LANDSLIDE MONITORING BY PHOTOGRAMMETRY IN MONSET AREA, NORTHWESTERN PART OF VIETNAM

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ABSTRACT

The stereo-photogrammetry technique, using Photomodeler software, has been applied for monitoring a landslide twice in Monset area, northwestern part of Vietnam in 2002 to 2003. This technique has allowed us to derive surface deformation maps of the landslide with a high spatial resolution and accuracy. Photomodeler software can treat it easily using reference point and the photograph, which they have been taken photograph with the common digital camera.

Using this software, we estimated the amount of movements of whole landslide for one year. The results have been validated by comparing independent measurements carried out by laser telemeter.

1. INTRODUCTION

The landslide monitoring is technology for protecting a life. Therefore, many researchers develop the method of landslide monitoring. The monitoring of a landslide is mainly expressed except the monitoring method using GPS (Paolo *et al*, 2003 etc) and extensometer by the amount of change of geographical feature using SAR-interferometry (Dario et al, 2003 etc) etc. This method is effective to know change of landslide landform, but it is not suitable for calculating the exact amount of movements of landslide because of this data is just landform of landslide. In order to calculate the exact amount of movements of landslide, it is necessary to develop the method suitable for it.

In this research, we used the stereo-photogrammetry technique using Photomodeler Pro 4.0 (Eos System Inc, 2000), in order to calculate the exact amount of movements of the landslide. It was applied twice in Monset area, northwestern part of Vietnam in 2002 to 2003. The amount of movements of a landslide estimated from these two data. Further, we did the geological survey in this area. Those two results are mentioned in this paper.

2 TOPOGRAPHICAL AND GEOLOGICAL SETTING

The first line of each paragraph (except the first in each section) should be indented by 10 mm, like this one. The main route (Rroad No.4) from Lao Cai to Sa Pa is running along the straight valley of the Ngai Dum River in the direction of NE-SW. Along this route, Proterozoic and Cambrian Systems are widely distributed (Fig.1).

The lower mountain area (altitude less than 500m) which is located from Lao Cai to the southwest side of Lao Cai, mainly consists of Cambrian schist including sandy schist and marble. The Cambrian system having remarkable schistosity and faults of NW-SE direction formed mountain ridge trending NW-SE direction. The Mon Set landslide area (altitude form 700-900m) mainly consists of Proterozoic granitic rocks (the Po Sen complex; Geological Survey Inter-Group, 1978). The main lithology of these granitic rocks is sheared hornblende biotite granodiorite. The main shear foliations in these rocks are formed by right lateral displacements NNW-SSE direction along the regional geological structure affected by the Red River Fault. The week foliations dipping to east are observable in granite in Mon Set area dip to east. Main joint system is formed along these foliations. Sheeting joints dipping to the valley are formed in the upper part of weathered granite. On the lower part of the mountain slope (altitude from 500 to 1000m), very thick weathered part (from 50 to100 m thick) is generally distributed. The foliation structure is still remained in these weathered soils. Debris flow deposits including boulder gravels with muddy matrix are distributed at the small branch valleys.

Mong Set Bridge is located in the midpoint of the Lao Cai - Sa Pa route (Fig.2). Several land slides occur in this area. We tried topographical survey at a landslide site adjacent the Road No.4. This landslide is 100 - 200 meter wide and is located at southern slope dipping 20 - 35 degree. The Road No.4 is located through the foot part of the landslide. The gravity retaining wall and surface water drainage are constructed for slope protection. But, the surface water drainage has broken by slope movement.

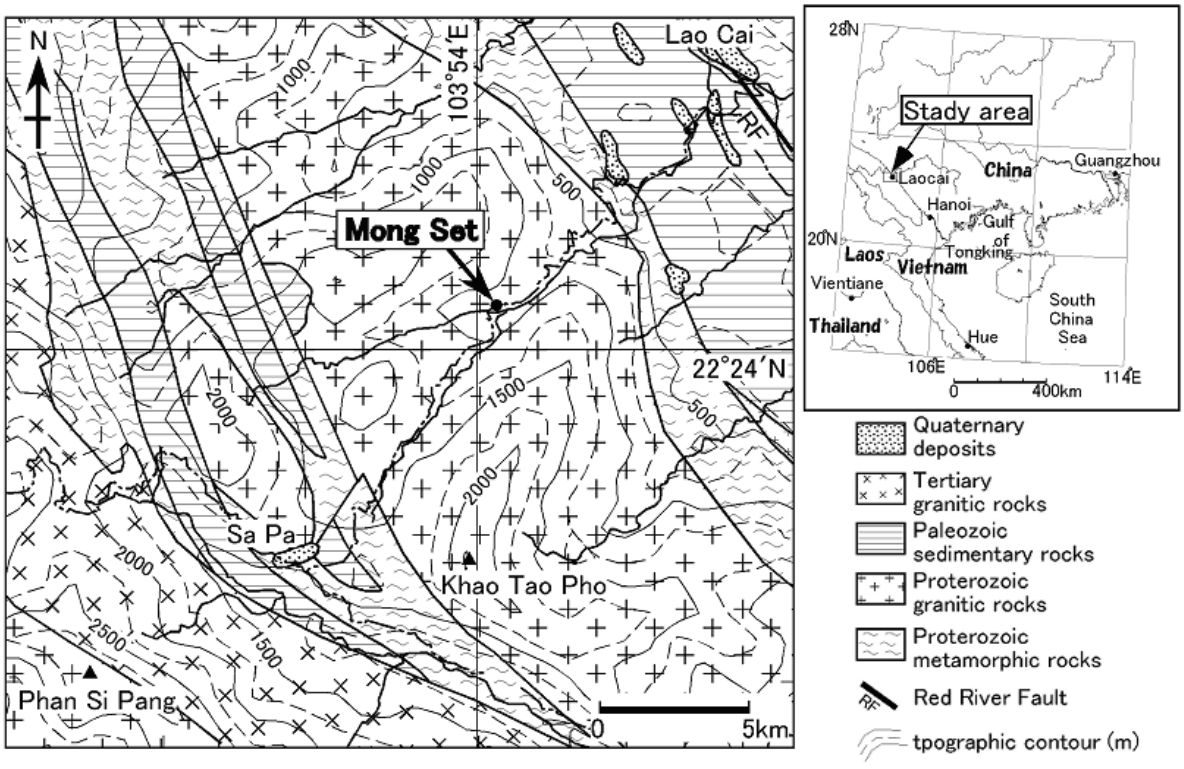


Figure 1. Geological map of Lao Cai and SaPa area

(Modified from Geological Survey Inter-Group, 1978)

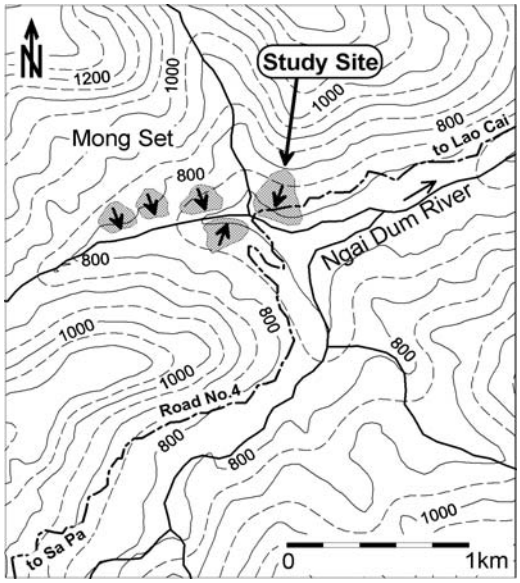


Figure 2. Topographical map adjacent the Mong Set landslide area.

(Modified from Department of Survey and Mapping, Vietnam, 1978)

3 MATERIALS AND METHODS

MATERIALS

The stereo-photogrammetry is the principle currently used for the aerial photogrammetry like aerial triangulation etc. In order to use this technology, some reference points and stereo photographs are required as a material.

(1) Reference point

We putted the reference point, which is needed for the stereo-photogrammetry in 2002, as shown in Fig.3. A1-A4 in Fig.3 the reference points for the stereo-photogrammetry. P0, P2-P9 and P20 in Fig.3 are the reference points for laser telemeter.

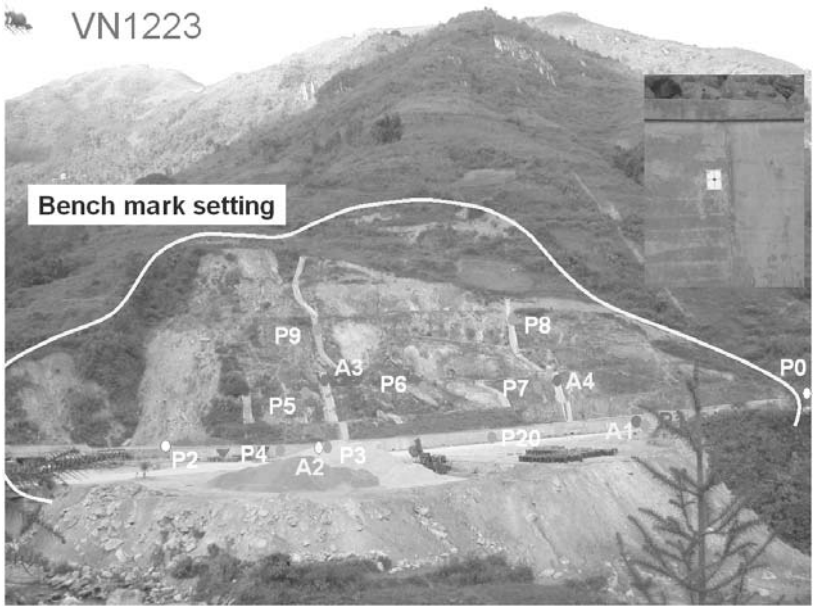


Figure 3. Mong Set landslide area and the distribution of reference point.

In order to estimate the amount of movements for one year, we studied about investigation and the location survey again after one year in this place. However, all point could not be measured again because some points were lost. It is the point of P2-P5, P8 and P9 that the difference for two years could be seen, as shown in Tab.1. System of coordinates is X-axis in the direction of north and is the Y-axis in the direction of the east and P2 is starting point (0,0,0).

Table 1. The reference points by laser telemeter.

	2002			2003		
	X(m)	Y(m)	Z(m)	X(m)	Y(m)	Z(m)
P2	0.00	0.00	0.00	0.00	0.00	0.00
P4	19.25	5.23	−0.74	19.26	5.23	−0.74
P3	38.48	10.66	−0.24	38.47	10.65	−0.24
P5	25.69	23.82	9.91	25.97	23.06	9.52
P9	22.59	47.82	26.44	22.76	46.77	25.88
P8	71.37	57.10	29.34	73.82	52.96	27.90

(2) Photograph

The stereo-photograph for modeling the target area.

METHODS

The stereo-photogrammetry must determine the position of each photograph from the position of a reference point first. Then, we can calculate the value of the coordinates by calculation when same position is chosen within two photographs. Photomodeler can do this work easily. The method of carrying out monitoring using the data of two different times is as follows

(1) The database of each time in Photomodeler, is created and photograph position is decided by analysis.

(2) The respectively same place is chosen from the database of two different times, and the value of the place is calculated.

(3) By searching for the difference of the same point, the amount of movements for one year of the point can be estimated.

Fig.4 is the database created using the reference point and photograph for the stereo-photogrammetry. The every place point in a Fig.4 is the point used in order to decide a photograph position.

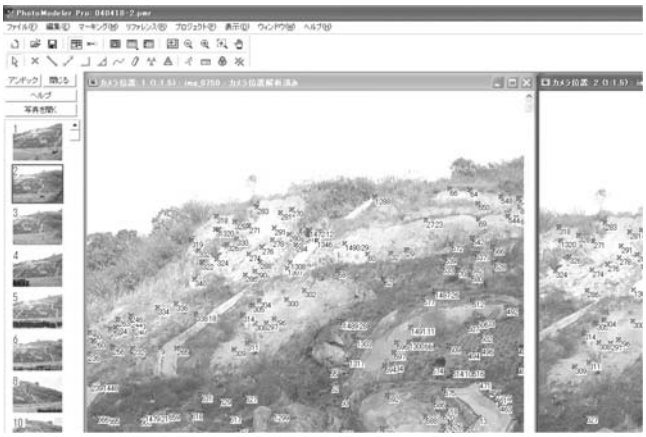


Figure 4. Database using Photomodeler.

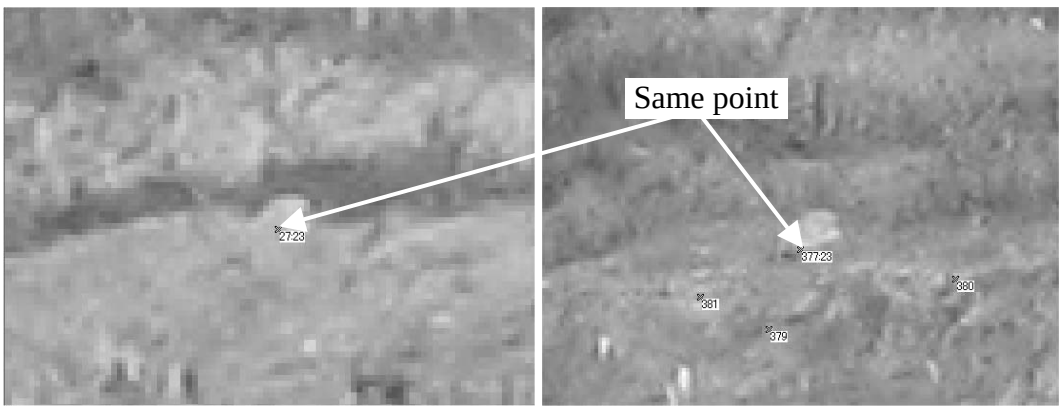
4 RESULTS AND CONCLUSION

Tab.2 is the result of the analysis obtained by the stereo photogrammetry. The same numbers in a table are the coordinates of the same point, as shown in Fig.5. Fig.6 shows how many each point (Circle point) moved based on the data of 2002. The each point (Triangle point) in Fig.6 is the result of measuring using laser telemeter. The numerical value on the coordinates in Fig. 6 is each amount of movements. The amount of movements in Fig.6 is the value, which pulled the data in 2003 from the data in 2002. For example, in Fig.6(a) the sign - of the number of point means that point moved facing west.

From this figure, we can say that the each point, which measured by the stereo-photogrammetry, is almost the same as the data, which measured by the laser telemeter. In a future, we will research the relation between this landslide mechanism and geology.

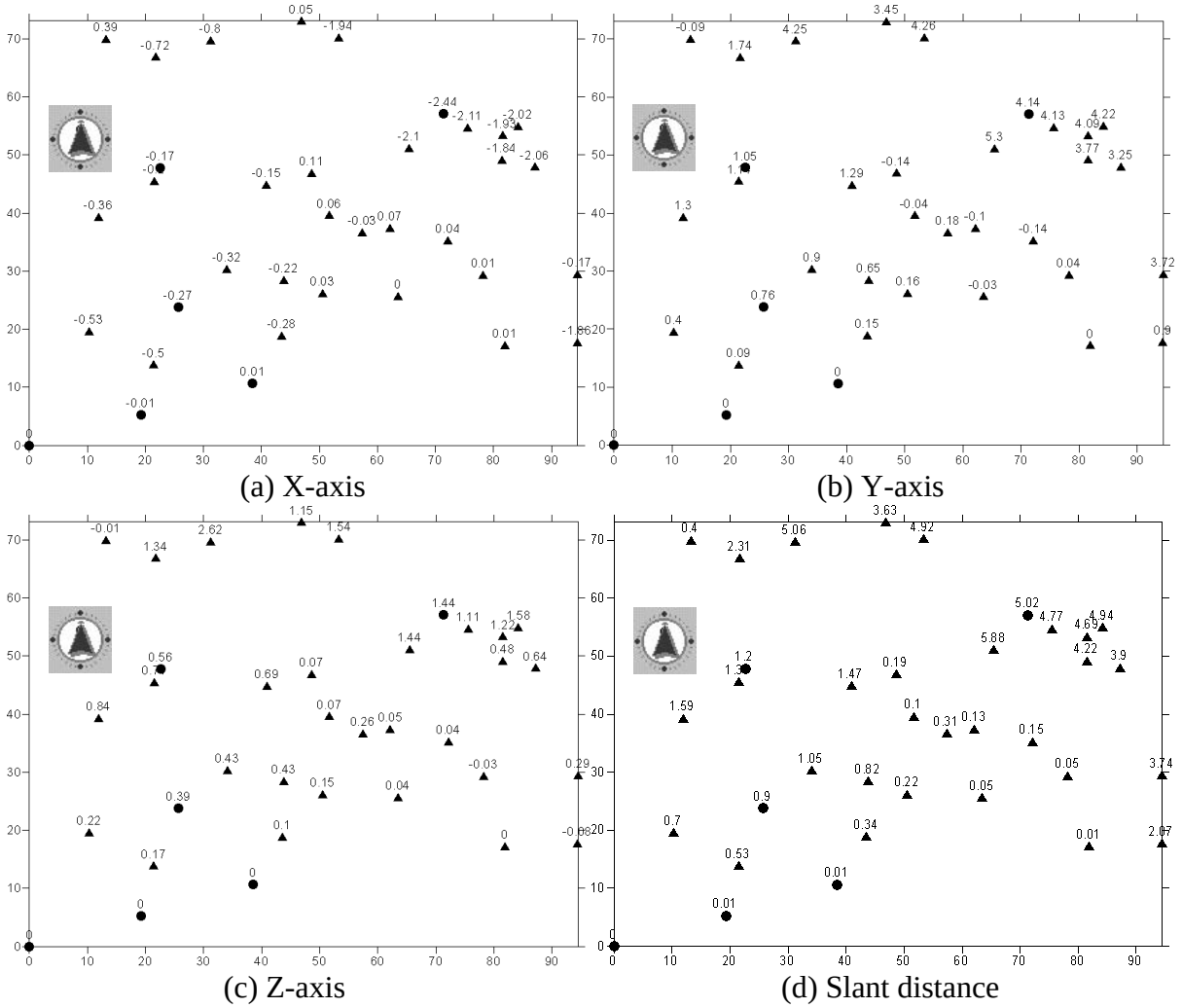
Table 2. The results of stereo-photogrammetry.

	2002			2003			2002−2003			
ID	X(m)	Y(m)	Z(m)	X(m)	Y(m)	Z(m)	X(m)	Y(m)	Z(m)	S(m)
1	81.93	17.25	5.39	81.92	17.25	5.39	0.01	0.00	0.00	18.07
2	78.25	29.38	11.81	78.24	29.34	11.84	0.01	0.04	−0.03	31.64
3	87.18	47.99	24.17	89.24	44.74	23.53	−2.06	3.25	0.64	50.59
4	81.49	49.20	23.79	83.33	45.43	23.30	−1.84	3.77	0.48	51.09
5	72.17	35.27	15.72	72.13	35.41	15.69	0.04	−0.14	0.04	38.73
6	94.50	29.47	14.25	94.67	25.75	13.95	−0.17	3.72	0.29	29.29
7	63.50	25.67	8.84	63.49	25.70	8.80	0.00	−0.03	0.04	27.17
8	62.16	37.46	16.21	62.10	37.56	16.15	0.07	−0.10	0.05	40.88
9	75.57	54.76	28.62	77.68	50.63	27.52	−2.11	4.13	1.11	57.66
10	57.41	36.69	15.02	57.43	36.51	14.77	−0.03	0.18	0.26	39.38
11	51.68	39.65	19.13	51.62	39.68	19.06	0.06	−0.04	0.07	44.02
12	13.20	69.98	42.63	12.80	70.08	42.63	0.39	−0.09	−0.01	82.03
13	43.82	28.51	10.18	44.04	27.85	9.74	−0.22	0.65	0.43	29.51
14	94.42	17.78	8.11	96.28	16.89	8.19	−1.86	0.90	−0.08	18.86
15	84.24	55.01	28.20	86.26	50.80	26.62	−2.02	4.22	1.58	57.39
16	11.92	39.31	22.52	12.29	38.01	21.68	−0.36	1.30	0.84	43.76
17	10.29	19.62	10.17	10.82	19.22	9.95	−0.53	0.40	0.22	21.65
18	21.50	45.56	25.13	21.70	44.42	24.42	−0.20	1.14	0.71	50.69
19	43.53	18.90	4.23	43.81	18.74	4.13	−0.28	0.15	0.10	19.20
20	50.54	26.24	8.39	50.51	26.08	8.24	0.03	0.16	0.15	27.35
21	34.07	30.36	12.30	34.38	29.45	11.87	−0.32	0.90	0.43	31.76
22	21.43	13.90	3.59	21.92	13.80	3.42	−0.50	0.09	0.17	14.23
23	31.23	69.71	40.44	32.04	65.46	37.81	−0.80	4.25	2.62	75.60
24	46.88	73.09	41.94	46.83	69.65	40.79	0.05	3.45	1.15	80.71
25	53.32	70.29	38.65	55.26	66.04	37.11	−1.94	4.26	1.54	75.78
26	48.60	46.93	24.13	48.49	47.07	24.06	0.11	−0.14	0.07	52.87
27	65.48	51.17	25.88	67.58	45.87	24.44	−2.10	5.30	1.44	52.02
28	40.89	44.88	21.97	41.04	43.58	21.28	−0.15	1.29	0.69	48.50
29	21.73	66.91	38.52	22.45	65.17	37.18	−0.72	1.74	1.34	75.03
30	81.57	53.40	27.25	83.50	49.31	26.03	−1.93	4.09	1.22	55.79



(a) The point 23 in 2002 (b) The point 23 in 2003

Figure 5. The coordinates of the same point.



(a) X-axis (b) Y-axis

(c) Z-axis (d) Slant distance

Figure 6. Move distance of each point.

ACKNOWLIDGEMENTS

We wish to express our sincere thanks to Dr. Hoang Minh Hien of Disaster Management Center, and Dr.Venkatesh Raghavan of the Osaka City University for their helpful support.

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