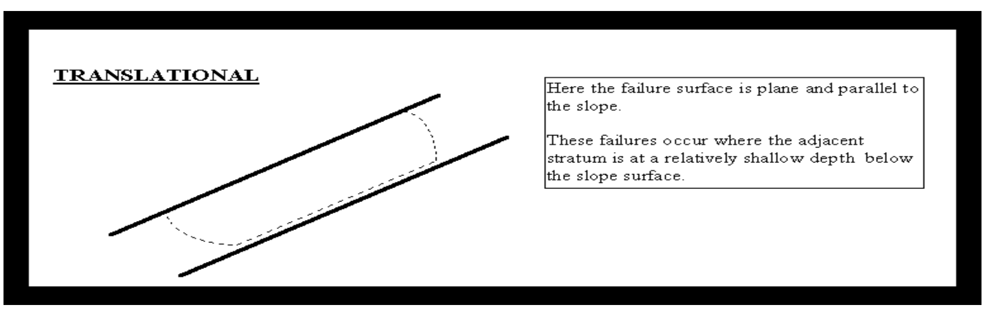


Figure 2.2 Translational type of failure

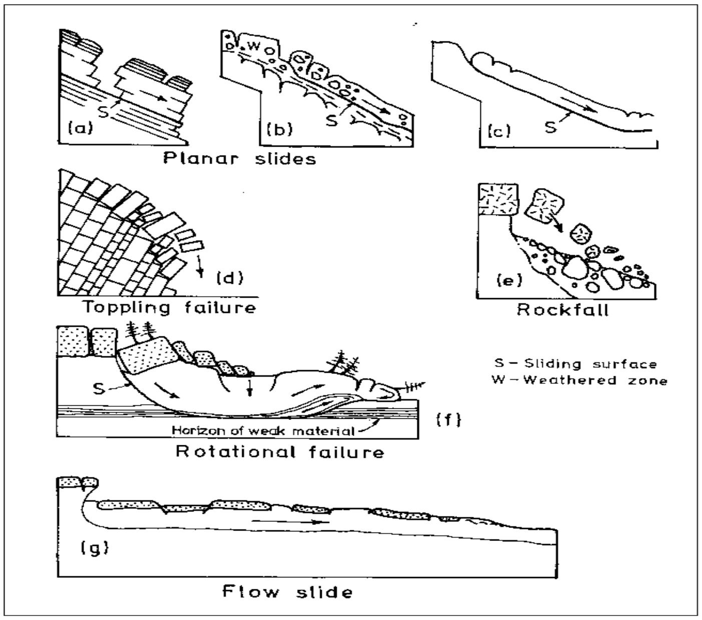


Figure 2.3: Type of slope movement (after Blyth and de Freitas, 1974)

(R.N. Chowdhury,1982 – Slope Analysis, Developments in Geotechnical Engineering Vol22)

• <u>Flow</u>

A flow is a movement of a mass of soil which involves a much greater internal deformation then a slide. In a cohesive, clay soil, the moisture content of the soil must be above the liquid limits, otherwise the movement is a slide. In this case the material behaves as a fluid. This is not the case for non-cohesive, granular soils, where flows can even take place in dry soil.

2.4 FACTOR OF SAFETY

In slope design, and in fact generally in the area of geotechnical engineering, the factor which is very often in doubt is the shear strength of the soil. The f.o.s is therefore chosen as a ratio of the available shear strength to that required to keep the slope stable.

Guidelines for limit equilibrium of a slope:-

FACTOR OF SAFETY	DETAILS OF SLOPE
<1.0	Unsafe
1.0-1.25	Questionable safety
1.25-1.4	Satisfactory for routine cuts and fills, Questionable for dams, or where failure would be catastrophic
>1.4	Satisfactory for dams

Table 2.2 Factor of safety

For highly unlikely loading conditions, factors of safety can be as low as 1.2-1.25, even for dams. E.g. situations based on seismic effects, or where there is rapid drawdown of the water level in a reservoir.

(Connolly H, 1997. MEng final year project report, School of Engineering: University of Durham, pp 43.)

2.5 GEORAPHIC INFORMATION SYSTEM (GIS)

Simply put, a GIS combines layers of information about a place to give you a better understanding of that place. The unique capability of GIS to work (to capture, store and mange the data) with data referenced by geographic coordinates and its ability to incorporated appropriate engineering models, especially in the analyze slope stability (Mukesh et al. 2001).

Using GIS module, integration of the past landslide data, lineaments and the geological information have been attempted to evaluate the risk in the study area.

2.6 RELATED CASE STUDY

1. Slope Instability and Hazard Zonation Mapping Using Remote Sensing and GIS Techniques in the Area of Cameron Highlands, Malaysia (Jasmi Ab. Talib, Malaysian Centre for Remote Sensing (MACRES))

(i) With the availability of different types and various scale of remotely sensed data, several parameter maps can be generated, emphasizing the mass movements distribution map. GIS, on the other hand, can assist in terms of speeding up processing and moreover in the hazard zonation and prediction assessment.

(ii) The result of slope instability study by using the Information Value Method, has given the indication of the most relevant causative factors influencing the mass movements occurrences in this study area.

(iii) By summation of causative factor maps in that method, resulted in the delineation of the mass movement hazard zonation. Hence with the classified information from the infrastructure and land use units, the risk to the area can be assessed.

(iv) The data that used are:

(a) Topographic map and digital elevation data, which later on were used for DTM generation.

(b) Geology map

(c) Distance map that generated from fault, drainage and road map respectively

(d) Land use map

(e) Remotely sensed data: satellite data and aerial photographs.

(v) The calculation applied to this hazard information method is based on the following formula, as for the calculation the information value I_i for variable X_i:

$$I=\log (S_i/N_i)/(S/N)$$

In which:

S_i= the number of pixels with mass movements and the presence of variable X_i

N_i= the number of pixel with variable Xi

N_i= the total number of pixels with mass movements

N= the total number of pixel

The degree of hazard for a pixel j is calculated by the total information value Ij:

$I_j = {}^{m}\Sigma_{i=0}\ X_{ij}\ I_i$

In which :

M= number of variables

X_{ij}= 0if the variable X_i is not present in the pixel j and 1 if the variable is present

The bigger the I_j valve is, the more unstable pixel j within the slope.

(vi) The relation of information value with causative factor maps blow shown the most relevant factors influencing the mass movement occurrences in the area, the factor maps are:

(a) Distance from road

(b) Land Use

(c) Classified slope

(d) Distance from river

(vii) The hazard zonation map was generated by reclassifying the total information value map. The map was reclassify to there arbitrary classes such as low, medium and high hazard. The low hazard can be described as the probability of occurrences of landslides is very limited even with strong triggering factors, such as heavy rainfall and tremendous land use changes. On the other hand, the medium hazard means that some mass movements will be generated under the influence of intense triggering factors whereas for the high hazard, a considerable number of mass movements will be expected even with the presence of weak triggering factors.

2.7 SLOPE PREVENTION

All slopes are susceptible to mass-wasting hazards if a triggering event occurs. Thus, all slopes should be assessed for potential mass-wasting hazards. Mass-wasting events can sometimes be avoided by employing engineering techniques to make the slope more stable. Among them are:

- Steep slopes can be covered or sprayed with concrete to prevent rock falls
- Retaining walls could be built to stabilize a slope.
- Drainage pipes could be inserted into the slope to more easily allow water to get out and avoid increases in fluid pressure, the possibility of liquefaction, or increased weight due to the addition of water.
- Over steepened slopes could be graded to reduce the slope to the natural angle of repose.
- In mountain valleys subject to mudflows, plans could be made to rapidly lower levels of water in human-made reservoirs to catch and trap the mudflows.

Some slopes, however, cannot be stabilized. In these cases, humans should avoid these areas or use them for purposes that will not increase susceptibility of lives or property to mass-wasting hazards.

2.8 SUMMARY

The assessment of landslide behavior is usually undertaken by means of monitoring scheme. That's why an economic model is developed to produce a database for identifying, modeling and monitoring the critical area of the slope. The models are an approach to deal with the limitations to our knowledge of natural processes. This developed model's enable monitoring activity of existing slope, analysis and prediction of slope failures in the future.

Besides, the system would help in controlling and preparing development plan including the framework of future land use and development in that respective area. With this technology, hope that it'll help to increases the accuracy, productivity, monitoring capability, rapidity and economy with respect to size of the study area.

CHAPTER 3

METHODOLOGY

Figure 3.1 Satellite Image of USM new hostels

The work to build the system for analysis of slope failure is point on the work of database assembly, monitoring, analysis and system of protection. The parts of database assembly are site investigation, in-site test and laboratory, map digitizing and key in database. The type of map will be created such as contour map and soil profile map. Monitoring is a part of the system to reduce the risk of slope failure. The methods of monitoring are maintenance inspection and preventive maintenance works. The analysis past is checking the factor of safety for design slope or natural slope by using different model of analysis. The system of protection for slope is to protect the different categories of slope away from failure. The method of prevention depends on the type of slope, possible type of land slide, factor of safety and also experience.

The methodology of the whole project from starting till the end is as shown in the flow chart on Appendix B.

3.1 GENERAL

The process of assemble the data which need in the project to build the system of analysis of slope failure is start from site investigation, that is the procedure which include desk studies, field studies and various in-site test and laboratory. The references that can provide valuable information and guidance for the site investigation are shown below.

1. Code of Practice for Site Investigation, BS5930
2. Report of the International Association of Engineering Geology Commissions on Site Investigation

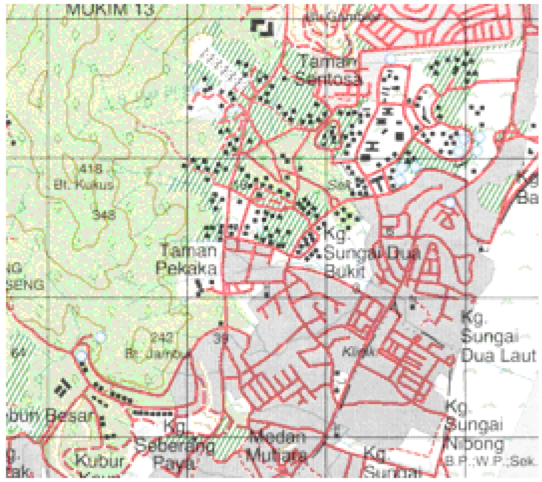
In desk studies, the topographic map and plan can be used to identify geomorphologic forms and drainage patterns. Geological maps can be used to obtain information on materials and geological structures that affect the site, the information about maps and plan can get from agencies of Survey and Mapping Malaysia (JUPEM). Besides the map plan, the documents related to information about soil profile and slope also very valuable to study, for example such as record of the development and report of site investigation, this type of information normally can get from Agencies of Work Malaysia (JKR).

The fields studies is the process for engineer to more understand the condition of site, for large or difficult site, the full-scale surface investigation and geological map should carry out together. The soil and rock description is one of the important features of a competently executed site investigation; the suitable qualified and experienced persons should go for this purpose. Got various methods to do the subsurface investigation, those are Trial Pits and Trenches, Hand-excavated Caissons, slope surface stripping, Dynamic Probing, Boring and Drilling. For the in-site test, various tests can be used to asses strength, deformation properties and permeability of both soils and rocks, such as

Standard Penetration Test, Impression Parker Survey, Dutch Cone Test, Pressure Meter, Plate Bearing Test, Vane Test, Permeability test and Packer Test. For the laboratory test, the parameter of soil can get with more accuracy, such as moisture content, specific gravity and particle size distribution. Besides the parameter that have been mention before, few another test also can be used to get another parameter such as compaction test to get dry density of soil, permeability test for the permeability of a soil or rock sample from site, consolidation test are used to determined shear strength parameter of soils. The laboratory test can refer to the Test of Soil for Civil Engineering Purpose, BS1377, 1990.

The report of site investigation for USM new hostel and the soil profile have been provide and the topographic map and other related also be collect and digitizer using ERDAS Imagine 8.3. The data related will show in Appendix C.

3.2 DATA COLLECTION



Map 3.1 USM topographic Map

From topographic map, some information can be figured out such as;

a. coordinate of the study area

b. surrounding environment

c. contour of the area

d. land use

Some of the soils properties are provided in the Site Investigation report such as;

a. soil strength

b. soil characteristic like cohesion, c , angle of friction, ø and bulk density, γ

c. water level

From these two sources, the analysis of slope failure will be carry out by ERDAS Imagine 8.3 software and the result will be compared with result analysis using SLOPE/W.

3.3 SOFTWARE

3.3.1 ERDAS IMAGINE VER. 8.3

Figure 3.3 ERDAS Imagine Ver. 8.3 Software

The analysis of slope failure at USM new hostels is ERDAS Imagine Ver. 8.3. ERDAS are suitable for database processing. These data provide important information about many sectors such as hydrology engineering, ecology, forest and planning. The software is easy to use because it is user-Friendly type of software.

3.3.2 SLOPE/W Ver. 5

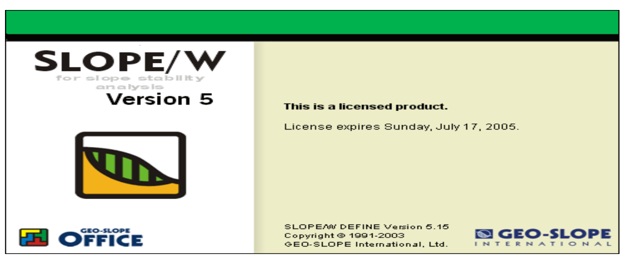


Figure 3.4 SLOPE/W Software

SLOPE/W is a software product that uses limit equilibrium theory to compute the factor of safety of earth and rock slopes. The comprehensive formulation of SLOPE/W makes it possible to easily analyze both simple and complex slope stability problems using a variety of methods to calculate the factor of safety. SLOPE/W has application in the analysis and design for geotechnical, civil, and mining engineering projects.

3.4 METHODOLOGY

3.4.1 ERDAS IMAGINE 8.3

Opening the image file;

Procedure: Viewer / File / Open / Raster Layer / File Name / OK.

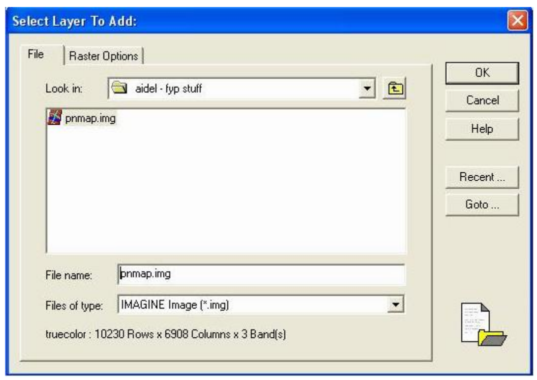


Figure 3.5 Opening an Image File

3.4.1.1 RECTIFICATION

Raster Image rectification can record Ground Control Point (GCP), compute a transformation matrix and use the transformation matrix and a resample method to rectify the image.

Procedure: Viewer / Open / Raster / Geometric Correction / Polynomial Model Properties

↓ (Geometric Correction)
- Set Geometric Model
- Polynomial
- OK

↓ (Polynomial Model Properties)
- Projection
- Map Units: Meter

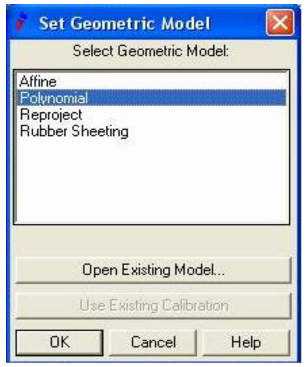


Figure 3.6 Set Geometric Model Dialog Box

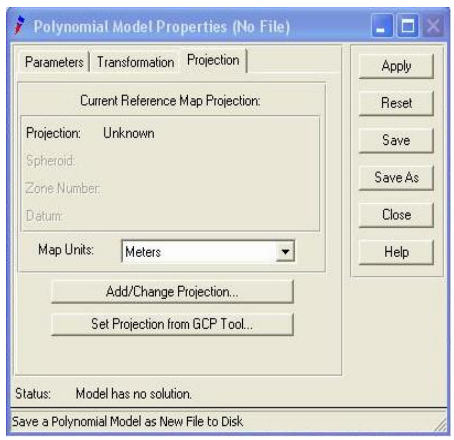


Figure 3.7 Polynomial Model Properties Dialog Box

Ground Control Point is the location in the image for a map which its coordinate are known. In the rectification, the GCP coordinate should be known in the system where data will be processed.

Procedure: GCP tool / icon create GCP / set 4 point GCP

Set 4 GCP at every corner of the image that wants to rectify. The coordinate should be in the intersection grid of the map.

The GCP must be in the intersection so it is easy for us to find the reference coordinate in topography map and those values were put into X Ref. and Y Ref. After all the CGP have been set, click Resample icon on Geo Correction Tools. In the Resample Dialog Box, insert the output file name (ex. scanresample.img). In the Output Corners on the Resample Dialog Box, the ULX (Upper Left X) value and ULY (Upper Left Y) value is the coordinate of GCP#1. For LRX (Lower Right X) value and LRY (Lower Right Y) value is the coordinate of GCP#3.

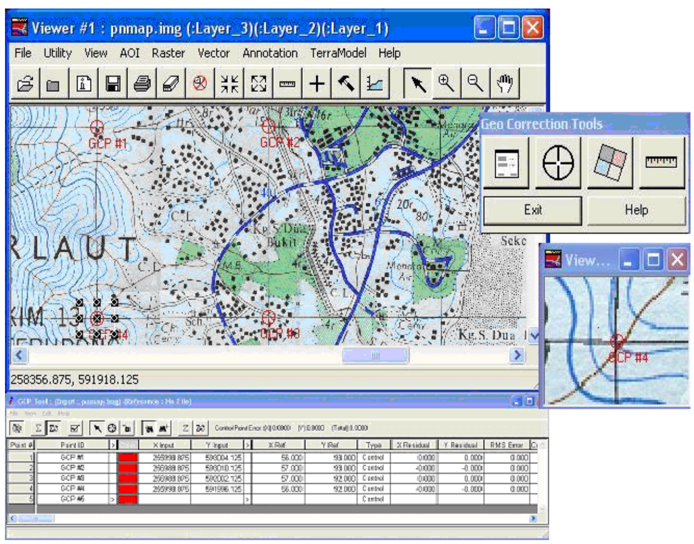


Figure 3.8 Input a GCP Coordinate Process

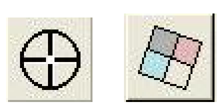


Figure 3.9 Create CGP and Resample Icon