LANDSLIDE PREDICTION BY DETERMINE THE POTENTIAL HAZARDOUS LOCATION USING GPS MAPPING

SAIFULLIZAN MOHD BUKARI
DEVRAJ KENNETH SUBRAMANI

PROSIDING KEBANGSAAN AWAM '07,
LANGKAWI, KEDAH (AWAM 2007)
29 – 31 MEI 2007

Landslide Prediction By Determine the Potential Hazardous Location Using GPS Mapping

[1]Saifullizan Bin Mohd Bukari, [2]Devraj Kenneth Subramani
Department of Building and Construction Engineering
Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia (UTHM), *Beg Berkunci 101*,
86400 Parit Raja, Batu Pahat, Johor, Malaysia.
E-mail: [1]saifulz@uthm.edu.my, [2]dave_kenneth@hotmail.com

Abstract

This document demonstrates the use of a Global Positioning System (GPS) to predict landslide hazard areas. Landslide is a general term used to describe a movement of a mass of rock, earth or debris down a slope under the influence of gravity, Cruden (1991). These occurrences cause property damage, injury, death and adversely affect a variety of resources in the disaster areas. Nowadays, GPS technology has shown that it is capable of monitoring sub-centimeter deformations of ground movement. GPS requires no line-of-sight between the stations which in turn enables it to monitor landslides even during unfavorable weather conditions, either in real-time or post-processing mode. However, the attainable accuracy of a GPS based system is limited by the satellite geometry and by systematic errors such as multi-path and weak satellite geometry. This paper therefore highlights an investigation of landslide motions to produce a prediction map of mass movement using GPS mapping. The research is conducted at a small landslide area along new road from Pos Selim to Kampong Raja.

Keywords: Landslide prediction, GPS survey, GPS Mapping

1.0 Introduction

Every year, at least a landslide disaster occurs in Malaysia. This is because a planner, developer, engineer or a geologist has failed to recognize the warnings from an existing landslide, initial slope movement or areas of potential failure. Often landslide hazard is only thought to be significant from more rapid, violent events, which are recognized for their size, speed and devastation. The economic implications of these landslides are numerous. Among the direct effect to humans are the loss of life, damage to natural resources and damage to development projects such as roads, dams, communication lines, bridges and many more.

The measurement of landslide behavior is usually undertaken by means of monitoring scheme. Usually, the measurement of superficial displacement is the simplest way to observe the history of a landslide and to analyze the kinematics of the movement. In all cases, measurements have to be made efficiently in terms of time, manpower and budget.

In the past, a variety of surveying techniques have been used to detect the superficial movements of unstable areas (Mikkelsen, 1996). Nowadays, Global Positioning System (GPS) has been fully operational. The GPS equipment is more reliable, cheaper, faster, and easier to use compared to conventional instruments. New hardwares, field procedures and softwares have also been developed to assist users in data collection and processing purposes. Thus, the GPS equipment has become more progressive and used for a wide range of monitoring applications. This paper therefore highlights the performance of GPS technology in landslide monitoring and mapping encompassing a specific large-scale area.

1.1 Problem Statement

The natural instabilities and movement of material on the earth surface (landslide) have continued to be a source of interest to government authorities and resource managers responsible for mitigating any hazards they may impose. On many occasions, landslides have been the cause for the shutting down of entire stretches of highway, swept away villages, buried families and reduced homes to rubble. Most of the landslides happened along highways where slopes were made and cut to make way for the construction of the highway itself. In order to prevent unfortunate events such as landslide from happening, a landslide prediction map can be produced with the aim of preventing the landslide from occurring rather than to sit by and accept that things as a matter of chance.

In this research, with the adaptation of GPS technology, a landslide prediction map can be developed to determine the potential hazardous location of the area.

1.2 Objective

The objectives of this study are:

i) To create a landslide prediction map using GPS technology.
ii) To determine the potential hazardous point of the area of research from the GPS mapping.

1.3 Scope of Research

In this research, the map of the hazardous area is produced. GPS survey will be conducted to get the points and data required to produce the hazardous map.

- This study is focused on the area along new road from Pos Selim to Kampong Raja.
- Most cutting parts of the slope area along the new road from Pos Selim to Kampong Raja are very dangerous.
- The developed map will portray the surface of the area with have layers of different data input.

2.0 Methodolody

This research is conducted to determine the potential hazardous point of the area of research from the GPS mapping. The level of risk of landslide is being valued. Rapid Static GPS differential surveying techniques is used during the GPS survey. The data from the survey are analyzed using the appropriate software and compared with the previous data. Finally, combination of all the analyzed data makes the production of the landslide prediction map possible.

3.0 Analysis

During the static survey, data such as latitudes, longitudes, ellipsoid heights and orthographic heights are recorded. From the parameters, the degree of present activity of the landslide and the depth to which the movement has occurred are known and the mapping process will show the potential hazardous locations for landslide at the locations where the survey is conducted.

The parameter-orthographic heights from all the parameters recorded possess the most valuable elements in determining the degree of hazardous. The differential of past orthographic heights with the present orthographic heights of the determined locations produced movements which can be classed to specific class according to WP/WLI, 1994. The higher difference produces more movement and this results in higher risk of landslide occurring.

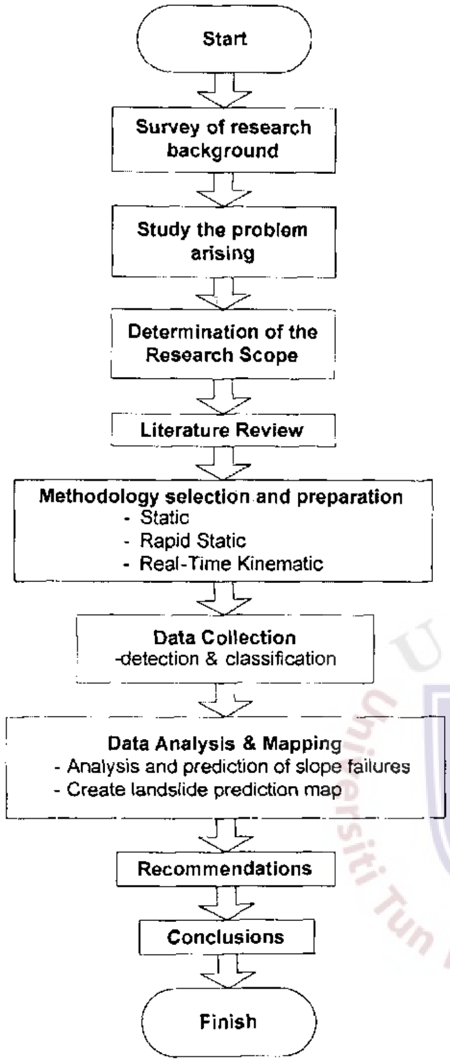

Figure 2.1: Methodology flow chart

3.1 Data processing

There are a total of 12 spots or locations where the static survey is conducted. The identified spots have been divided into 3 which are as follow:

- Master - with site ID bears alphabet "C" (C002, C001).
- Safe area - with site ID bears alphabet "P" (P002, P003, P004 and P005) and "J" (J001, J002, J003).
- Landslide area - with site ID bears alphabet "S" (S001, S002 and S003).

The site positions after processing of raw data with Ashtech Solutions is shown in Table 1 in the Appendix.

3.2 Mapping process

After the data from the survey is processed and analyzed, the mapping process is proceeded to determine whether or not movements occur in the area of survey. The survey areas have been divided into 2, which are the safe area and landslide area so that comparison can be made to give a clearer picture.

3.2.1 Safe area

The area of survey which has been defined as safe area because of the safety features such as retaining structures, the degree of the slope cutting and vegetation covering helps maintain the condition of the slope and prevent any or just little movements and landslides from happening. There are a total of 4 spots where the GPS survey has been done. The description of each point is shown in Table 2 below:

Table 3.1: Site description of each point in the safe area

Site ID	Site Descriptions
P002	BM4051 / MS Kg. Raja 13 / Ipoh 57
P003	BM4053 / MS Kg. Raja 11 / Ipoh 59
P004	BM4055 / MS Kg. Raja 9 / Ipoh 61
P005	BM4057 / MS Kg. Raja 7 / Ipoh 63

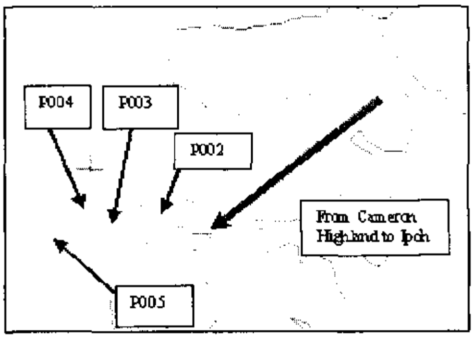

Figure 3.1: Map showing the points in the safe area

3.2.2Landslide area

The area of survey which has been defined as landslide area is due to the condition of the slope which is potentially dangerous with numerous number of landslide activities happening.

There are a total of 7 points including 1 master point where the static survey has been conducted. 3 points which bear the ID J001, J002 and J003 are located on the road surface just below the slope surface. Meanwhile, the other 3 points which bear the ID S001, S002 and S003 are located on the slope surface.

Figure 3.2: Map view of the landslide area using Quickbird Spatial Image.

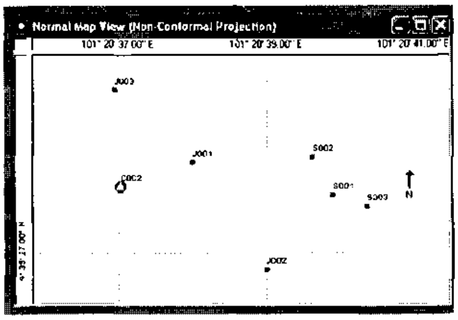

Figure 3.3: Normal map view of the landslide area using Ashtech Solutions

3.2.2.1 *Spot S001*

S001 is located on chainage 23860.00 along the Pos Selim road to Kampong Raja road. S001 has the latitude of 4° 35' 27.77347" N, longitude of 101° 20' 39.94523" E, ellipsoid height of 1346.809m and orthographic height of 1352.449m. From the January's data of S001, the orthographic height was 1356.929m. This shows little movement occurring at point S001.

From Figure 3.4 shown in the Appendix, we can calculate the difference of the orthographic height and determine the class of the movement according to WP/WLI, 1994.

$$Velocity = \frac{Present\,Orthographic\ Height - Past\,Orthographic\ Height}{Time}$$

$$Velocity = \frac{1356.929m - 1352.449m}{1year} = 4.48\,m/_{year}$$

3.2.2.2 *Spot S002*

S002 is located on chainage 23900.00 along the Pos Selim road to Kampong Raja road. S002 has the latitude of 4° 35' 28.29715" N, longitude of 101° 20' 39.66226" E, ellipsoid height of 1348.524m and orthographic height of 1354.164m. From the January's data of S002, the orthographic height was

1354.342m. This shows little movement occurring at point S002.

From Figure 3.5 shown in the Appendix, we can calculate the difference of the orthographic height and determine the class of the movement according to WP/WLI, 1994.

$$Velocity = \frac{1354.342m - 1354.164m}{1year} = 0.178 \, m/year$$

3.2.2.3 *Spot S003*

S003 is located on chainage 23860.00 along the Pos Selim road to Kampong Raja road. S003 has the latitude of 4° 35' 27.67709" N, longitude of 101° 20' 40.39308" E, ellipsoid height of 1351.778m and orthographic height of 1357.418m. From the January's data of S003, the orthographic height was 1364.972m. This shows some movement occuring at point S003.

From Figure 3.6 shown in the Appendix, we can calculate the difference of the orthographic height and determined the class of the movement according to WP/WLI, 1994.

$$Velocity = \frac{1364.972m - 1357.418m}{1year} = 7.554 \, m/year$$

3.3 Results and discussions

At the end of the analysis, calculation and mapping, the velocity of each point in the landslide area is recorded in Table 6 which show the classes of each movement according to classes of landslide (WP/WLI, 1994). It was found that Point S003 showed the highest velocity with 7.554 m/year, followed by S001 with velocity of 4.480 m/year and S002 with velocity of 0.178 m/year.

Table 6: Classes for landslide for each point in the landslide area

Site ID	Velocity (m/year)	Classes for landslide (WP/WLI, 1994)
S001	4.480	Class 3 (Slow)
S002	0.178	Class 2 (Very Slow)
S003	7.554	Class 3 (Slow)

4.0 Conclusions

GPS is a very useful tool to be utilized for a wide range of scientific applications. This technology increases the accuracy, productivity, monitoring capability, rapidity and economy with respect to size of the study area and it is often better than classical geodetic survey techniques. This paper evaluates the appropriate GPS technique in creating a landslide prediction map to determine the potential hazardous point along new road from Pos Selim to Kampong Raja. The results indicated that the GPS modern techniques are very reliable for landslide monitoring survey and mapping whereby deformation of superficial displacements will be determined with another epoch of GPS data collection (Martin Vermeer, 2002).

From the analysis, it was found that the area which has been defined as the landslide area, chainage 23000 shows movement of the slope surface. Even though the velocity of 7.445 m/year is only classified as class 3 from the classes for landslide (WP/WLI, 1994), the area shows potential of larger velocity in areas near to the survey area.

Factors such as weathering effects, the vibration of the working heavy machineries and the heavy vehicles will cause the area to become unsafe as time goes and eventually large movement with higher velocity than can trigger the landslide from happening will occur.

4.1 Recommendations

Below are some of the recommendations to increase the capability of the research:

i. More survey points should be done to provide more accurate data with wider range of mapping instead of few points where the mapping process is limited to the survey points only.
ii. Monitoring scheme should be done so that the data will be updated in real-time and the actual movement of the landslide can be detected on real-time basis.

5.0 References

Bobrowsky, P. T. (Ed.) (2002). "Geoenviromental Mapping, Methods, Theory And Practice." Netherlands: A.A. Balkema Publisher.

Elizabeth John. "Focus: *Disaster by calendar*" News Straight Times, 31st July 2005, page 2.

Gili J.A. ; Corominas J.; Rius J, (2000). "Using Global Positioning System techniques in landslide monitoring". Engineering Geology, Volume 55, Number 3, February 2000, pp. 167-192(26), Elsevier Science

Kavanagh, B. F. (2003). "Surveying, Principles And Applications." USA: Pearson Education.

Kaplan, E. D. (1996). "Understanding GPS, Principles And Applications." USA: Artech House Publisher.

Leick, A. (1995). "GPS Satellite Surveying." 2nd edition. USA: John Wiley & Sons, Inc.

Malet J.-P; Maquaire O.; Calais E.(2002). "The use of Global Positioning System techniques for the continuous monitoring of landslides: application to the Super-Sauze earthflow (Alpes-de-HauteProvence,France)".Geomorphology, Volume 43, Number 1,1 February 2002, pp. 33-54(22), Elsevier Science.

Moffitt, F. H. and Bessler, J. D. (1998). "Surveying." 10th edition. USA: Addison Wesley Longman, Inc. 349-368.

Omar S.N.S.; Jeber F.k.M.; Mansor S., (2004), "GIS/RS for landslides zonation in Pos Slim-Cameron Highlands district, Peninsula Malaysia", Disaster Prevention and Management: An InternationalJournal,Volume13, Number 1, 2004, pp. 2432(9), Emerald Group Publishing Limited.

Richard Dikav, Denys Brunsden, Lothar Schrott and Maia-Laura Ibsen (Ed.) (1997). "Landslide Recognition, Identification, Movement and Causes." United Kingdom: John Wiley and Sons.

Uren, J. and Price, W. F. (1994). "Surveying For Engineers." 3rd edition. UK: Palgrave. 278-292.

http://www.colorado.edu/geography/gcraft/notes/gps/gps.html (1st August 2005)

http://www.malaysiagis.com/ (2nd August 2005)

http://www.colorado.edu/geography/gcraft/notes/gps/gps.html (1st August 2005)

http://www.cmtinc.com/gpsbook.htm (10th October 2005)

Appendix

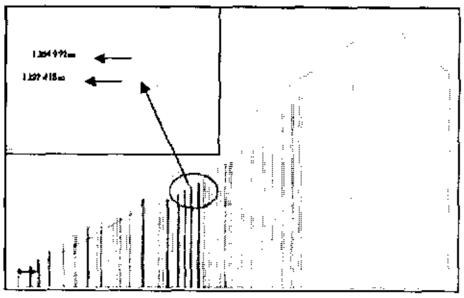

Figure 3.4: Movement occur at point S001

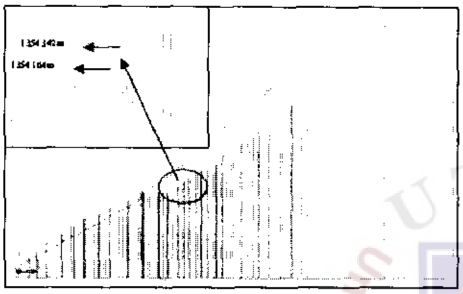

Figure 3.5: Movement occur at point S002

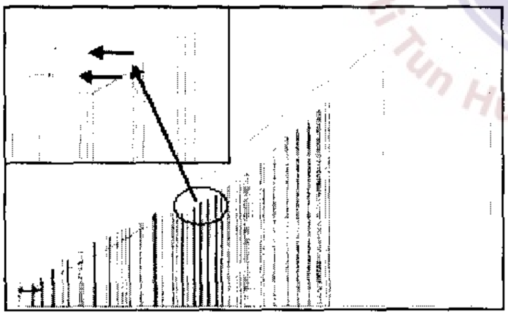

Figure 3.6: Movement occur at point S003