DEVELOPMENT AND TESTING OF SLOPE STABILITY MONITORING SYSTEM DESIGN

By

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CERTIFICATION OF APPROVAL

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Main Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2006

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted for this project, that the original work is my own except as specified in the references, and that the original work contained herein have not been taken or done by unspecified sources or persons.

MOHD AZRI BIN MOHD KAMIL

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Thank you to all.

ABSTRACT

This final report is for the project on slope deformation monitoring system. It covers the background of the study, some literature reviews and related theories; methodology used for the project and finally, some discussion throughout the first semester of the project. The main objective of this project is to design a slope monitoring system. In order to test the system, a simulated slope movement also has to be monitored. The site of this project is at the New Academic Building, UTP, where a slope is to be monitored continuously in real time. Collected data will be interpret using relevant positioning software and analyze by the system. Alarm will rise if there's a significant deformation is detected.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Slope deformation is the down slope movement of materials under the influence of gravity. Slope deformation can occur at rates of only a few inches per year and cause little damage and no loss of life, or it can occur at over 100 miles per hour and result in great loss of life and property damage. Slope deformation can often be unpredictable. A slope deformation event in China in 1920 resulted in over 220,000 deaths. Slope deformation events may also be linked to other geological events that trigger the failure of an unstable slope.

Since the slope deformation is unpredictable, a system should be implemented to monitor the slope which had been identified as a critical slope, continuously to reduce severity of injuries. Nowadays, Survey Engineering plays an important role to cater this issue. Several equipments have been introduced to overcome these problems. The use of GPS technology in landslide mapping widely, helps to prevent this disaster from becoming worst. This project focuses on the use of geodetic instrument to monitor the movement of a slope.

In this project, one of the slopes at the New Academic Building UTP will be monitored using Total Station. This slope is assumed to be a critical slope and need to be monitored. A set of data will be analyzed to enumerate the magnitude deformation of the slope.

1.2 PROBLEM STATEMENT

Unstable slope has to be monitored in order to detect any movement prior to their collapse. However manual continuous monitoring is cumbersome and impractical. Therefore need a system that could monitor not only the unstable slope movement continuously but also can alert the community rapidly.

1.3 OBJECTIVE AND SCOPE OF STUDY

There are several objectives needed to be achieved in this project which are:

- To design a slope monitoring system
- To monitor simulated slope movement in order to test the system.

This project involved monitoring a slope behind the Civil Engineering Department (Building 13 and Building 14), New Academic Buildings, UTP. This slope is assumed to be a critical slope. The slope has to be monitored continuously in real time using Total Station, connected to computer via RS-232 cable. The data will be transferred to appropriate positioning software. A system will be created to observe the deformation of the slope. If significant movement is observed, the system gives an output to raise an alarm.

CHAPTER 2

LITERATURE REVIEW AND/OR THEORY

2.1 THEORY OF SLOPE DEFORMATION

2.1.1 Introduction

Although the root cause of mass wasting is the force of gravity, there are a number of other factors that increase the risk of slope failure. When one or more of these risk factors is high, mass wasting is likely to occur.

2.1.2 Slope Angle

The angle at which material slopes is the major determining how much of the force of gravity is directed downslope. If a block of rock weighing 10 pounds is placed on a flat surface, gravity acts vertically and perpendicular to the flat surface, as shown in **(Figure 1)** and the full force of gravity is directed downward onto the surface. If the slope is rotated, some of the force of gravity is directed, or resolved, perpendicular to the sloped surface, called normal force, and part is resolved parallel to the surface, called shear force. As the angle of the sloped surface increases, the force of gravity remains the same however the amount of that force resolved as shear force increases and the amount resolved as normal force decreases as shown **(Figure 1)**. At some point the ratio of shear/normal force, called the coefficient of sliding friction, reaches a critical level and the block begins to slide down **(Figure 1)**. Every material and slope type has an inherent angle at which the material becomes unstable, called the angle of repose. Most unconsolidated materials, such as soil or sediment, have angles between 30 and 40 degrees. The angle of repose for solid rock materials depends on the smoothness of the sloped surface and the nature of the rock material, and can vary from 20 – 45 degrees.

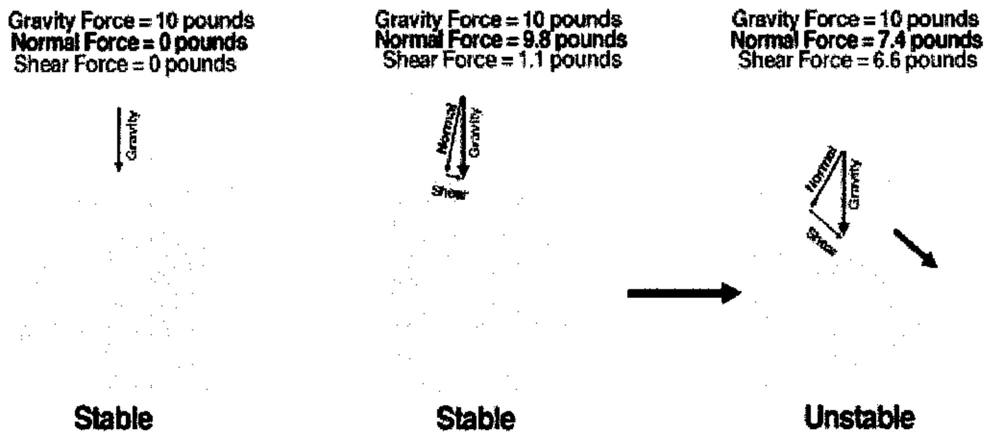

Figure 1: Slope Angle

2.1.3 Pore Water

Pore water is the water held within the void spaces, or pores, in the rock or sediment. Pore fluid has two distinct effects on mass wasting risk. Pore water has a tendency to liquefy and disaggregate unconsolidated materials, such as sediment or soil. Pore water tends to destabilize rock layers on sloped surfaces. When pore water is under pressure it reduces the normal force holding rock layer stable on the sloped surface without reducing the shear force that causes the downward motion of the rock.

2.1.4 Material

The type of material within a sloped terrain is another important risk factor. Unconsolidated materials, such as soil and sediment, tend to be more prone to slope failure than rocks. Sand-rich sediment tends to be the least stable because there is more void space and the packing of individual grains is not as close as sediment with clay sand and silt. Layered rocks are more stable than sediment or soil but are less stable than massive igneous rocks. Layered rocks tend to be more friable and can be fragmented and broken away from the bedrock. Massive rocks tend to be less prone to fracturing and fragmentation except when they are highly fractured.

2.1.5 Orientation

The orientation of rock layers has a significant effect on the stability of the slopes containing layered rock units. When rock layers dip in the same direction as the slope, failure of the slope is most likely. Horizontal layering is a somewhat more stable configuration. The most stable configuration is when the rock layering dips into the slope, in the opposite direction of the slope direction.

2.1.6 Vegetation

Vegetation has an anchoring effect on slopes. The roots of the vegetation form a physical anchor for the soil and sediment along the slope. Vegetation also reduces the amount of water in the pore spaces for nutrition. When human development occurs vegetation is often stripped from slopes, increasing the risk of slope failure.

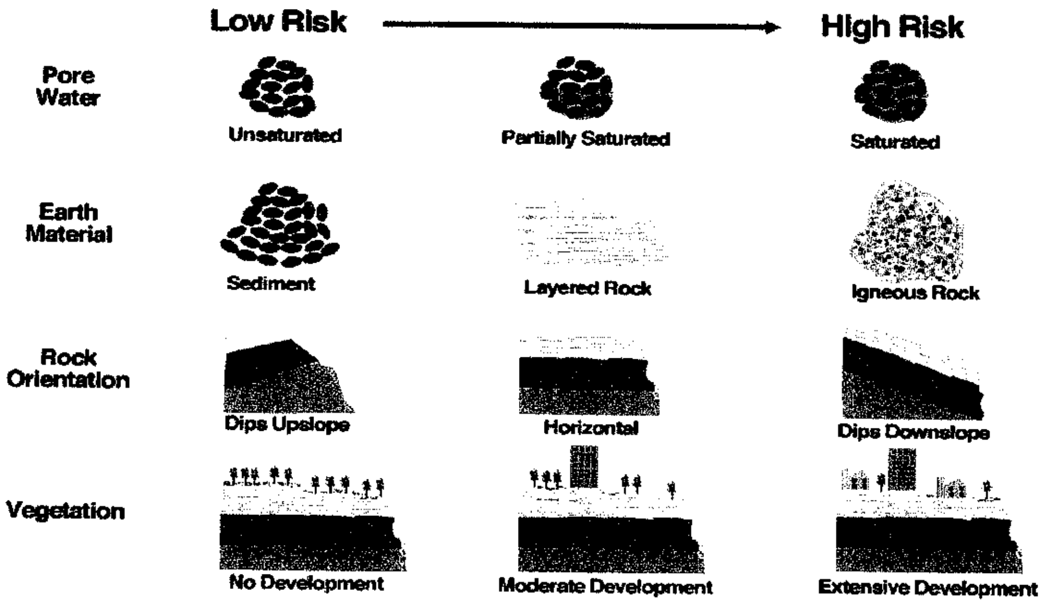

Figure 2: Vegetation Effects

2.2 MATLAB Programming

MATLAB® is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

2.2.1 Programming function

MATLAB® is also a powerful programming language as well as an interactive computational environment. Files that contain code in the MATLAB language are called M-files. It can be created by using a text editor, and then it can be used as any other MATLAB function or command.

There are two kinds of M-files:

- Scripts, which do not accept input arguments or return output arguments. They operate on data in the workspace.
- Functions, which can accept input arguments and return output arguments. Internal variables are local to the function.

2.2.2 Loop Control -- for, while, continue, break

The *loop* control statements, you can repeatedly execute a block of code, looping back through the block while keeping track of each iteration with an incrementing index variable. Use the *for* statement to loop a specific number of times. The *while* statement is more suitable for basing the loop execution on how long a condition continues to be true or false. The *continue* and *break* statements give more control on exiting the loop.

- **For**

The *for* loop executes a statement or group of statements a predetermined number of times. Its syntax is

```
for index = start:increment:end
        statements
        end
```

- **While**

The while loop executes a statement or group of statements repeatedly as long as the controlling expression is true (1). Its syntax is

while expression

statements

end

- **Continue**

The continue statement passes control to the next iteration of the for or while loop in which it appears, skipping any remaining statements in the body of the loop. In nested loops, continue passes control to the next iteration of the for or while loop enclosing it.

- **Break**

The break statement terminates the execution of a *for* loop or *while* loop. When a break statement is encountered, execution continues with the next statement outside of the loop. In nested loops, break exits from the innermost loop only.

2.2.3 Graphical User Interface (GUI)

GUIDE, the MATLAB graphical user interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). These tools greatly simplify the process of designing and building GUIs. The GUIDE tools can be used to

- Lay out the GUI:

  Using the GUIDE Layout Editor, you can lay out a GUI easily by clicking and dragging GUI components -- such as panels, buttons, text fields, sliders, menus, and so on -- into the layout area. GUIDE stores the GUI layout in a FIG-file.

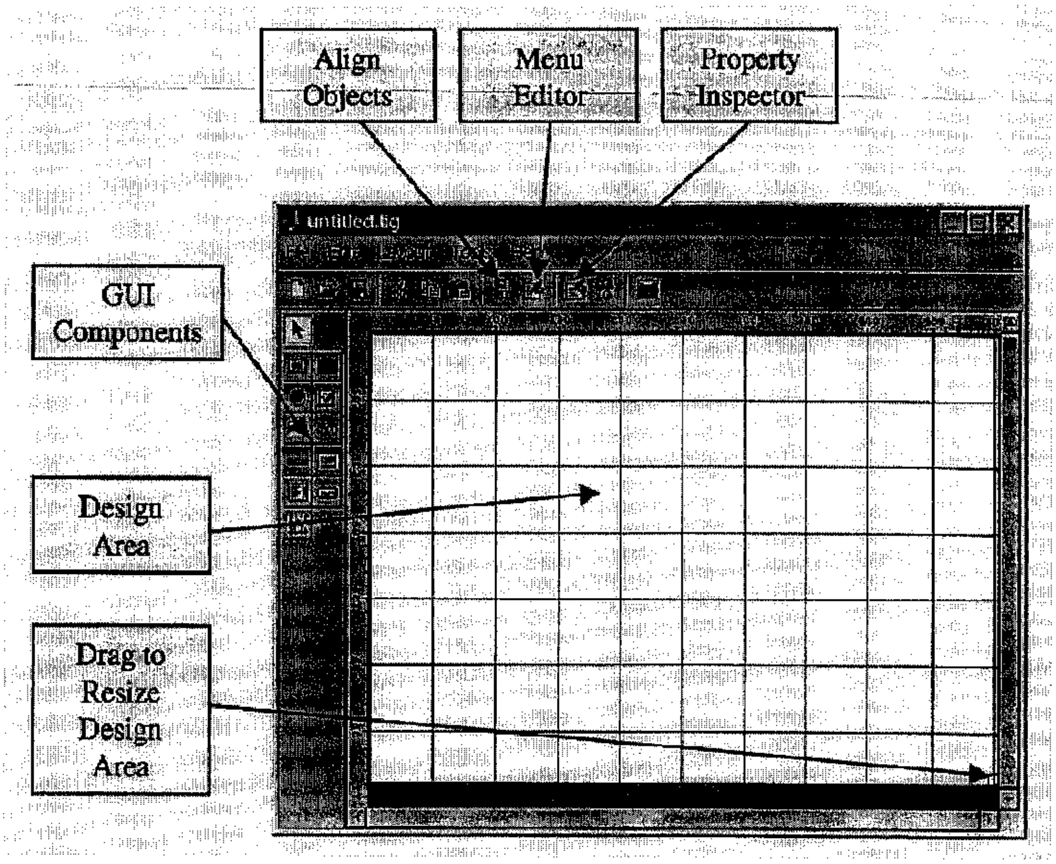

Figure 3: GUI Layout

- Program the GUI:

  GUIDE automatically generates an M-file that controls how the GUI operates. The M-file initializes the GUI and contains a framework for the most commonly used callbacks for each component -- the commands that execute when a user clicks a GUI component. A code can be added to the callbacks to perform the desire functions by using the M-file editor.

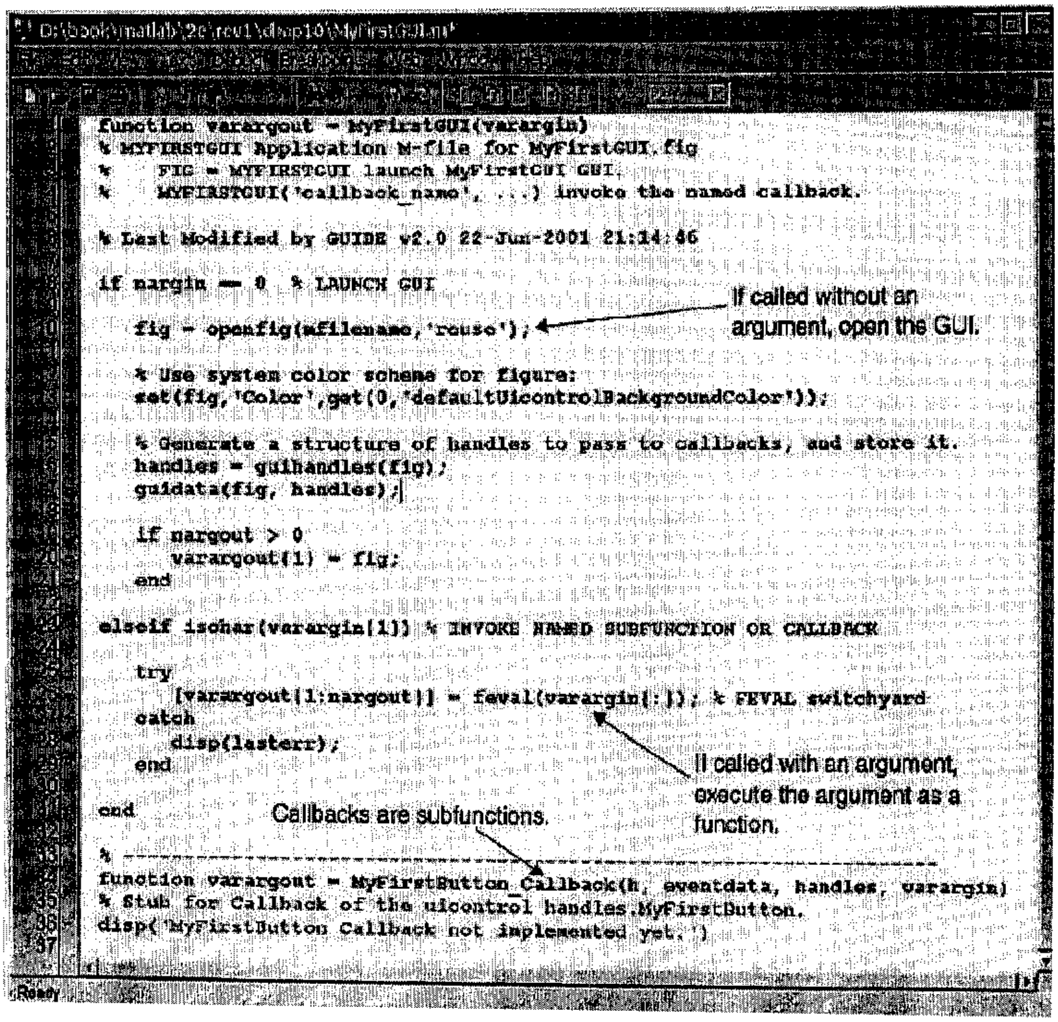

Figure 4: M-file editor

2.3 Surveying Tools

2.3.1 Topcon Total Station

Please refer Appendices A (**Figure 9** and **Figure 10**)

CHAPTER 3
METHODOLOGY / PROJECT WORK

Five stages involve in this project as seen in figure below:

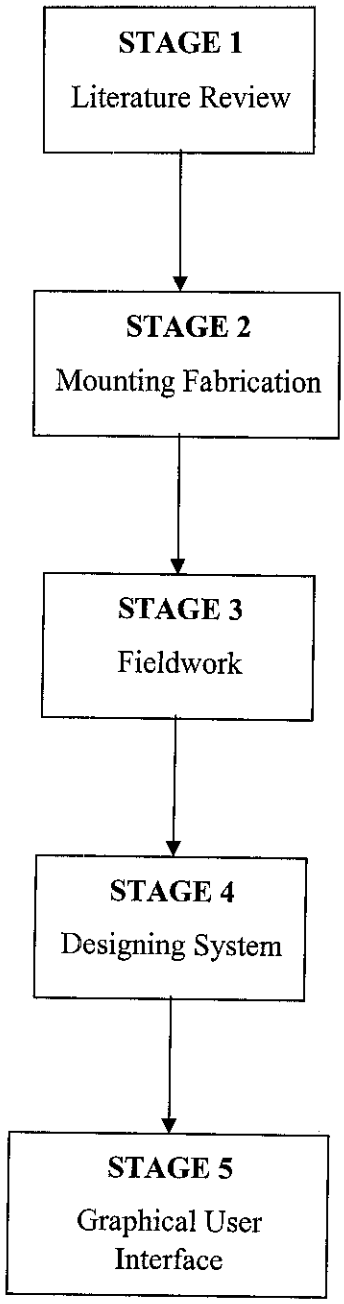

Figure 5: Methodology stages

3.1 Methodology Process

3.1.1 Stage 1: Literature Review

Literature review done concerning on the theory of slope deformation, MATLAB Programming software and surveying equipment used in this project. The source for literature reviews varies from books, knowledgeable people, published paper and web sites.

3.1.2 Stage 2: Mounting Fabrication

A mounting pod for the total station is designed to ensure the *base point* didn't move during the observation. This mounting pod will be placed at the site permanently throughout the project so that the inaccuracy due to human contact can be minimized. Several designs are made in order to find a suitable mounting pod that can be used at the project site. The final design of the mounting pod is as shown in **Figure 6**. This mounting pod is made from mild steel and being fabricated at one of the steel workshop at Batu Gajah.

The challenging part in fabricating this mounting pod is when to find the exact bolt which can fixed the total station. It's quit difficult to find a bolt with exact thread so it won't damage the total station. A minor alteration is made to the bolt so it can be matched with the total station.

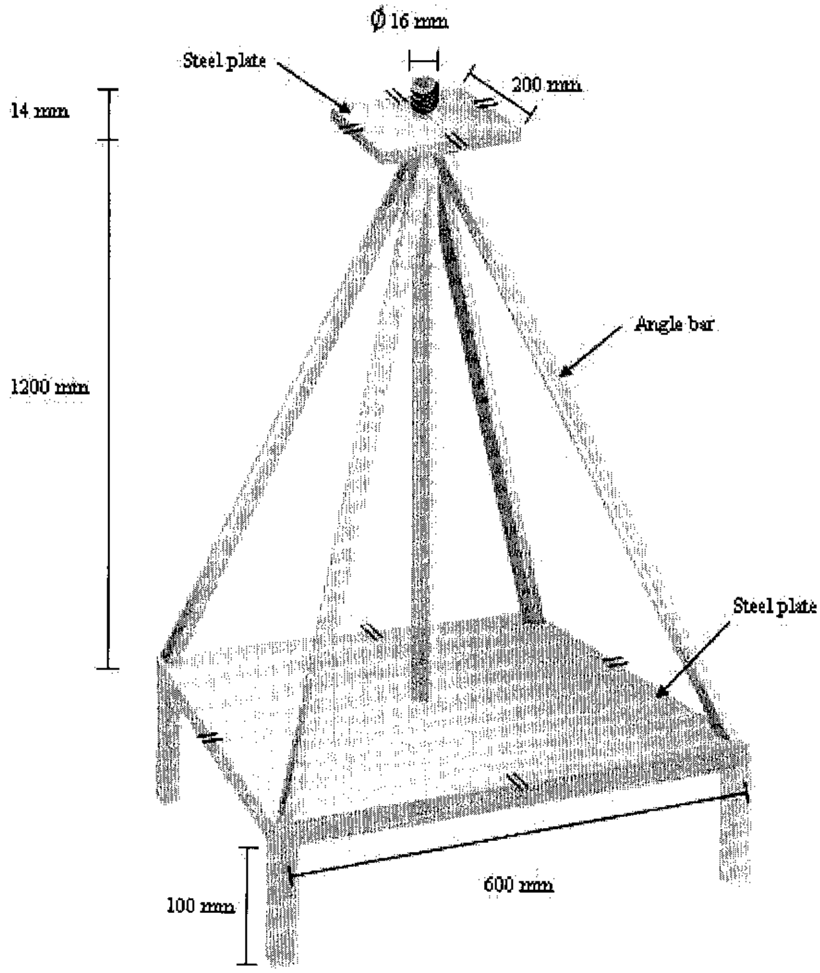

Figure 6: Final design of the mounting pod

3.1.3 Stage 3: Fieldwork

The fieldwork for this project is done at a slope, behind Civil Engineering Department (Building 13 and Building 14), New Academic Buildings. Although the slope at this area is stable, it's assumed to be a critical slope in order to perform this project. A total station is placed at a base point, near the Building 13, permanently throughout the observation. It will monitor observation points, which were marked with a pole with prism, placed at the proposed slope for a period of time. The reading is made for every 10 minutes intervals and recorded in the total station. The layout procedure of the project is as in **Figure 7**

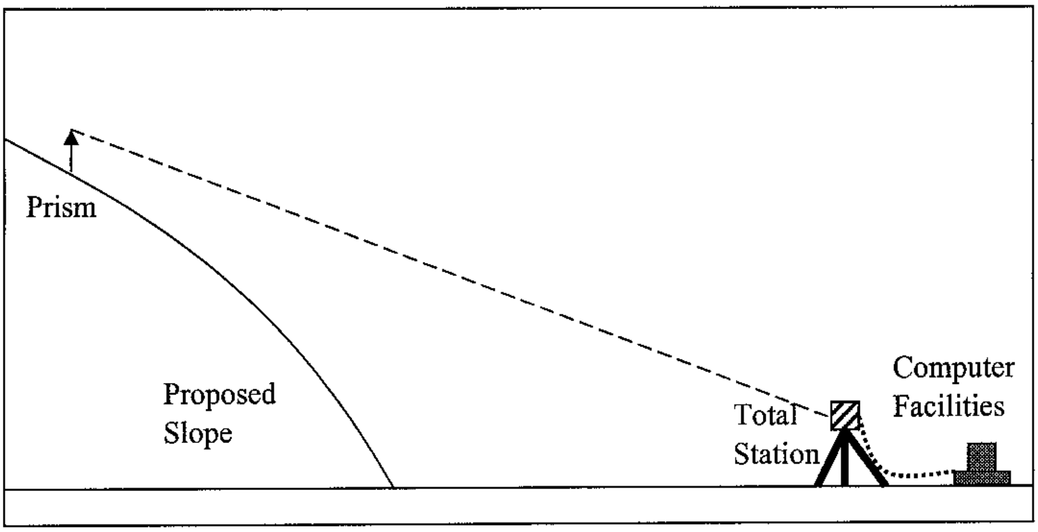

Figure 7: Project Layout

3.1.3.1 Control Points Location

Three (3) control points are established during observations. These points act as a fixed point for data collection throughout the observation.

- Base point

Total station will be placed at the *base point*, located near the Building 13. The leg of the mounting pod will be buried and the total station is set up on the mounting pod.

- Reference point

A hydrant near the base point is used to be reference point. This point is to ensure that the coordinate of the base point is not moved when the equipment is set up again. The reference point should not exhibit any deformation and does not obstruct continual activities around it.

- Observation point

For this project, there are two observation points are need to be observed. First point is to shows that the slope is stable and another point to show that there is a movement of the slope. This is to make a comparison of data and to test the system.

3.1.3.2 Total Station

For this project, a Topcon GTS-220 series manufactured by Topcon Corporation is used. Throughout the research done on the web site, the total station that's really suit for these project is the Topcon GPT-8000/8000A series. These models are robotic total station where it can keep track the movement of the prism by it selves. Since these models are still new in the market and due to the availability of the equipment, the Topcon GTS-220 series is used. This equipment is connected to computer via RS-232 cable and the data recorded in the total station will be transferred to Topcon Link positioning software.

3.1.4 Stage 4: Designing System

This project required to create a warning system in order to warn if there's a deformation of the slope / slope failure is occurred. The MATLAB Programming software is used as an option to create the system, integrated with Microsoft Excel spreadsheet, where the data is stored in that spreadsheet. Flow of the system is designed as in **Diagram 1.**

The system design is actually based on comparison function. An initial condition is set in the system. This condition is actual a coordinate of the prism before deformation. If deformation occurs, the coordinate of the prism will change. The system will loop the data until it found that the data is differing with the initial data, and then it will stop looping. The system will execute an alarm to give an alert due to deformation occurred.

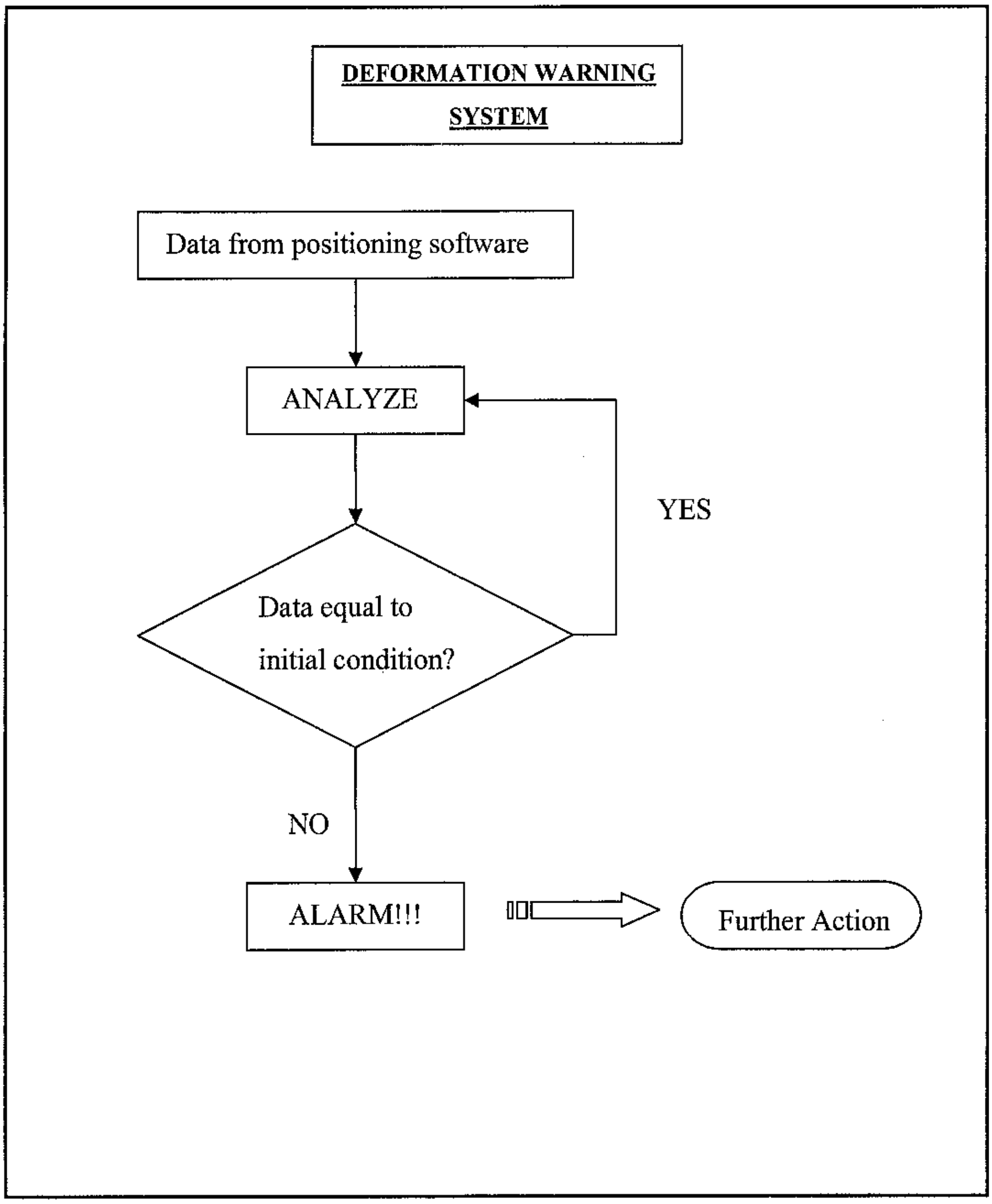

Figure 8: Flow process of warning system

3.1.4.1 MATLAB Programming

- *If else* function

Using the MATLAB Programming, the system is done by using the *if else* function. This function is actually comparing one or more expressions. It's a conditionally statements. If the expression evaluates as false, MATLAB executes another expressions as a result of the comparisons.

Applying to this project, the system will asked to enter the initial condition which is the initial coordinate of the prism. Then the system will display the first expression, asked to enter the coordinate of the observation point, which the coordinate of the prism after a period of time. If the coordinate is same as the initial coordinate, the expression evaluates as true. And if the coordinate is differ, the expression is evaluates as false.

The general syntax is,

if (statement),

else (statement).

- Array of data

The sets of data obtained from the observation, which are the coordinate of the points can be read by the MATLAB programming by using *array* function. This function allows the data to be read in a form of vector (x, y, z) rather than a single digit number. The *array* operator that being used is '[ ]'.

- Data import

For this system, the data is imported from the Microsoft Excel spreadsheet since all the observations data are stored there before it can be loaded to the system. The data is stored in two (2) separated sheets, which are the observation data and the initial data. Both sheets will be used in this system but not all of the information in the spreadsheets is required, only the coordinates (x, y, z) are needed.

The general syntax is,

N = xlsread('filename', sheet, 'range')

- Warning alarm

A sound clip is added to this system as an alert if the deformation is occurred. A wave sound format is loaded to the system by syntax,

[y,Fs]=wavread('filename');

wavplay (y,Fs)

This wave sound will be played together with the output displayed and only be played when there's a deformation occurred.

3.1.5 Stage 5: Graphical User Interface (GUI)

Finally, graphical user interface is built to ease the user to use the system. The interface is using the GUI offered in the MATLAB programming software. Figure below shows the graphical user interface for this project.

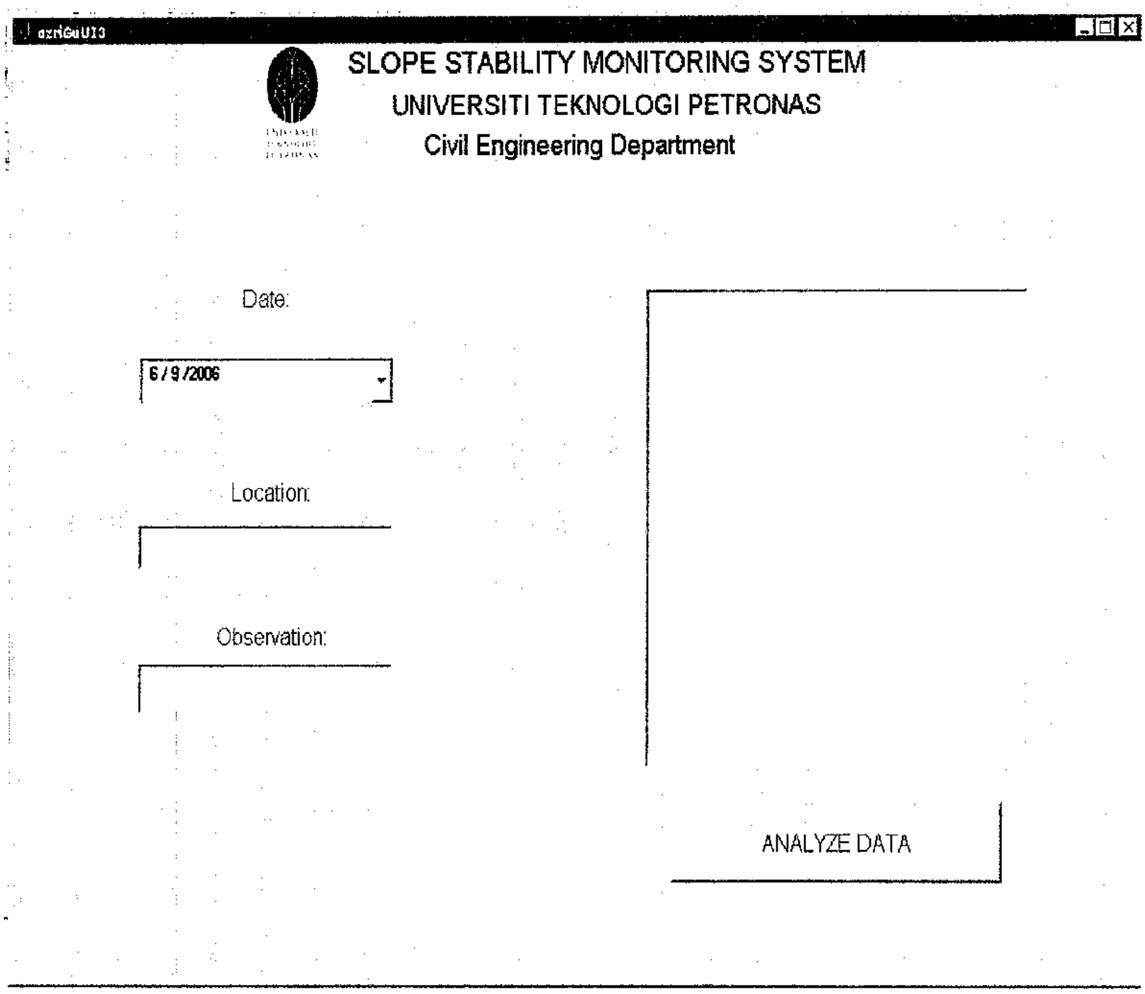

Figure 9: Graphical User Interface

3.2 Tools

Tools used for this project are:-

i. Topcon Total station, GTS-220 series
ii. Mounting pod
iii. Prism & pole
iv. RS-232 cable
v. Topcon Link positioning software
vi. MATLAB programming software
vii. Computer facilities

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT

Initial Data

Coordinate (m)				
N	E	Z	Point No.	Data Label
35.798	21.415	5.654	1	1

Observation Point 1 data (transferred in spreadsheet)

Coordinate (m)				
N	E	Z	Point No.	Data Label
35.798	21.415	5.654	1	1
35.798	21.415	5.654	1	2
35.798	21.415	5.654	1	3
35.798	21.415	5.654	1	4
35.798	21.415	5.654	1	5
35.798	21.415	5.654	1	6
35.798	21.415	5.654	1	7
35.798	21.415	5.654	1	8
35.798	21.415	5.654	1	9
35.798	21.415	5.654	1	10
35.798	21.415	5.654	1	11
35.798	21.415	5.654	1	12
35.798	21.415	5.654	1	13
35.798	21.415	5.654	1	14
35.798	21.415	5.654	1	15
35.798	21.415	5.654	1	16
35.798	21.415	5.654	1	17
35.798	21.415	5.654	1	18
35.798	21.415	5.654	1	19
35.798	21.415	5.654	1	20
35.798	21.415	5.654	1	21
35.798	21.415	5.654	1	22
35.798	21.415	5.654	1	23
35.798	21.415	5.654	1	24
35.798	21.415	5.654	1	25
35.798	21.415	5.654	1	26
35.798	21.415	5.654	1	27
35.798	21.415	5.654	1	28

35.798	21.415	5.654	1	29
35.798	21.415	5.654	1	30
35.798	21.415	5.654	1	31
35.798	21.415	5.654	1	32
35.798	21.415	5.654	1	33
35.798	21.415	5.654	1	34
35.798	21.415	5.654	1	35
35.798	21.415	5.654	1	36
35.798	21.415	5.654	1	37
35.798	21.415	5.654	1	38
35.798	21.415	5.654	1	39
35.798	21.415	5.654	1	40
35.798	21.415	5.654	1	41
35.798	21.415	5.654	1	42
35.798	21.415	5.654	1	43
35.798	21.415	5.654	1	44
35.798	21.415	5.654	1	45
35.798	21.415	5.654	1	46
35.798	21.415	5.654	1	47
35.798	21.415	5.654	1	48
35.798	21.415	5.654	1	49
35.798	21.415	5.654	1	50

Table 1: Point 1 result data

Result from Observation Point 1 after analyze using the system (ran without the interface)

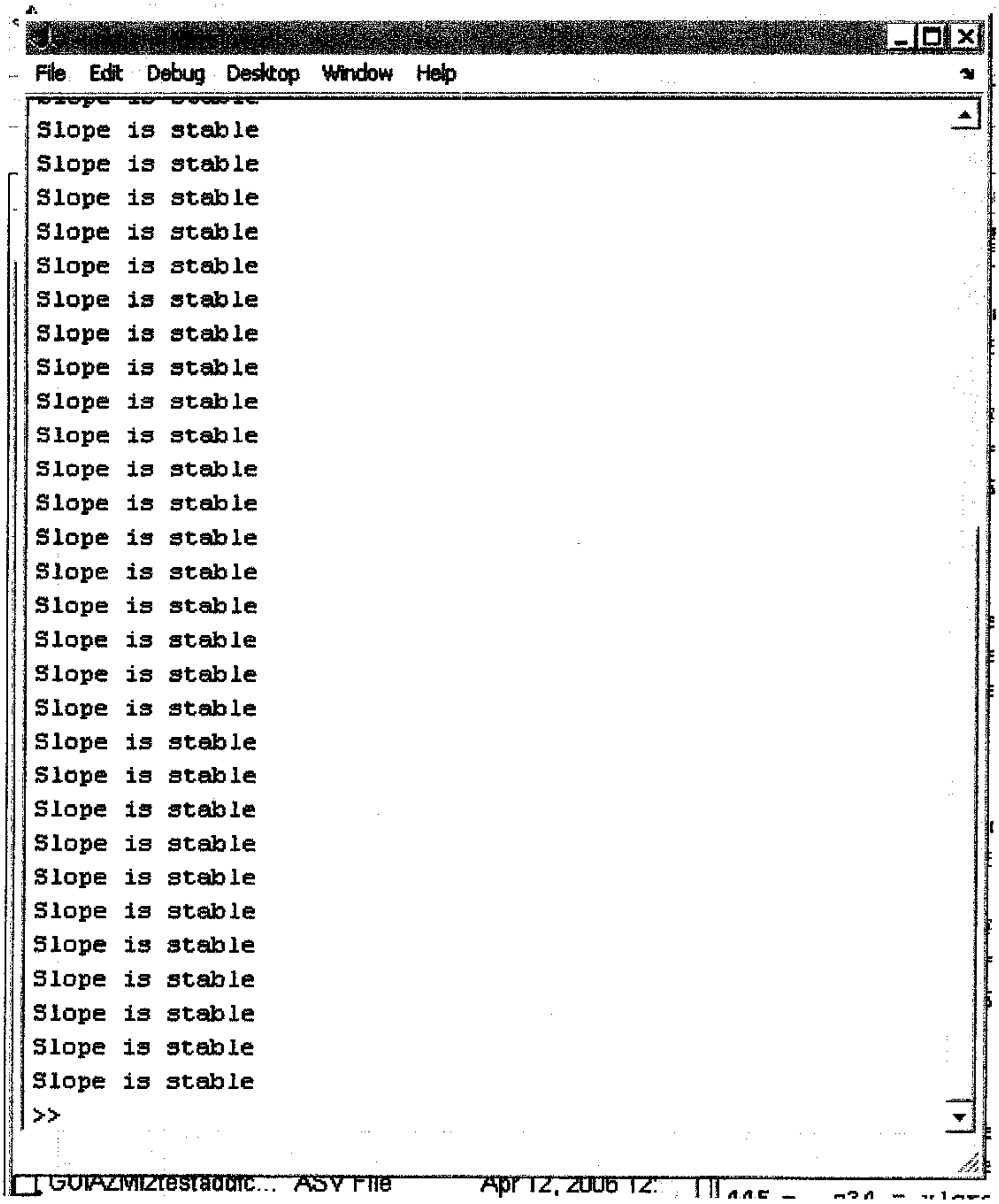

Figure 10: Result displayed in MATLAB programming

Initial Data

Coordinate (m)				
N	E	Z	Point No.	Data Label
38.731	11.958	7.011	2	1

Observation Point 2 data (transferred in spreadsheet)

Coordinate (m)				
N	E	Z	Point No.	Data Label
38.731	11.958	7.011	2	1
38.731	11.958	7.011	2	2
38.731	11.958	7.011	2	3
38.731	11.958	7.011	2	4
38.526	11.967	6.779	2	5
38.526	11.967	6.779	2	6
38.526	11.967	6.779	2	7
38.329	12.002	6.714	2	8
38.329	12.002	6.714	2	9
38.329	12.002	6.714	2	10
38.329	12.002	6.714	2	11
38.329	12.002	6.714	2	12
38.328	12.002	6.713	2	13
38.328	12.002	6.713	2	14
38.328	12.002	6.713	2	15
38.328	12.002	6.713	2	16
38.328	12.002	6.713	2	17
38.328	12.002	6.713	2	18
38.328	12.002	6.713	2	19
38.328	12.002	6.713	2	20
38.328	12.002	6.713	2	21
38.328	12.002	6.713	2	22
38.328	12.002	6.713	2	23
38.328	12.002	6.713	2	24
38.328	12.002	6.713	2	25
38.328	12.002	6.713	2	26
37.689	11.900	6.299	2	27
37.689	11.900	6.299	2	28
37.689	11.900	6.299	2	29
37.689	11.900	6.299	2	30
37.689	11.900	6.299	2	31
37.689	11.900	6.299	2	32
37.689	11.900	6.299	2	33
37.689	11.900	6.299	2	34
37.689	11.900	6.299	2	35
37.689	11.900	6.299	2	36
37.689	11.900	6.299	2	37
37.689	11.900	6.299	2	38
37.689	11.900	6.299	2	39
37.689	11.900	6.299	2	40

Table 2: Point 2 result data

Result from Observation Point 2 after analyze using the system (ran without the interface)

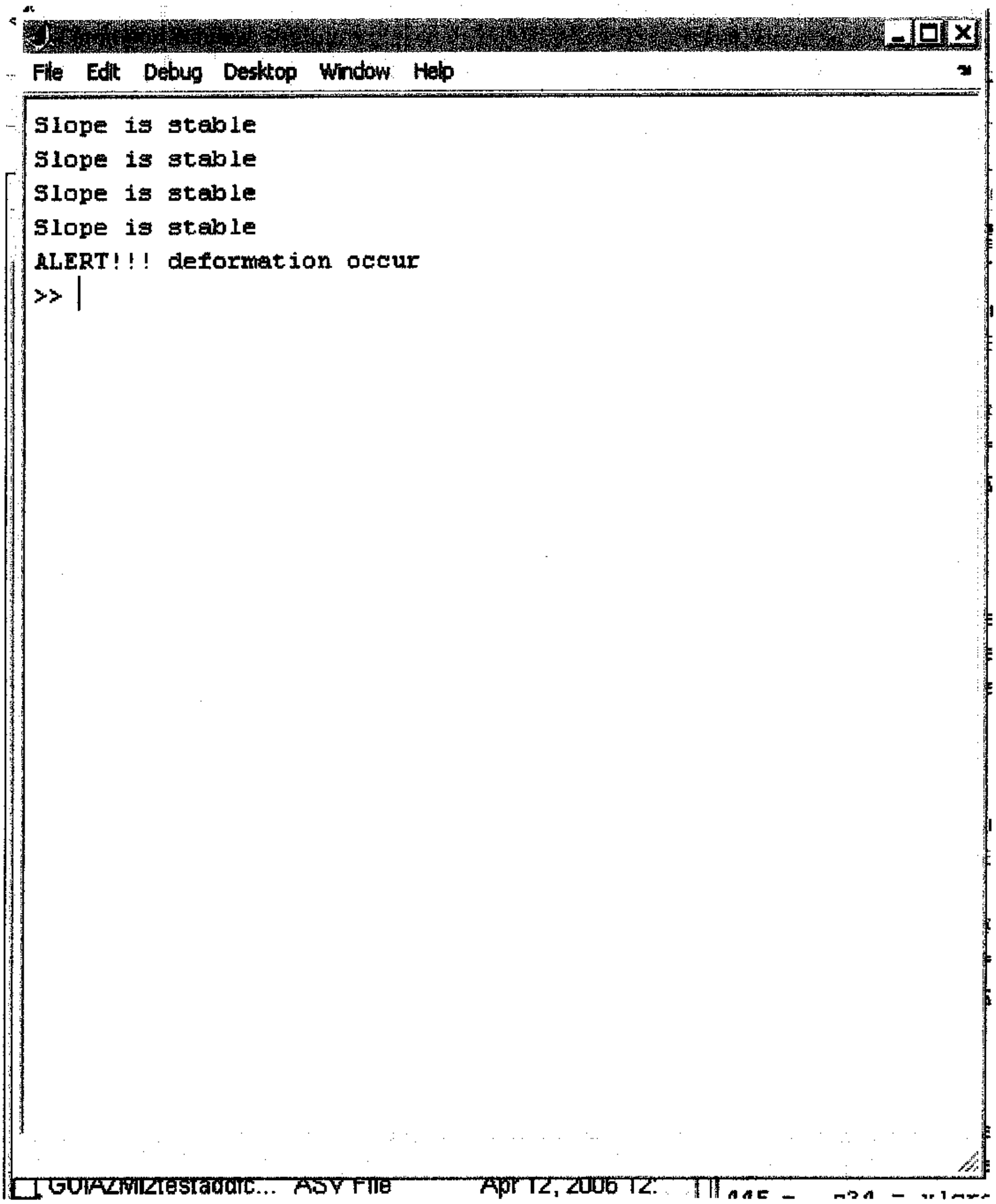

Figure 11: Result displayed in MATLAB programming

The system stop looping at Data Label 5 since it's differing with Initial Data and the sound of alarm is made.

4.2 DISCUSSION

All the data obtained is transferred to computer using Topcon Link software and then the data are stored in the Microsoft Excel spreadsheet. Two (2) sets of data were obtained throughout the observation. *Observation point 1* simulates the stable slope while the *observation point 2* simulates a critical slope. The data is recorded for every 10 minutes interval.

During the observation, several environmental factors is neglected to ease the observation. The reading is assumed not being influenced by the climate and the weather effect. The distance between the equipment (total station) and the observation points (prism) is shorten to reduce the error while recording the data. The prism at the observation points is assumed to safe from disturbance such as wild animal and windy condition.

The data for the observation point 1 are almost the same in value since there's no movement at all but at the observation point 2, the value of the data are vary. These two conditions of the slope are made in order to test the effectiveness of the system created.

Testing of the system is need to be done to check whether this system can distinguish a stable and a critical / unstable slope or not. The system should display a statement ***"Slope is stable"*** when no different between initial data and observed data, to show that the slope is stable. And the system should display a statement ***"ALERT!!! Deformation occurs"*** together with an alarm if there's a different between initial data and observed data to show that the slope is unstable.

There's several weakness found in the system after conducting the testing. Only one set of data can be recorded to the Microsoft Excel spreadsheet before it can be loaded to the system. The remaining sets of data will be leaved at the Topcon Link software. It's mean that this system can only perform or analyze a single set of data at a time. For a second time analyzing, the data have be recorded from Topcon Link software to Microsoft Excel spreadsheet again before it can be loaded to the system.

The data is limited to 50 data per set. It's mean that only 50 data can be recorded in the spreadsheet for a set of data. It also found that the duration of the alarm is too short. The alarm is repeating twice and then its stop.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

In conclusion, it's a need to have a system that can monitor the slope stability in Malaysia and this simple system can be one of the alternatives that can be applied.

As for the recommendation, this project can be more reliable if the equipment used is more advance such as the Topcon GPT-8000 series, which can track the movement of the prism by itself.

Environmental factor also should be considered to get more accurate and precise data. The prism at the observation point should be guard or fenced to ensure there are no disturbances.

The location for the reference and base point should be far away from the observation area since the area within the observation area is actually moving too.

In further research, the system might be able to be implementing with other devices such as GPS since the basic function of this system is similar, which is to detect a deformation of a slope.

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APPENDICES

APPENDIX A

Topcon Corporation has been a world leader in optical, mechanical, and electronic integration (Optomechatronics) for over 70 years. With hundreds of patents to their credit, Topcon is the recognized leader in the manufacture of high accuracy positioning laser and optical products used world wide by the construction, civil engineering and medical industries.

Topcon continues to produce the world's most innovative products for the construction, survey, agriculture, and mining industries. We offer a full line of laser, sonic, GPS+, LPS, and optical devices for numerous specialized industry applications and tasks.

Topcon maintains a world wide network of factory trained and certified service and support technicians. Combined with our network of authorized distributors, we offer service and support second to none.

Operating Distance	16.4ft - 920ft (5m - 250m)
Weather Proof	RC-2RII: IPX5 / RC-2HII: IPX4
Operating Temperature	4°F - 122°F (-20°C - +50°C)
Power Supply	Four AA size dry cells (6V)
Operating Time	Normal use: Approx. 30+ hours
Weight	0.66lbs. (0.3kg)
Dimensions	6"(D) × 2.7"(W) × 1.40"(H) 154mm(D)×69mm(W)×38mm(H)

For more info on these or any other Topcon product log onto:
www.topcon.com

TOPCON

Model Name	GPT-8001/A	GPT-8003/A	GPT-8005/A
Auto tracking servo Mechanism (GPT-8000A series only)			
Max. rotation speed		50°/sec	
Max. auto tracking speed		12°/sec	
Auto tracking range		2,640' (800m)	
Drive range		Throughout full revolution	
Search range		User definable	
Auto Tracking		User definable	
Auto Collimating		±5°	
Coarse Movement		Shuttle control (output: 7 speed change)	
Fine Movement		Jog control (Minimum 1 sec.)	
Tracking accuracy (Repeatability)		Standard deviation 3" (at stable air condition)	
Optical Communications (Radioless)			
2-way FastTrak range		825' (250m)	
1-way FastTrak range		825' (250m)	
Distance Measurement			
Measurement range			
Mini Prism		7' - 4,900' (2 - 1,500m)	
Single Prism		7' - 22,900' (- 7,000m)	
Visibility about 12.5 miles (20km), moderate sunlight			
Measuring accuracy		(±3mm + 2 ppm × D) m.s.e.	
Minimum reading		Fine 0.2mm/1mm Coarse 1mm/10mm	
Measuring time		Fine 1mm mode	
Average		approx. 1.2 sec.	
Initial		approx. 3 sec.	
Distance Measurement (Non Prism)			
Measurement range		10' - 393' (3m - 120m)	
Measuring accuracy		<25m (±10mm) m.s.e. >25m (±5mm + 2 ppm) m.s.e.	
Angle Measurement			
Method		Absolute encoder	
Detecting		Horizontal: 2 sides Vertical: 2 sides	
Minimum reading	0.5"/1"	1"/5"	1"/5"
Accuracy	1"	3"	5"
Tilt sensor			
Type		Dual axis	
Compensating range		±4'	
Level sensitivity			
Circular level		10'/2mm	
Plate level		30"/2mm	
Plummet			
Standard		Optical plummet	
Optional		Laser plummet	
Others			
Tracking Indicator		Yes	
Waterproof		IP54	
Operating time		Normal use: 2.5h Distance and Angle measurement: 4.0h	
Battery		2 pcs	

Figure 12: Topcon Total Station GPT-8000

	GTS-223	GTS-225	GTS-226	GTS-229
SCOPE				
h	150mm			
tive lens diameter	45mm (EDM: 50mm)			
ification	30×			
	Erect			
of view	1°30′			
ring power	2.5″			
num focusing distance	1.3m			
ANCE MEASUREMENT				
tion 1				
n	3,000m (9,900ft)			2,000m (6,600ft)
ns	4,000m (13,200ft)			2,700m (8,900ft)
ns	5,000m (16,400ft)			3,400m (11,200ft)
tion 2				
n	3,500m (11,500ft)			2,300m (7,500ft
ns	4,700m (15,400ft)			3,100m (10,200ft)
ns	5,800m (19,000ft)			4,000m (13,200ft)
tion 1: Slight haze with visibility about 20 km (12.5 miles) moderate sunlight with light heat shimmer. 2: No haze with visibility about 40 km (25 miles), overcast with no heat shimmer.				
acy	±(2mm + 2ppm×D)m.s.e.			±(3mm+3ppm×D)m.s.e.
	D: Measuring distance (mm)			
count in measurement mode	1mm (0.005ft.)/0.2mm (0.001ft.)			
se mode	10mm (0.02ft.)/1mm (0.005ft.)			
ing mode	10mm (0.02ft.)			
rement display	11 digits max. display 99999999.9999			
ring time mode	1mm: 1.2 sec. (Initial 4 sec.) 0.2mm: 2.8 sec. (Initial 5 sec.)			
se mode	0.7 sec. (Initial 3 sec.)			
ing mode	0.4 sec. (Initial 3 sec.) (The initial time will be different by a condition and setting EDM off time.)			
pheric correction range	−999.9 to +999.9ppm (By 0.1ppm)			
onstant correction range	−99.9 to +99.9mm (By 0.1mm)			
E MEASUREMENT				
d	Absolute reading			
ing system	H: 2 sides V: 1 side		H: 1 side V: 1 side	
um reading	1″/5″ (0.2mgon/1mgon)			5″/10″ (1mgon/2mgon)
acy*	3″ (1mgon)	5″ (1.5mgon)	6″ (1.8mgon)	9″ (2.7mgon)

	GTS-223	GTS-225	GTS-226	GTS-229
Measuring time	Less than 0.3 sec.			
Diameter of circle	71mm			
DISPLAY				
Display unit	Dot matrix LCD 20 characters × 4 lines with Backligh			
	2 sides		1 side	
Keyboard	10 function keys			
TILT CORRECTION (AUTOMATIC INDEX)				
Tilt sensor	Dual axis			Single axi
Method	Liquid type			
Compensating range	±3′			
Correction unit	1″ (0.1mgon)			
OTHERS				
Instrument height	176mm (6.93in)			
LEVEL SENSITIVITY				
Circular level	10′/2mm			
Plate level	30″/2mm		40″/2mm	
LASER PLUMMET: STANDARD				
OPTICAL PLUMMET TELESCOPE (OPTION)				
Magnification	3×			
Focusing range	0.5m to infinity			
Image	Erect			
Field of view (at 1.3m)	5° (114mmø)			
DIMENSIONS				
	336(H)×184(W)×150(L)mm [13.2(H)×7.2(W)×5.9(L)in.]			
Weight				
Instrument (with battery)	4.9kg (10.8 lbs.)			
Plastic carrying case	3.2kg (7.1 lbs.)			
DURABILITY				
Water protection	IPX 6 (with BT-52QA)			
Ambient temperature range	−20°C to +50°C (−4°F to +122°F)			
BATTERY BT-52QA				
Output voltage	7.2V			
Capacity	2.7AH (Ni-MH)			
Maximum operating time at +20°C (+68°F) Including distance measurement	10 hours (12,000 points)			
Angle measurement only	45 hours			
Weight	0.3kg (0.7 lbs.)			
BATTERY CHARGER BC-27BR/27CR				
Input voltage	AC120V (BC-27BR) AC230V (BC-27CR)			
Frequency	50/60Hz			
Recharging time (at +20°C/+68°F)	1.8 hours			
Operating temperature	+10°C to +40°C (+50°F to 104°F)			
Weight	0.5kg (1.1 lbs.)			

Figure 13: Topcon Total Station GTS-220

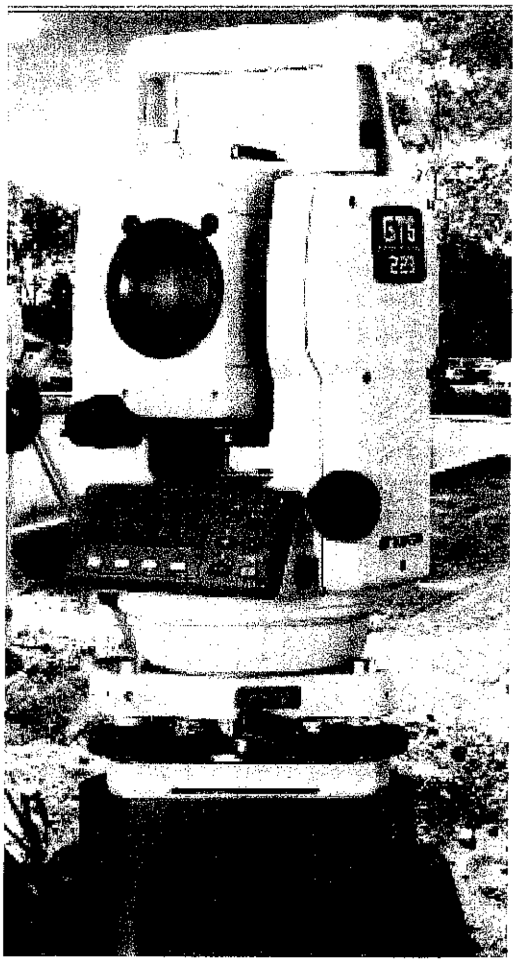

Figure 14: Topcon's Total StationGTS-220 Series

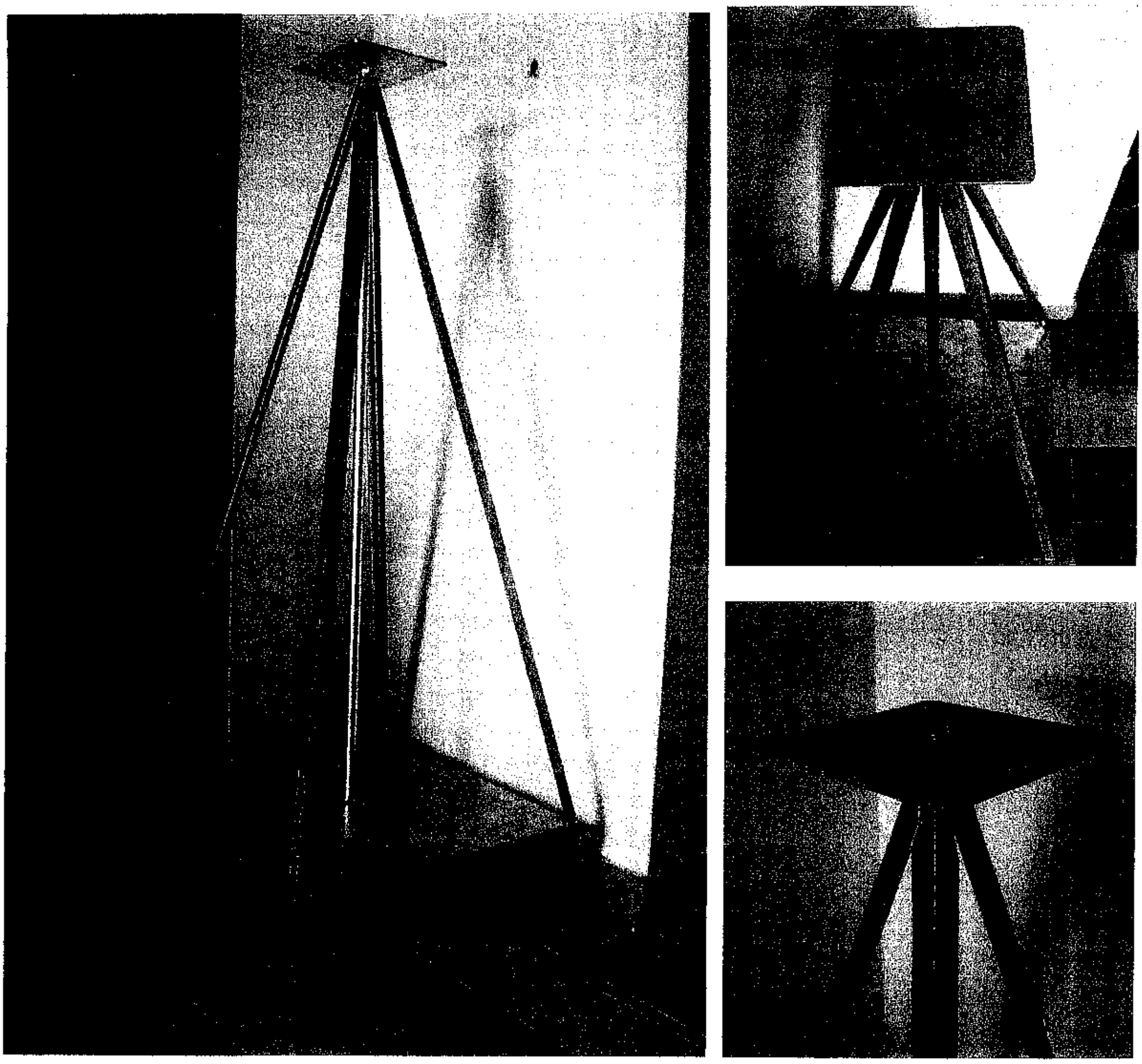

Figure 15: Total Station Mounting Pod

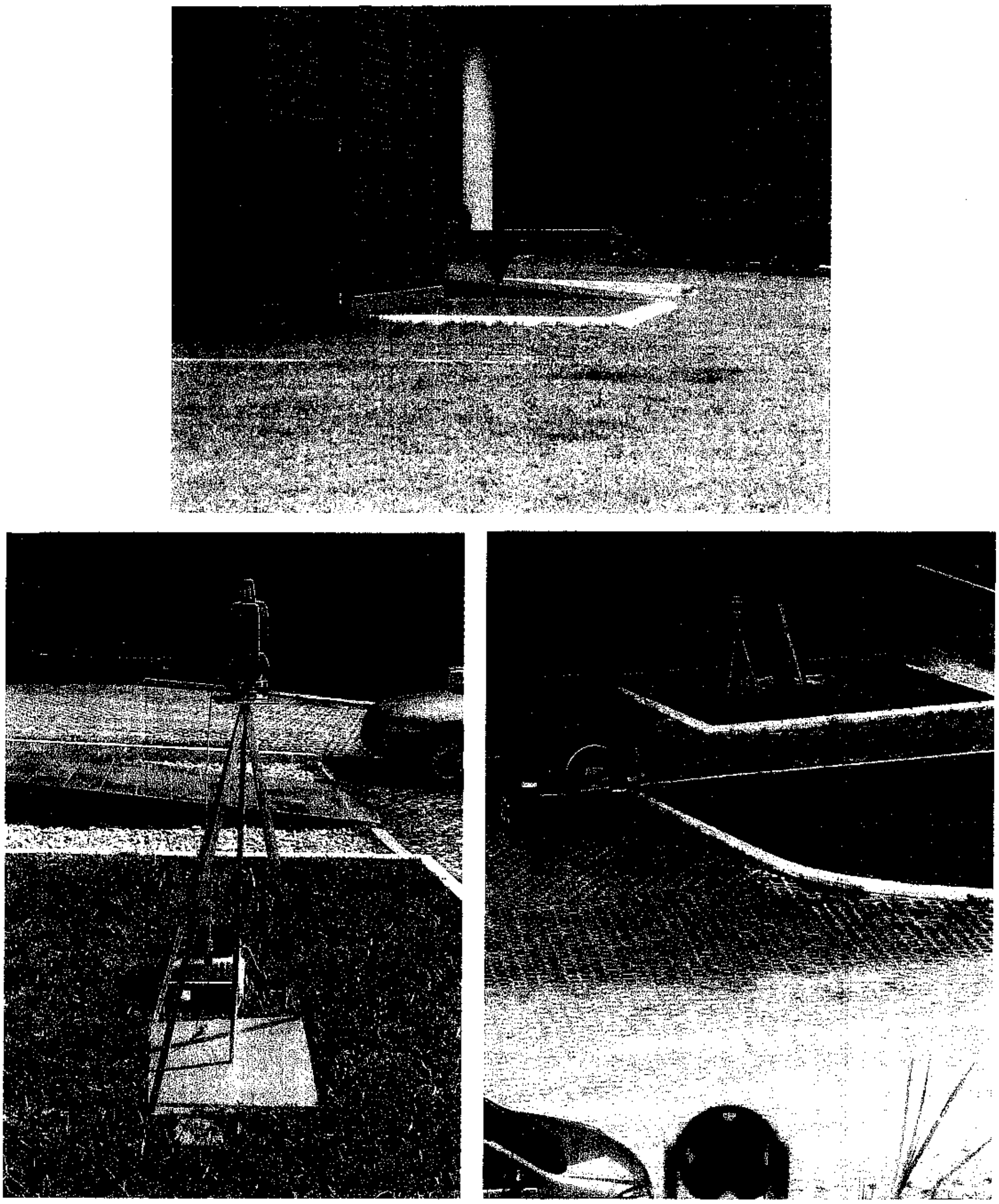

Figure 16: Base Point

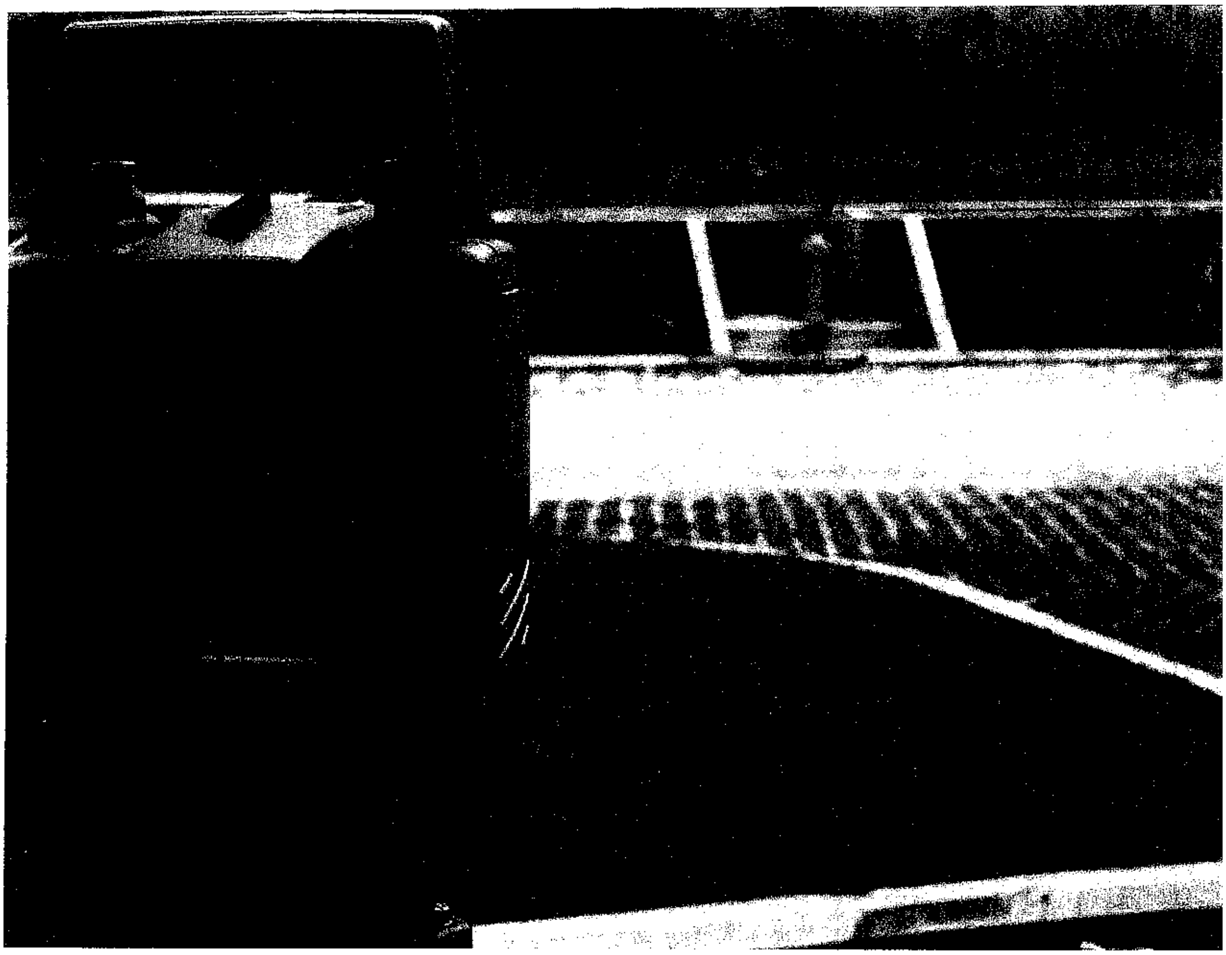

Figure 17: Reference Point

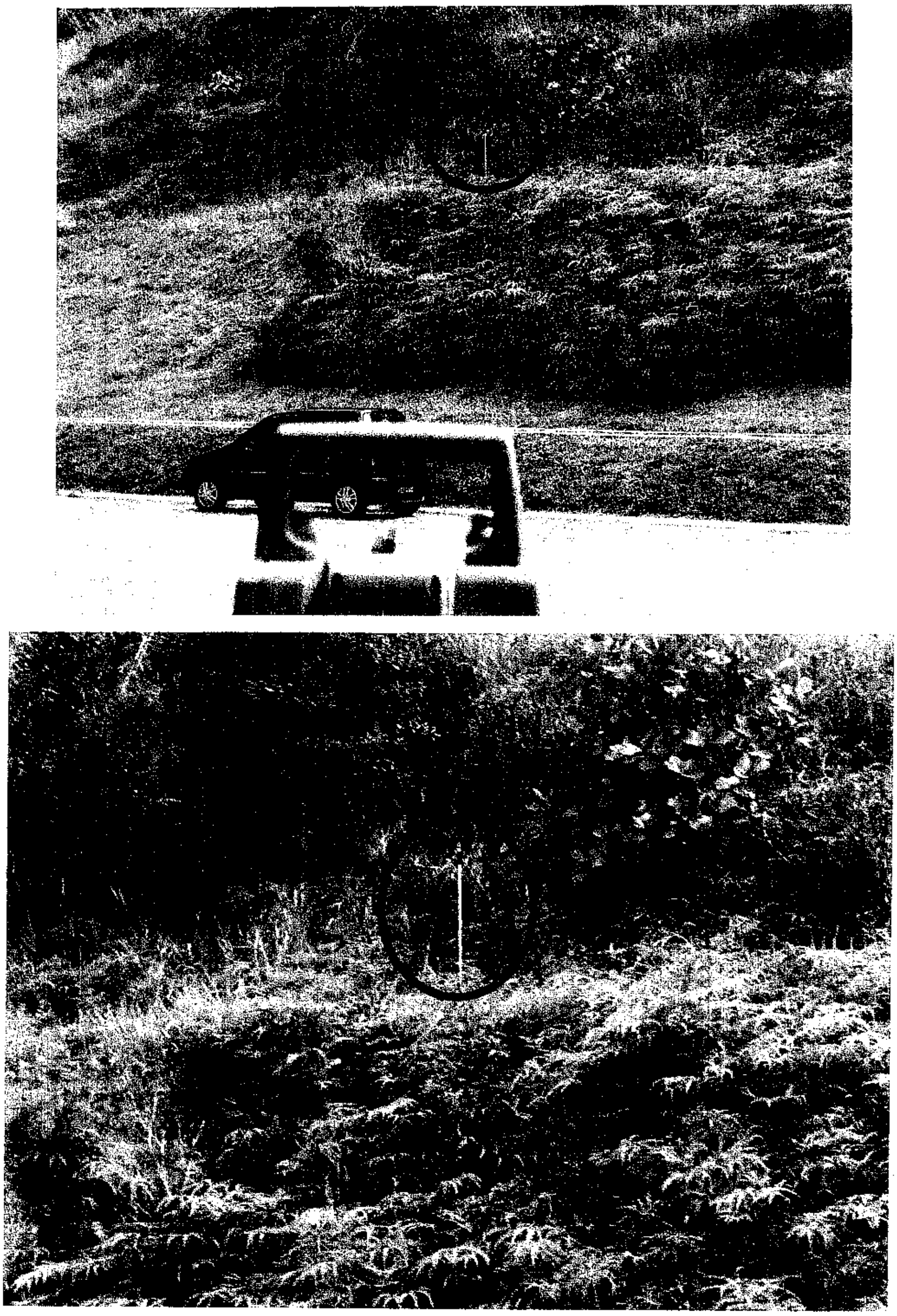

Figure 18 : Observation Point 1 (Prism)

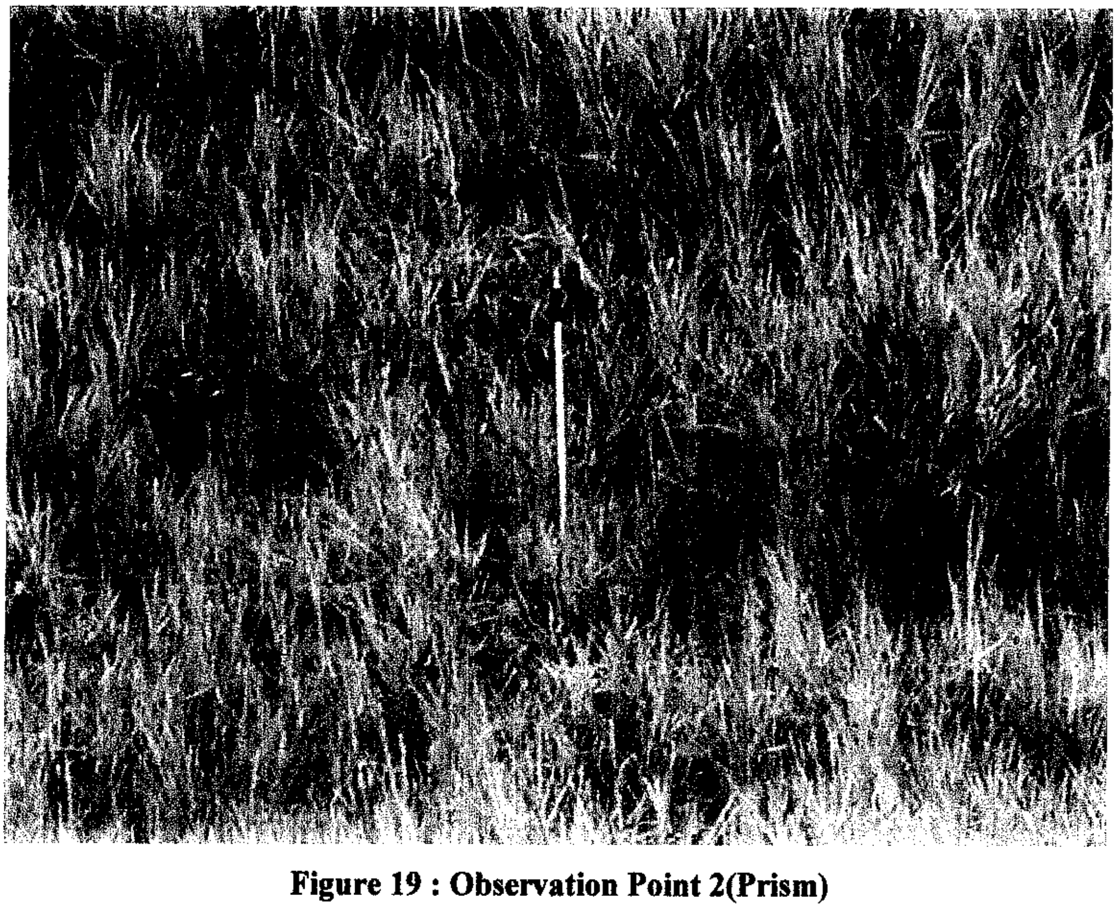

Figure 19 : Observation Point 2(Prism)

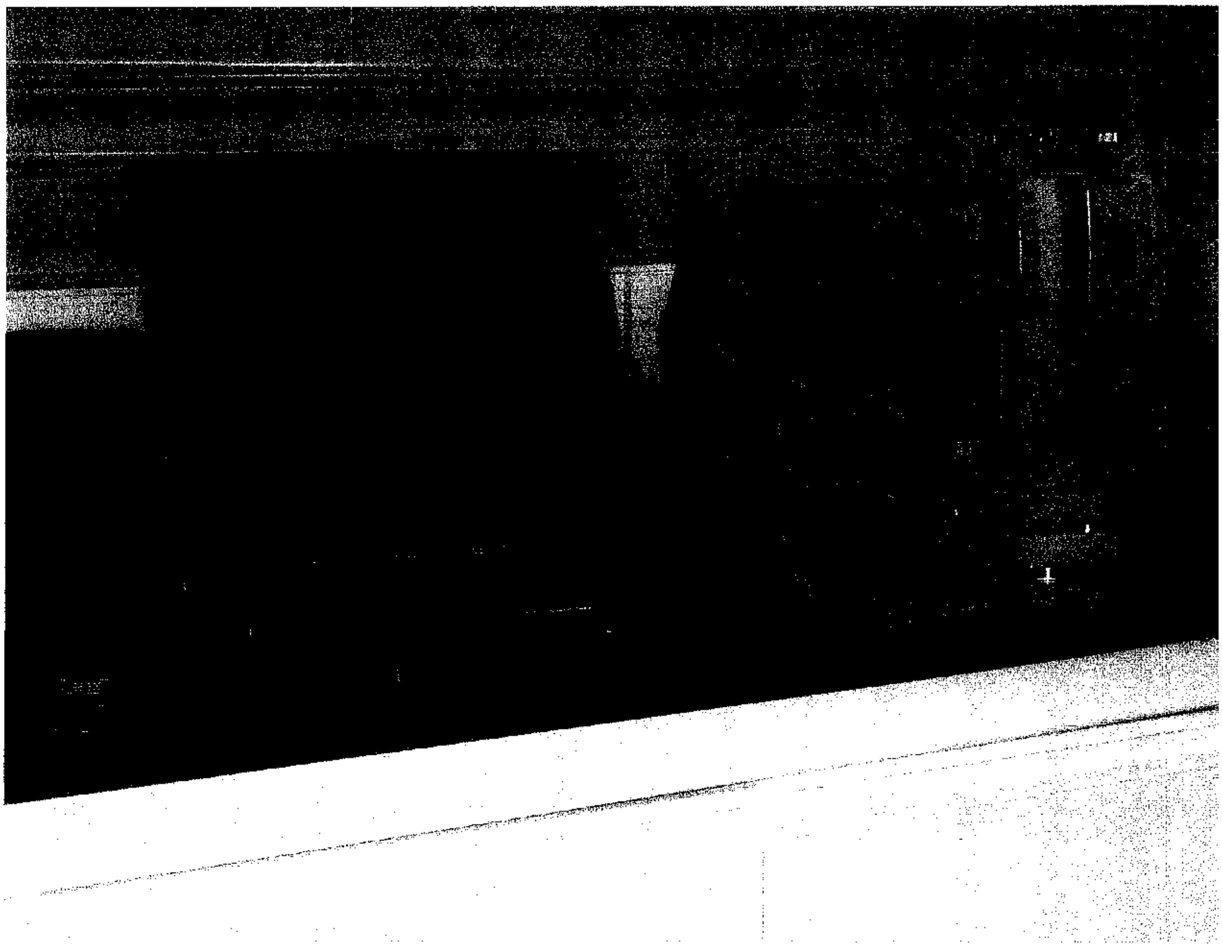

Figure 20: Data transfer via RS-232 cable

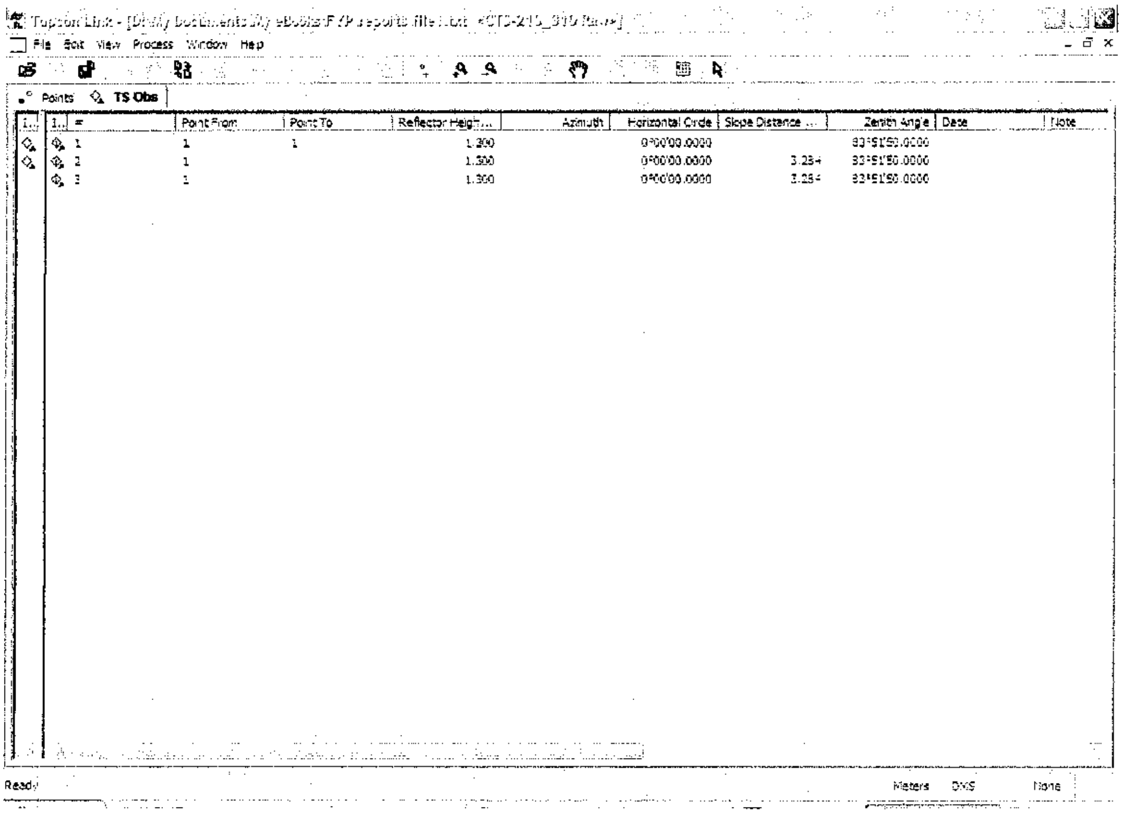

Figure 21: Topcon Link Software

APPENDIX B

MATLAB PROGRAM

```
x = xlsread('testing fyp1.xls', 2, 'A5:A5');
y = xlsread('testing fyp1.xls', 2, 'B5:B5');
z = xlsread('testing fyp1.xls', 2, 'C5:C5');
D = [x y z];


x5 = xlsread('testing fyp1.xls', 1, 'A5:A5');
y5 = xlsread('testing fyp1.xls', 1, 'B5:B5');
z5 = xlsread('testing fyp1.xls', 1, 'C5:C5');
A5 = [x5 y5 z5];


if isequal(A5, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x6 = xlsread('testing fyp1.xls', 1, 'A6:A6');
y6 = xlsread('testing fyp1.xls', 1, 'B6:B6');
z6 = xlsread('testing fyp1.xls', 1, 'C6:C6');
A6 = [x6 y6 z6];


if isequal(A6, D)
```

```
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x7 = xlsread('testing fyp1.xls', 1, 'A7:A7');
y7 = xlsread('testing fyp1.xls', 1, 'B7:B7');
z7 = xlsread('testing fyp1.xls', 1, 'C7:C7');
A7 = [x7 y7 z7];



if isequal(A7, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x8 = xlsread('testing fyp1.xls', 1, 'A8:A8');
y8 = xlsread('testing fyp1.xls', 1, 'B8:B8');
z8 = xlsread('testing fyp1.xls', 1, 'C8:C8');
A8 = [x8 y8 z8];



if isequal(A8, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
```

```
   break
end;

x9 = xlsread('testing fyp1.xls', 1, 'A9:A9');
y9 = xlsread('testing fyp1.xls', 1, 'B9:B9');
z9 = xlsread('testing fyp1.xls', 1, 'C9:C9');
A9 = [x9 y9 z9];



if isequal(A9, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x10 = xlsread('testing fyp1.xls', 1, 'A10:A10');
y10 = xlsread('testing fyp1.xls', 1, 'B10:B10');
z10 = xlsread('testing fyp1.xls', 1, 'C10:C10');
A10 = [x10 y10 z10];



if isequal(A10, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x11 = xlsread('testing fyp1.xls', 1, 'A11:A11');
y11 = xlsread('testing fyp1.xls', 1, 'B11:B11');
```

```
z11 = xlsread('testing fyp1.xls', 1, 'C11:C11');
A11 = [x11 y11 z11];


if isequal(A11, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x12 = xlsread('testing fyp1.xls', 1, 'A12:A12');
y12 = xlsread('testing fyp1.xls', 1, 'B12:B12');
z12 = xlsread('testing fyp1.xls', 1, 'C12:C12');
A12 = [x12 y12 z12];


if isequal(A12, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x13 = xlsread('testing fyp1.xls', 1, 'A13:A13');
y13 = xlsread('testing fyp1.xls', 1, 'B13:B13');
z13 = xlsread('testing fyp1.xls', 1, 'C13:C13');
A13 = [x13 y13 z13];


if isequal(A13, D)
```

```
  disp('Slope is stable')
else
  disp('ALERT!!! deformation occur')
  [y,Fs]=wavread('alert');
  wavplay (y,Fs)
  break
end;

x14 = xlsread('testing fyp1.xls', 1, 'A14:A14');
y14 = xlsread('testing fyp1.xls', 1, 'B14:B14');
z14 = xlsread('testing fyp1.xls', 1, 'C14:C14');
A14 = [x14 y14 z14];


if isequal(A14, D)
  disp('Slope is stable')
else
  disp('ALERT!!! deformation occur')
  [y,Fs]=wavread('alert');
  wavplay (y,Fs)
  break
end;

x15 = xlsread('testing fyp1.xls', 1, 'A15:A15');
y15 = xlsread('testing fyp1.xls', 1, 'B15:B15');
z15 = xlsread('testing fyp1.xls', 1, 'C15:C15');
A15 = [x15 y15 z15];


if isequal(A15, D)
  disp('Slope is stable')
else
  disp('ALERT!!! deformation occur')
  [y,Fs]=wavread('alert');
  wavplay (y,Fs)
```

```
   break
end;

x16 = xlsread('testing fyp1.xls', 1, 'A16:A16');
y16 = xlsread('testing fyp1.xls', 1, 'B16:B16');
z16 = xlsread('testing fyp1.xls', 1, 'C16:C16');
A16 = [x16 y16 z16];


if isequal(A16, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x17 = xlsread('testing fyp1.xls', 1, 'A17:A17');
y17 = xlsread('testing fyp1.xls', 1, 'B17:B17');
z17 = xlsread('testing fyp1.xls', 1, 'C17:C17');
A17 = [x17 y17 z17];


if isequal(A17, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x18 = xlsread('testing fyp1.xls', 1, 'A18:A18');
y18 = xlsread('testing fyp1.xls', 1, 'B18:B18');
```

```
z18 = xlsread('testing fyp1.xls', 1, 'C18:C18');
A18 = [x18 y18 z18];


if isequal(A18, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x19 = xlsread('testing fyp1.xls', 1, 'A19:A19');
y19 = xlsread('testing fyp1.xls', 1, 'B19:B19');
z19 = xlsread('testing fyp1.xls', 1, 'C19:C19');
A19 = [x19 y19 z19];


if isequal(A19, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x20 = xlsread('testing fyp1.xls', 1, 'A20:A20');
y20 = xlsread('testing fyp1.xls', 1, 'B20:B20');
z20 = xlsread('testing fyp1.xls', 1, 'C20:C20');
A20 = [x20 y20 z20];


if isequal(A20, D)
```

```
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x21 = xlsread('testing fyp1.xls', 1, 'A21:A21');
y21 = xlsread('testing fyp1.xls', 1, 'B21:B21');
z21 = xlsread('testing fyp1.xls', 1, 'C21:C21');
A21 = [x21 y21 z21];



if isequal(A21, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x22 = xlsread('testing fyp1.xls', 1, 'A22:A22');
y22 = xlsread('testing fyp1.xls', 1, 'B22:B22');
z22 = xlsread('testing fyp1.xls', 1, 'C22:C22');
A22 = [x22 y22 z22];



if isequal(A22, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
```

```
  break
end;

x23 = xlsread('testing fyp1.xls', 1, 'A23:A23');
y23 = xlsread('testing fyp1.xls', 1, 'B23:B23');
z23 = xlsread('testing fyp1.xls', 1, 'C23:C23');
A23 = [x23 y23 z23];


if isequal(A23, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x24 = xlsread('testing fyp1.xls', 1, 'A24:A24');
y24 = xlsread('testing fyp1.xls', 1, 'B24:B24');
z24 = xlsread('testing fyp1.xls', 1, 'C24:C24');
A24 = [x24 y24 z24];


if isequal(A24, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x25 = xlsread('testing fyp1.xls', 1, 'A25:A25');
y25 = xlsread('testing fyp1.xls', 1, 'B25:B25');
```

```
z25 = xlsread('testing fyp1.xls', 1, 'C25:C25');
A25= [x25 y25 z25];


if isequal(A25, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x26 = xlsread('testing fyp1.xls', 1, 'A26:A26');
y26 = xlsread('testing fyp1.xls', 1, 'B26:B26');
z26 = xlsread('testing fyp1.xls', 1, 'C26:C26');
A26 = [x26 y26 z26];


if isequal(A26, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x27 = xlsread('testing fyp1.xls', 1, 'A27:A27');
y27 = xlsread('testing fyp1.xls', 1, 'B27:B27');
z27 = xlsread('testing fyp1.xls', 1, 'C27:C27');
A27 = [x27 y27 z27];


if isequal(A27, D)
```

```
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x28 = xlsread('testing fyp1.xls', 1, 'A28:A28');
y28 = xlsread('testing fyp1.xls', 1, 'B28:B28');
z28 = xlsread('testing fyp1.xls', 1, 'C28:C28');
A28 = [x28 y28 z28];


if isequal(A28, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x29 = xlsread('testing fyp1.xls', 1, 'A29:A3');
y29 = xlsread('testing fyp1.xls', 1, 'B29:B3');
z29 = xlsread('testing fyp1.xls', 1, 'C29:C29');
A29 = [x29 y29 z29];


if isequal(A29, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
```

```
   break
end;

x30 = xlsread('testing fyp1.xls', 1, 'A30:A30');
y30 = xlsread('testing fyp1.xls', 1, 'B30:B30');
z30 = xlsread('testing fyp1.xls', 1, 'C30:C30');
A30 = [x30 y30 z30];


if isequal(A30, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x31 = xlsread('testing fyp1.xls', 1, 'A31:A31');
y31 = xlsread('testing fyp1.xls', 1, 'B31:B31');
z31 = xlsread('testing fyp1.xls', 1, 'C31:C31');
A31 = [x31 y31 z31];


if isequal(A31, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x32 = xlsread('testing fyp1.xls', 1, 'A32:A32');
y32 = xlsread('testing fyp1.xls', 1, 'B32:B32');
```

```
z32 = xlsread('testing fyp1.xls', 1, 'C32:C32');
A32 = [x32 y32 z32];


if isequal(A32, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x33 = xlsread('testing fyp1.xls', 1, 'A33:A33');
y33 = xlsread('testing fyp1.xls', 1, 'B33:B33');
z33 = xlsread('testing fyp1.xls', 1, 'C33:C33');
A33 = [x33 y33 z33];


if isequal(A33, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x34 = xlsread('testing fyp1.xls', 1, 'A34:A34');
y34 = xlsread('testing fyp1.xls', 1, 'B34:B34');
z34 = xlsread('testing fyp1.xls', 1, 'C34:C34');
A34 = [x34 y34 z34];


if isequal(A34, D)
```

```
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x35 = xlsread('testing fyp1.xls', 1, 'A35:A35');
y35 = xlsread('testing fyp1.xls', 1, 'B35:B35');
z35 = xlsread('testing fyp1.xls', 1, 'C35:C35');
A35 = [x35 y35 z35];


if isequal(A35, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x36 = xlsread('testing fyp1.xls', 1, 'A36:A36');
y36 = xlsread('testing fyp1.xls', 1, 'B36:B36');
z36 = xlsread('testing fyp1.xls', 1, 'C36:C36');
A36 = [x36 y36 z36];


if isequal(A36, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
```

```
    break
end;

x37 = xlsread('testing fyp1.xls', 1, 'A37:A37');
y37 = xlsread('testing fyp1.xls', 1, 'B37:B37');
z37 = xlsread('testing fyp1.xls', 1, 'C37:C37');
A37 = [x37 y37 z37];


if isequal(A37, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x38 = xlsread('testing fyp1.xls', 1, 'A38:A38');
y38 = xlsread('testing fyp1.xls', 1, 'B38:B38');
z38 = xlsread('testing fyp1.xls', 1, 'C38:C38');
A38 = [x38 y38 z38];


if isequal(A38, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x39 = xlsread('testing fyp1.xls', 1, 'A39:A39');
y39 = xlsread('testing fyp1.xls', 1, 'B39:B39');
```

```
z39 = xlsread('testing fyp1.xls', 1, 'C39:C39');
A39 = [x39 y39 z39];


if isequal(A39, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x40 = xlsread('testing fyp1.xls', 1, 'A40:A40');
y40 = xlsread('testing fyp1.xls', 1, 'B40:B40');
z40 = xlsread('testing fyp1.xls', 1, 'C40:C40');
A40 = [x40 y40 z40];


if isequal(A40, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x41 = xlsread('testing fyp1.xls', 1, 'A41:A41');
y41 = xlsread('testing fyp1.xls', 1, 'B41:B41');
z41 = xlsread('testing fyp1.xls', 1, 'C41:C41');
A41 = [x41 y41 z41];


if isequal(A41, D)
```

```
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x42 = xlsread('testing fyp1.xls', 1, 'A42:A42');
y42 = xlsread('testing fyp1.xls', 1, 'B42:B42');
z42 = xlsread('testing fyp1.xls', 1, 'C42:C42');
A42 = [x42 y42 z42];


if isequal(A42, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x43 = xlsread('testing fyp1.xls', 1, 'A43:A43');
y43 = xlsread('testing fyp1.xls', 1, 'B43:B43');
z43 = xlsread('testing fyp1.xls', 1, 'C43:C43');
A43 = [x43 y43 z43];


if isequal(A43, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
```

```
  break
end;

x45 = xlsread('testing fyp1.xls', 1, 'A45:A45');
y45 = xlsread('testing fyp1.xls', 1, 'B45:B45');
z45 = xlsread('testing fyp1.xls', 1, 'C45:C45');
A45 = [x45 y45 z45];


if isequal(A45, D)
  disp('Slope is stable')
else
  disp('ALERT!!! deformation occur')
  [y,Fs]=wavread('alert');
  wavplay (y,Fs)
  break
end;

x46 = xlsread('testing fyp1.xls', 1, 'A46:A46');
y46 = xlsread('testing fyp1.xls', 1, 'B46:B46');
z46 = xlsread('testing fyp1.xls', 1, 'C46:C46');
A46 = [x46 y46 z46];


if isequal(A46, D)
  disp('Slope is stable')
else
  disp('ALERT!!! deformation occur')
  [y,Fs]=wavread('alert');
  wavplay (y,Fs)
  break
end;

x47 = xlsread('testing fyp1.xls', 1, 'A47:A47');
y47 = xlsread('testing fyp1.xls', 1, 'B47:B47');
```

```
z47 = xlsread('testing fyp1.xls', 1, 'C47:C47');
A47 = [x47 y47 z47];


if isequal(A47, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x48 = xlsread('testing fyp1.xls', 1, 'A48:A48');
y48 = xlsread('testing fyp1.xls', 1, 'B48:B48');
z48 = xlsread('testing fyp1.xls', 1, 'C48:C48');
A48 = [x48 y48 z48];


if isequal(A48, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x49 = xlsread('testing fyp1.xls', 1, 'A49:A49');
y49 = xlsread('testing fyp1.xls', 1, 'B49:B49');
z49 = xlsread('testing fyp1.xls', 1, 'C49:C49');
A49 = [x49 y49 z49];


if isequal(A49, D)
```

```
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x50 = xlsread('testing fyp1.xls', 1, 'A50:A50');
y50 = xlsread('testing fyp1.xls', 1, 'B50:B50');
z50 = xlsread('testing fyp1.xls', 1, 'C50:C50');
A50 = [x50 y50 z50];


if isequal(A50, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x51 = xlsread('testing fyp1.xls', 1, 'A51:A51');
y51 = xlsread('testing fyp1.xls', 1, 'B51:B51');
z51 = xlsread('testing fyp1.xls', 1, 'C51:C51');
A51= [x51 y51 z51];


if isequal(A51, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
```

```
    break
end;

x52 = xlsread('testing fyp1.xls', 1, 'A52:A52');
y52 = xlsread('testing fyp1.xls', 1, 'B52:B52');
z52 = xlsread('testing fyp1.xls', 1, 'C52:C52');
A52 = [x52 y52 z52];


if isequal(A52, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x53 = xlsread('testing fyp1.xls', 1, 'A53:A53');
y53 = xlsread('testing fyp1.xls', 1, 'B53:B53');
z53 = xlsread('testing fyp1.xls', 1, 'C53:C53');
A53 = [x53 y53 z53];


if isequal(A53, D)
    disp('Slope is stable')
else
    disp('ALERT!!! deformation occur')
    [y,Fs]=wavread('alert');
    wavplay (y,Fs)
    break
end;

x54 = xlsread('testing fyp1.xls', 1, 'A54:A54');
y54 = xlsread('testing fyp1.xls', 1, 'B54:B54');
```

```
z54 = xlsread('testing fyp1.xls', 1, 'C54:C54');
A54 = [x54 y54 z54];


if isequal(A54, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;

x55 = xlsread('testing fyp1.xls', 1, 'A55:A55');
y55 = xlsread('testing fyp1.xls', 1, 'B55:B55');
z55 = xlsread('testing fyp1.xls', 1, 'C55:C55');
A55 = [x55 y55 z55];


if isequal(A55, D)
   disp('Slope is stable')
else
   disp('ALERT!!! deformation occur')
   [y,Fs]=wavread('alert');
   wavplay (y,Fs)
   break
end;
return;
```