A CASE STUDY ON THE LANDSLIDE BY THE 3D LASER MIRROR SCANNER

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ABSTRACT

Th topography surveying with 3D laser mirror scanner can provide the quick and detail data for creating the topographical maps during the disaster when the prompt resplendence is important. It is possible by this method to collect the surveying data easily and safely with high speed and density., and saves a lot of time and efforts in the total process. It is very important to create topographic maps promptly for restoration from the disaster and prevention of secondly disaster. This paper introduced the surveying and case study on the slope at which the landslide occurred by the 3D laser mirror scanner ground model. The landslide studied is about 400m long, 130m wide and 110 high in the scale. The area potogrammetried including the most active area in landslide is about 300m long, 130m wide and 80m high. The maps in different period of times are created for the planned measure works and comparison is conducted since the topography changes greatly due to the landslide activities

1 INTRODUCTION

1.1 Importance of rapid resplendence to the disaster

The slope disaster are inevitable natural phenomenon for Japan because of the large ratio of mountain areas to the total territory and a large amount of rain. It is an important issue for carrying on the social activities to prevent the disaster of landslide or respond to the emergency during the disaster. When the slope disaster happens, it is necessary to prevent the happening of the secondary disaster and investigate the factors of the slope disaster based on the rapid measurement, investigation and designing even for the sites that is difficult to access. It is possible to promptly acquire the topographic data at high density by using 3D Laser Mirror Scanner and therefore it can be said to be an effective method of topographic survey at the time disaster.

1.2 Importance of rapid resplendence to the disaster

The landslide happened at the north slope that is composed by the weathering volcaniclastic rocks and artificial banking in the mountain area of Fukui Prefecture which is located near the central of Japanese islands faced to the Japan Sea. The landslide was about 400m in length, 130m in width and 110m in height. As the land at the end of moving direction of soil blocks had been corroded by a river, the earth and sand checking the moving soil blocks of landslide began to run off. As a result, horizontal movement volume has reached 5 m / year at the portion where the movement was largest, and especially, the movement is conspicuous to the direction of landslide, and the change of topography is also acute.

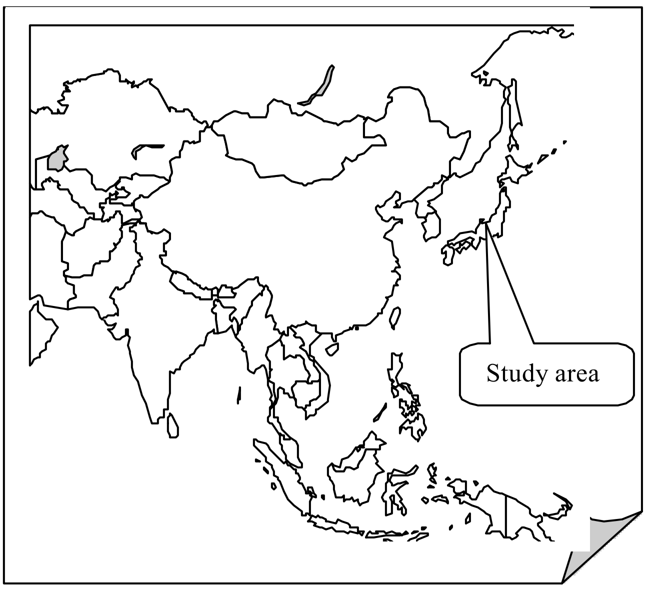


Fig.-1 Area guide map

2 COMPARISON AMONG EACH KIND OF SURVEYING METHODS

2.1 Comparison of surveying and shape identifying method using 3D Laser Mirror Scanner and other surveying method

The surveying method using 3D Laser Mirror Scanner is excellent comparing with other surveying method in a sense that measuring efficiency (measuring speed) is very high. Also, the possibility artificial error is minimized and data processing is easier as the data are acquired and outputted in a digital form. This is an important point when a huge volume of data are handled

Tab-1. Comparison of 3D scanning surveying method to the traditional surveying method

Method Type	General Surveying, Shape Understanding Method					3D scanning surveying method
	On-site surveying by Total-Station		Photo grammetry	GPS Surveying	long-distance scanning laser	**3D laser Mirror Scanner**
	With Mirror	Without Mirror				
Machine model used	TCA1800 By Leica	Rec Elta RL By Zeiss	6008metric By Rollei	Trimble 4000SSI By Trimble	INT5000 By NEC	**LMS Z210** By Riegl
Surveying Media	Near infrared laser		photo	Satellite	Near infrared laser	Near infrared laser
surveying method	Active		passive	passive	active	active
Data Collecting Method	Directly		indirectly	Directly	Directly	Directly
Syurveying Limit	Possible in the dark		Imossible in the dark	More than 5 Satellites available	Possible in the dark	Possible in the dark
Measuring Accuracy	2mm+2ppm (around 4 mm 1 km ahead)	5mm+3ppm (100m about 5mm)	1mm to several CMs	2cm+2ppm (against base line)	under ± 20mm	±2.5cm
Measuring arrange	2500m	150m	-	around 1 km	1500m	350m
Measuring efficiency	10^1 points/per hour	10^1 points/per hour	10^1 points/per hour	10^1 points/per hour	10^1 points/per hour	10^6 points / per hour
Remark				By RTK		Without Mirror Model Radial Scanning Method

Note: In the case of photogrammetry, the accuracy depends on the lens' zoom, scale and the accuracy
Note: It is not the strict comparison here although different surveying methods are listed in the same table.

2.2 General merits and demerits

The biggest merit of this method is the ability to acquire and output the data in a volume adequately enough for the use at emergency time, and therefore, it is possible to construct each kind of maps necessary at the time of disaster.

When to use 3D Laser Mirror Scanner, it is necessary to install the equipment at the place where the measuring area can be seen in whole or in part. This is because the laser used is the electromagnetic wave in the range of near infrared which has low transmissivity against physical solids, and it is not possible to acquire the data of objects behind the shielding obstacles; but the similar conditions are required even if other surveying methods are employed. As the near infrared can permeate the glasses, it can cope with various measuring environment by making contrivance to the container box.

Tab-3 Merits and demerits that can not be seen by other methods in the case of using 3D laser mirror

Merit: very high surveying speed and density that can be used to get the rapid and detail understanding of topography and shape. **Demerit:** surveying density varies according to the measuring distance and data collected can be huge in size(the nearer the higher in density, the further the lower in density)

The most excellent characteristic of 3D laser mirror scanner is that it can collect data actively, directly in digital format and in real time with high speed and high density, and the data can be output in very high speed

↓

Topography and shape can be quickly displayed on the computer graphic system based on the plentiful Data collected

↓

Information collected increases greatly on the sites that have been difficult to survey in high density and speed so far

Fig-4 The effect in the case of using 3D laser mirror scanner to collect data

3 SURVEYING METHOD USING 3D LASER MIRROR SCANNER

3.1 Outline of the system

3.1.1 Composition of measuring device. Composition of measuring device: The measuring device used in this study is composed of three elements of (1), (2) and (3) shown in Fig-5. (1) is the "3D Laser Mirror Scanner" which measures distance and angle using near infrared laser of the wave of 0.9 micro meter, with which it is possible to adjust the measuring range and measuring density. (2) is "personal computer" which controls (1) and stores the acquired data. (3) is "12V DC battery" which is a power source of (1). Besides them, a tripod, etc. will be necessary to support (1) according to the situation of measuring site. (1) can be used in the urban areas because it uses the class 1 laser. The number of data which can be acquired by one measurement from the installation position of (1) over the range of 80 degrees x 340 degrees is as follows.

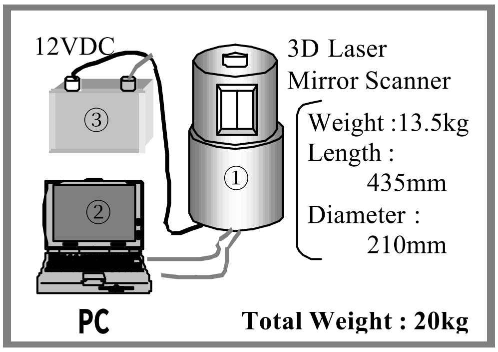


Fig-5 composition of measurement device

* When the data is acquired at the highest density: The data of about 5.2 million measuring points can be acquired by radiating the laser for each 0.072 angle, and the time necessary for the acquisition is about 15 minutes.
* When the data is acquired at the highest speed: The data of about 200,000 measuring points can be acquired by radiating the laser for each 0.36 degree, and the time necessary for the acquisition is 1.5 minutes.

3.1.2 Measurement of topography at the time of disaster. What is most important in the measurement of topography at the time of disaster is "to acquire the results as promptly as possible" and "to have the adequate accuracy which can be used for the counteractions." Table 2 shows the comparison of surveying method using 3D Laser Mirror Scanner and conventional methods, which can be used as a reference in discussing the above two points. The following seven items can be pointed as concrete items which are necessary for topographic measurement at the time of disaster.

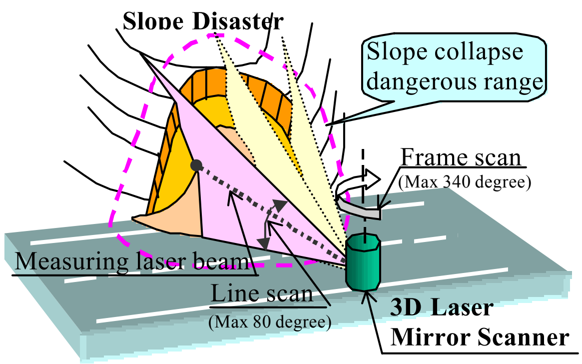


Fig. 6: Measurement system
The data are acquired spatially from a safe place

(1) To be able to measure in a short time;
(2) To have adequate accuracy which can be used for deciding the counteractions for the disaster;
(3) To be able to acquire and output the data in digital form so that they van be used immediately;
(4) Night time measurement should be possible;
(5) To be able to acquire the data at the outside of disaster site;
(6) To be able to measure even under the bad weather;
(7) Measuring equipment must be light weighted so as not to deteriorate the maneuverability

3.2 Flow of works

The following is the flow of works until the topographic map of disaster site is constructed.
(1) Selection of measurement location: To select the installation place of equipment where the objects can be measured efficiently and safely.

(2) Determination of measuring parameters: To specify measuring density and measuring range according to the purpose of measurement.
(3) Acquisition of data: It is possible to combine the data after measuring from plural directions.
(4) Data cleaning: To remove the unnecessary portions such as trees and objects outside the scope of map construction.
(5) Modeling: To construct tin model (triangular polygon model) to make each kind of maps; besides this, there is a method to make a mesh model.
(6) Construction of each kind of cross sections and plans: To construct each kind of drawings based on the model made in (5).

4 MEASUREMENT RESULTS

4.1 Results of measurement after the outbreak of landslide(july 1999)

As we had an opportunity to measure the site of disaster occurrence using the 3D Laser Mirror Scanner after one month from the outbreak of disaster, we made measurement at two location of "●" and "●" shown in Fig-7. The measuring operation was all done by one person, and the data of about 1 million measuring points in 1.5 hours of measuring time, out of which the data of about 300,000 measuring points were actually used for plotting.
The interval between measuring points was around 0.1 m in small portions and around 0.8 m in large portions.

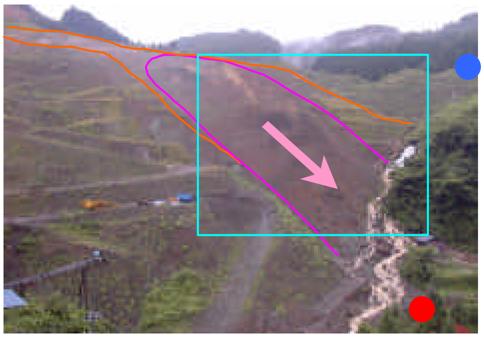


Fig-7 Total view of landslide locations on the next day of disaster occurrence
(1) is the range which shows most active displacement
(2) is a vale buried by the landslide
(3) is the area where landslide took place though the displacement is smaller than (1)

Fig-8 Enlargement of lower portion of landslide (the portion enclosed by blue frame in Fig.-7)
In this occasion, we measure the topography using 3D Laser Mirror Scanner

Fig-9 A scene of measurement
3D Laser Mirror Scanner is mounted on a tripod and control PC is installed below it.

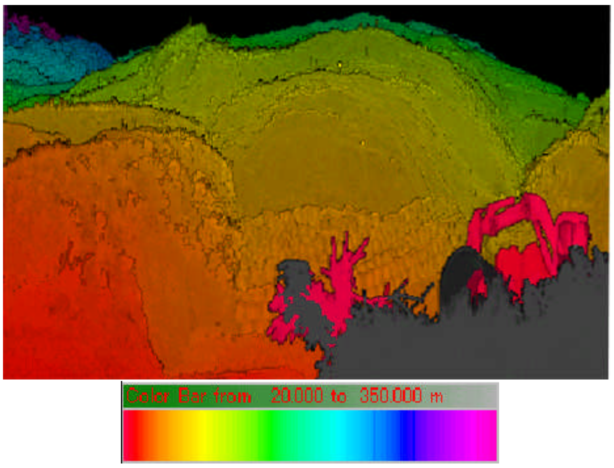


Fig-10 range image
The data measured by 3D Laser Mirror Scanner is displayed on PC on real time. The colors vary according to the distance from 3D Laser Mirror Scanner.

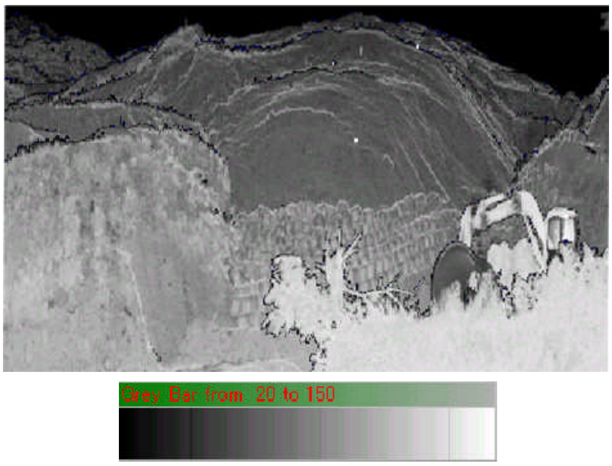
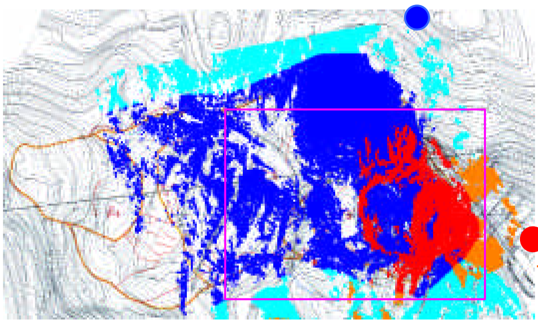


Fig-11 intensity image
The image of intensity of laser reflected from the measuring objects. The intensity varies according to the material, angle and distance of measuring objects

Fig-15 is a topographic map constructed with the data obtained by 3D Laser Mirror Scanner from the slope lands shown in Fig-7 to Fig-13. The time necessary for plotting was approximately 3 hours.

As shown in red curve on the topographic map, it is possible to clearly identify the area of landslide, and we can understand that the soil blocks of landslide moved from left to right in this map. It is important to identify the area of change resulting from the landslide, its scale and type for discussing the counteractions.



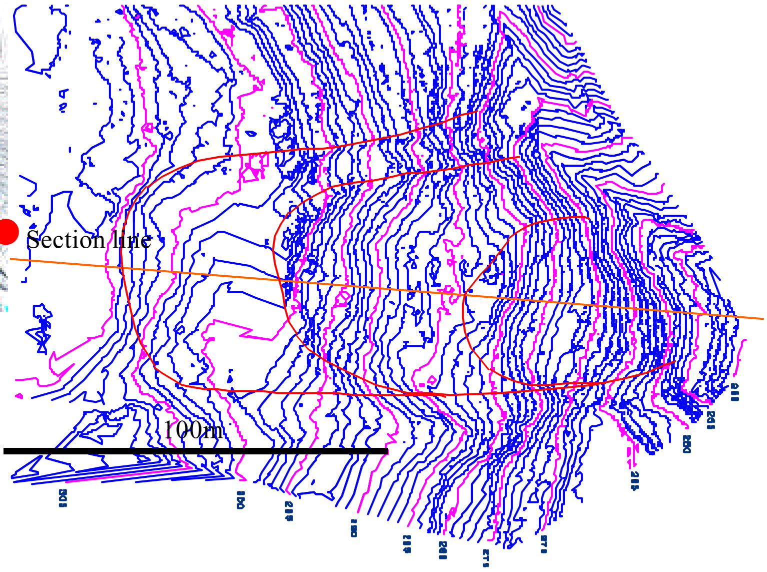
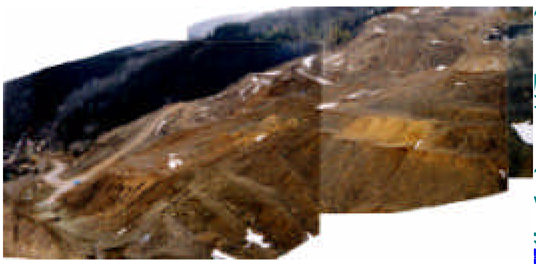


Fig.-14 Map of measuring points (up)
The measuring points obtained from the measurement made at 2 locations shown in Fig- 7 were plotted. The red frame shows the scope of Fig. 15 and dark colored portions are the measuring points used for the compilation of topographic map.

Fig.-15 Topographic map (right)
It is possible to identify fine and minute topographies made by the landslide. The contour interval is 1 meter.

4.2 Results of recent measurement (march 2000)

The Fig-16 and 17 show the result of measurement carried out after 8 months from the above investigation. We made measurement several times because the topography changed gradually after the landslide, and the figures shown below are the result of most recent measurement. It is clearly understood from the comparison with Fig-15 that the soil blocks of landslide displaced widely to downward slant direction (rightward in the map).



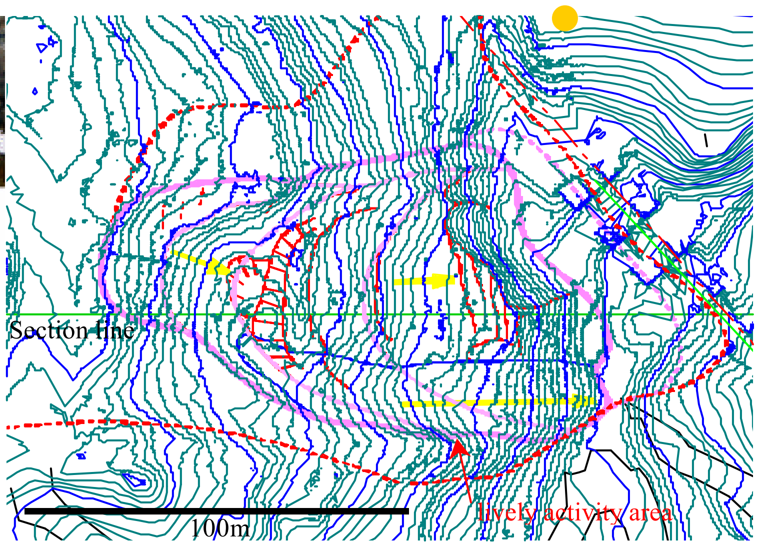


Fig-16 Situation of the landslide in march,2000(up)
Shot aphotograph from” ”of fig-17
Fig-17 Topographic map (right)
Form of a slope is changing in comparison with fig-15.Inside of a lively activity area as a max 5m. The contour interval is 1 meter.

4.3 Counteraction works

In the Fig-18, the design drawing used for the disaster counteraction works has been overlaid on the topographic map. Since the stability of landslide has clearly changed due to the change of topography, we discussed and decided the aspects of design to be changed by making stability analysis using the maps made by the data measured by 3D Laser Mirror Scanner in our current study.

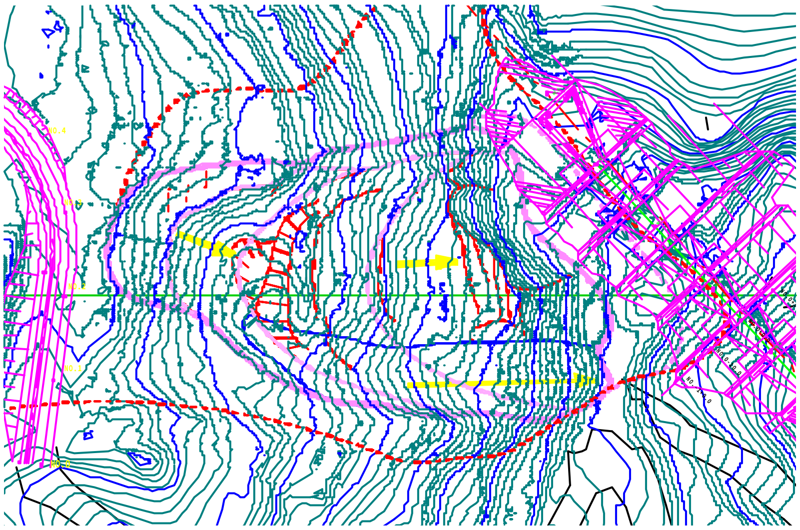


Fig-18: Plan of counteraction works

Although there was no big change, we reviewed the shape of banking constructed slant downward in order to reinforce the stability along with the movement of soil blocks of landslide.

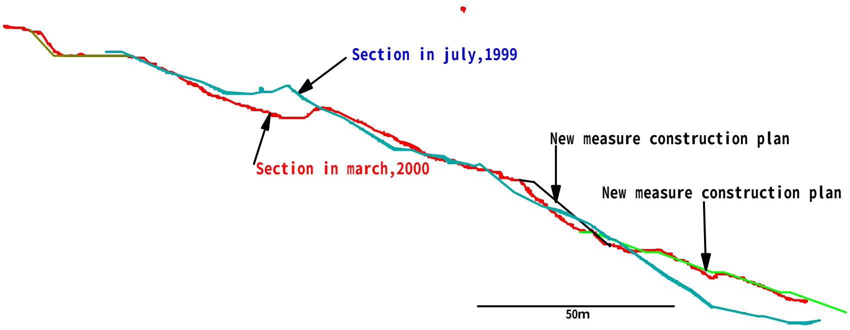


Fig-19: Cross section of topography

This Figure shows topographic cross section of each measurement time and the shape of banking of counteraction works after the review. It is clear that the shape in March 2000 is substantially different comparing with others.

Fig-20 The bird's-view that makes a polygon from points and attached a shadow
It is suited to grasp the detailed lay of the land.

5 CONCLUSION

As stated in the above, it is possible to rapidly acquire the results with the adequate accuracy suitable for discussing the countermeasures by applying the topographic measurement using 3D Laser Mirror Scanner to the disaster areas. So far in our country, the direct survey has been made by human hands or aerial photogrammetry has been used to construct the topographic maps of disaster site. In contrast, the topographic measurement using 3D Laser Mirror Scanner can be said to be very effective method excepting the cases where there are shielding obstacles around the measuring objects.

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