Study on topographic features and landslide development process in slope failure by Typhoon Talas

*Teruyuki Kikuchi[1], Teruyoshi Hatano[2], Satoshi Nishiyama[3]

1. JP-Design Co., Ltd., 2. Electric Power Development Co.,Ltd., 3. Okayama University Graduate School of Environmental and Life Science

1. Introduction

We have not established a prediction of landslide. The cause of this landslide is complicatedly related to the predisposition.In order to clarify the process leading to the slope failure, accumulation and analysis of cases and long-term observation and evaluation are necessary.The microtopography before disaster occurrence can clarify the process of collapse occurrence.Therefore, we tried to examine the topographic features and the landslide development process of the place where the collapse occurred, by micro-topography interpretation on the location of the slope failure occurrence site.

2. Location

Typhoon Talus crossing western Japan from 2 September to 5 September 2011 brought rain close to 2000 mm to the Kii mountain range, causing more than 50 deep-seated landslides. The scope covered by this research is the upper Totsu-gawa. In this basin, the LiDAR-data before and after the disaster is being carried out by the Kinki Regional Development Bureau, Ministry of Land, Infrastructure and Transport. Particularly in areas where many collapses occurred, the accumulated rainfall exceeded 600 mm. In addition, it corresponds to the distribution area of the Shimanto belt in the upper reaches of the Totsu-gawa, and the north to northwest slope is the dip slope.

3. Method

The verification, 38 places with a collapse area of 1,000 m^2 or more that collapsed due to the Talus. We tried micro topography interpretation of the aerial laser topographic map before the collapse. The authors chose main scarp, flank, and knickpoint, which are topographies showing the gravitational deformation of the mountain body as the topography of micro topography interpretation. In addition, as the characteristic topography recognized in the deep layer collapse in the Kii mountain range, the terminal cliff and the gravitationaldeformation appeared surface in which the back slope and the moving rock body are not completely separated are targeted. In addition, the gully was the topography showing the influence of surface water and groundwater. These micro topographies were classified into three types of "nothing", "unclear" and "clear". Next, as an index showing the developmental state of the collapsed terrain, we consider it in relation with the landslide topography development process.

4. Result

As a result of micro-topography interpretation in Table 1, seven places with the topographical features total as 1 to 3 were observed as the first group. For these, the clear of main scarp, flank is not recognized, and the gravitationaldeformation at the top of the slope is the subject. Comparing the collapsed range, the moving body is unclear. This can be classified as the earliest gravity deformation in the landslide topography development process shown in Table 2, which is very close to the initial stage. I concluded that this is also the stage of the earlier stage in the transitional stage. The topographical features of the second group are total number 3 to 7, including main scarp,flank or include clear topographical features. Since the gravitationaldeformation, knickpoint,terminal cliff is remarkable, it can be considered that gravity deformation is being clarified. The whole contour is partially clear. Although they are transitional stage, they are thought to be close to the main moving stage. It was separated from the late stage of the transitional stage. The third group has a total number of topographical features of 4 to 12, and it is a group including main scarp. Terminal cliff and accompanying knickpoint are also often clear. Gravitationaldeformation and knickpoint are clear in the slope. This is thought to be due to weight deformation progressing, juvenile landslide sliding surface connected and "main moving stage" equivalent.

5. Discussion

According to this study, the appearance of main scarp, gully, flank is uncertain though topographic features in the early and late stages of the transitional stage, but the appearance of gravitationaldeformation and terminal cliff was high probability. In addition, if it is a landslide slide in a narrow sense, it is thought that it undergoes a stepwise development process from the early stage to the late stage of the transitional stage, but in Talus in 2011 it has collapsed even at the earlier stage. The gravitational deformation which is frequently observed at this stage is thought to have appeared on the surface because it corresponds to gravitational rock creep and the structure of the basement rock is sound. Focusing on such gravitationaldeformation, we think that there is a possibility of predicting collapse by understanding the features.

Keywords: slope failure, development of landslide process, microtopography

表-1 崩壊地の解析結果

Table-2 Data used for microtopographic features analysis

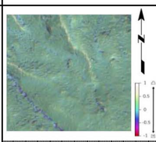
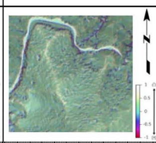
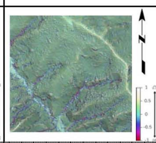
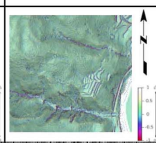
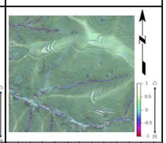
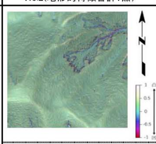
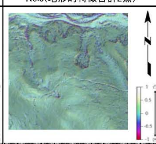
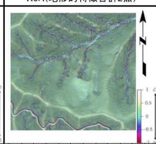
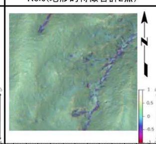
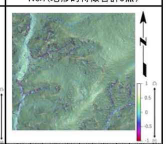
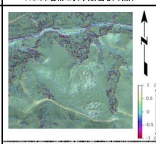
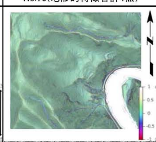
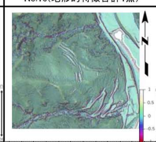
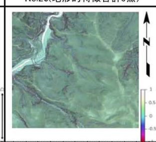
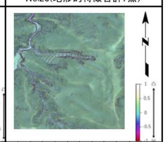
No.	面積 (m2)	比高 (m)	最大傾斜方向	崩壊範囲内の平均傾斜 (°)	地形的特徴 [0 無 ,1 有(不明瞭), 2 有(明瞭)]							地質 (*1)	地すべり地形発達過程
					滑落崖	側方崖	小崖	末端崩壊	ガリー	不規則凹凸	合計		
1	7,500	112	NNE	36.5	0	0	0	0	0	1	1	Ob	漸移期[前期]
2	5,100	96	E	37.7	0	0	0	0	0	1	1	My3	〃
3	48,000	56	N	38.3	0	0	0	1	0	1	2	My2	〃
4	28,700	176	WSW	35.3	0	0	0	1	0	1	2	My3	〃
5	26,400	124	SSE	32.8	0	0	0	1	0	1	2	H4	〃
6	6,600	108	NE	37.3	0	0	0	1	0	1	2	My2	〃
7	35,900	176	SW	31.1	0	0	1	0	1	1	3	Yk2	〃
8	29,900	254	NE	38.4	0	0	0	2	0	1	3	My3	漸移期[後期]
9	9,200	128	E	37.3	0	1	1	0	0	1	3	My1	〃
10	9,400	92	SW	38.8	0	1	0	1	0	1	3	My1	〃
11	14,000	114	NW	34.6	1	0	0	1	0	1	3	My3	〃
12	4,500	94	NNE	33.7	1	0	1	1	0	1	4	My4	〃
13	20,600	154	N	35.3	1	0	0	2	0	1	4	My3	〃
14	8,500	165	NW	39.8	0	1	0	1	1	1	4	Ry	〃
15	42,100	174	N	32.6	0	0	1	1	1	1	4	H4	〃
16	48,100	308	NW	38.5	0	0	0	2	1	1	4	My2	〃
17	5,044	103	W	39.8	0	0	0	1	2	1	4	Yk3	〃
18	14,300	154	NNW	38.2	1	0	1	1	1	1	5	My4	〃
19	34,100	234	NE	38.3	1	1	0	1	1	1	5	Ry	〃
20	13,500	136	ENE	39.6	1	1	1	0	1	1	5	Yk2	〃
21	7,400	64	W	41.8	1	1	0	2	1	1	6	My3	〃
22	14,700	126	NNW	37.8	0	2	1	2	2	0	7	My3	〃
23	42,300	218	WSW	38.8	1	1	1	2	1	1	7	My3	〃
24	5,100	158	NW	40.9	0	1	2	2	1	1	7	My3	〃
25	48,000	226	WSW	30.0	0	1	0	2	2	2	7	My2	〃
26	18,200	134	NNW	38.1	2	1	0	1	0	1	5	gc	滑動期
27	1,400	32	NE	39.9	0	2	0	2	1	0	5	My2	〃
28	51,700	227	NNW	32.2	1	0	1	2	0	2	6	Ry	〃
29	22,500	92	NNW	36.8	0	1	1	2	0	2	6	Ry	〃
30	77,200	124	ESE	29.6	0	0	2	2	1	1	6	H4	〃
31	38,600	120	NNW	35.1	2	0	1	1	1	1	6	H4	〃
32	59,000	254	ENE	37.3	1	1	1	1	1	1	6	My1	〃
33	86,300	396	NNE	42.1	1	1	0	2	2	1	7	My4	〃
34	10,300	144	SW	41.3	0	2	0	2	2	1	7	My2	〃
35	254,900	592	NW	38.3	2	1	1	1	1	2	8	My2	〃
36	19,200	120	NNE	34.2	0	2	0	2	2	2	8	My3	〃
37	182,700	400	NW	39.0	2	1	1	2	1	2	9	My2	〃
38	195,100	446	NNW	36.2	2	1	2	2	2	2	11	My2	〃

*1) 地質

Ry: 竜神層, H1～4: 花園層(ユニット1～4), gc 花園層緑色岩チャート, My1～4: 美山層(ユニット1～4)

表-2 崩壊事例の地すべり地形発達過程における検討結果

Conceptual map of Landslide developing history of slopes at micro-topography interpretation

先行研究		本研究							
大八木[4]		新区分	地形的特徴の傾向	合計点数と箇所数	上段:具体的な事例(それぞれ5箇所) ／下段:通しNo.と地形的特徴合計点 [先滑動期と後滑動期には崩壊事例がない]				
先滑動期	対象斜面に地すべりによる変形や運動が全体のみならず部分にも発生していない期間。地質時代に形成された地質構造が地表環境下の諸営力によって変化する。特定の構造や地層が地すべり構造の基本的な要素に移化する。	先滑動期	本研究では事例はないが, 重力変形が生じる前段階の組織地形から生じる小崖地形が断続的に分布する これ以外の地形変状は認められない.	地形的特徴は認められない	–	–	–	–	–
漸移期	対象斜面の一部に小さい変形が生じているが、変動部分全体がまだ基岩から分離していない。全体の輪郭となる構造がまだ形成されていない	漸移期[前期]	初期的な重力変形によって生じる不規則凹凸, 末端崩壊が主体. 滑落崖・側方崖が認められない. また明瞭な地形的特徴が認められない 特定の外的要因によって急激に不安定化する全体の輪郭は不明瞭	合計数:1～3 箇所数:7	 No.2(地形的特徴合計1点)	 No.3(地形的特徴合計2点)	 No.4(地形的特徴合計2点)	 No.5(地形的特徴合計2点)	 No.7(地形的特徴合計3点)
		漸移期[後期]	重力変形が明瞭化. 不規則凹凸・小崖地形・末端崩壊が顕著. 滑落崖・側方崖を含むか, 明瞭な地形的特徴を含む. 全体の輪郭は部分的に明瞭	合計数:3～7 箇所数:17	 No.8(地形的特徴合計3点)	 No.13(地形的特徴合計4点)	 No.15(地形的特徴合計4点)	 No.20(地形的特徴合計5点)	 No.23(地形的特徴合計7点)
滑動期	対象斜面の変動域構成体とその下位の非変動域構成体とを限る輪郭構造が形成されて変動域構成体は非変動域から独立して運動しているか、運動できる状態になっている。活層、休止、再活動、移行拡大に細分も可能	滑動期	滑落崖, 側方崖は明瞭. 移動体の輪郭は明瞭. 移動体内のガリー地形の進行が顕著 末端崩壊やこれに伴う小崖地形も明瞭なことが多い. 斜面内に不規則凹凸や小崖が明瞭となる	合計数:4～12 箇所数:13	 No.26(地形的特徴合計6点)	 No.30(地形的特徴合計6点)	 No.32(地形的特徴合計6点)	 No.35(地形的特徴合計8点)	 No.37(地形的特徴合計9点)
後滑動期	対象斜面における地すべり移動体が運動を完全に停止し、移動体の移動・活動中に形成された構造が運動を停止(体積)下状態において削剥される状態	後滑動期	滑落崖を含むが, 一部消失している場合もある. エッジが消失することがある. 移動体の輪郭は明瞭. 移動体内のガリー地形の進行が顕著 移動体内の不規則凹凸やは拡大しないため不明瞭化する. 削剥が進行するため, 末端崩壊は明瞭なことがある.	–	–	–	–	–	–