DEBRIS FLOW DISASTER AT UBUYAZAWA AZUMI MATSUMOTO CITY NAGANO PREFECTURE

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INTRODUCTION

Kamikouchi, Matsumoto-city Nagano Prefecture, one of the best of the beauty spots in Japan and about 1.4 million visitors come to enjoy the site. On June 23rd 2011, at about 1:30 pm, debris flow happened at Ubuyazawa which is close to Kama tunnel (1,310m long, 7m width, 4.7m height), entrance of Kamikouchi, and also happened at Warabizawa.

Debris flow that has happened at Ubuyazawa, acrossing prefectural road 24, flew down along with road through Kama tunnel and it even came out from Sawatari side gate way, which is the other side of the tunnel. Debris flow also happened at Warabizawa which is acrossing national road 158 and it made sediment of 100m in length and 5-2m in height. Basin divide of these two streams join together at their upper stream.

Just before it happened, the officer of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and prefectural officer realized abnormal condition (seriously heavy rain and turbid flow) of the area. So they decided to close the road. It ensured buses and taxies of tourists not to get into worst accidents.

Disaster of debris flow led black outs of all facilities in Kamikouchi and the home phones and cell phones except satellite phones were out of order. Since secondary disaster was expected, they decided to give up cleaning the debris on the same day. About 1,200 people of tourists and employees of hotels in Kamikouchi were left behind.

They started to clean up the road and recovered the life line on the next morning (the 24th). Tourists started going down the disaster area on foot in the afternoon and more than 800 people arrived safely by the evening. All electricity and phone fully recovered by the 26th. After that happening MILT and Nagano Prefecture decided to placed sensors to notify the debris flow.

The disaster site has been experiencing a lot of debris disasters. In the fall of 1999, slope failure blocked the transportation and 1,300 tourists were left behind. It spent two weeks to reopen the road for that happening.

TOPOGRAPHY AND GEOLOGY AROUND UBUYAZAWA

Fig.1 shows topographical map around disaster site, Fig.2 shows aerial photo, and Fig.3 shows geological map.

The site is in 1,800 - 1,500m high mountains, and its topography and geology correspond each other well. Majority of Mt. Kasumizawadake, at the east of the site, is composed of igneous rocks such as granite then it makes topography steep. Around Mt. Yakedake, groups of volcano, which has been active since quaternary period, it can be seen topographical feature of volcano with pyroclastic rock and lava, shown in left upper side in Fig.1. Although these are gentle slope, it makes

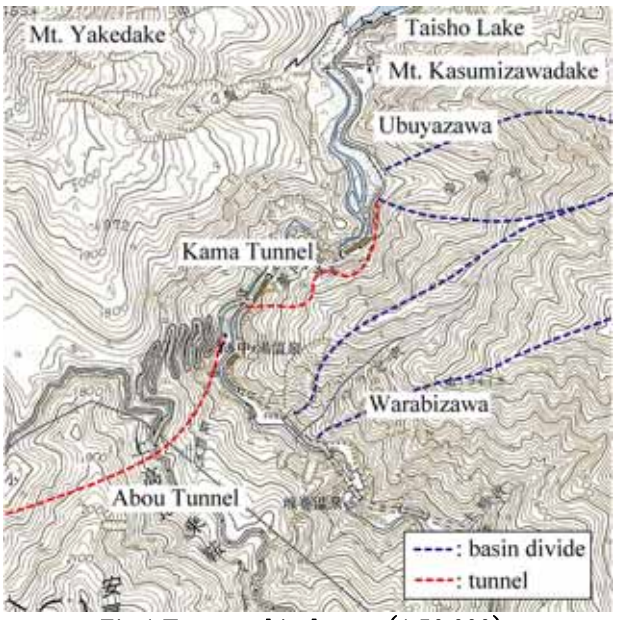


Fig.1 Topographical map（1:50,000）

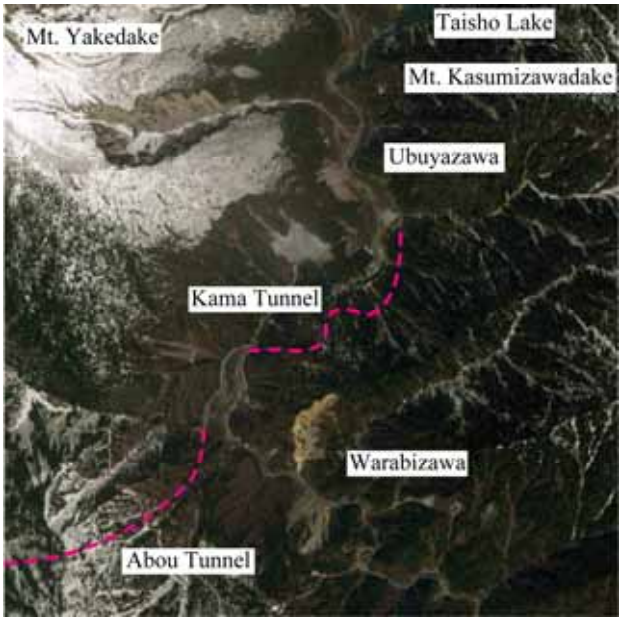
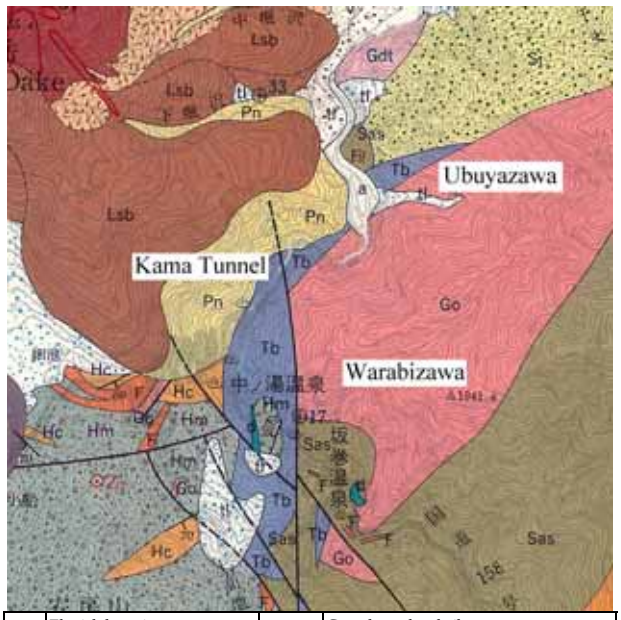


Fig.2 Aerial photo

i) Murao Chiken Co., Ltd. (http://www.muraochiken.co.jp/)
ii) Ministry of Land, Infrastructure, Transport and Tourism, Matsumoto Sabo Office.



Quaternary	Fluvial deposits	a	Gravel, sand and silt
	Talus and small fan deposits	tl	Gravel, sand and silt
	Shimoborisawa Lava	Lsb	Biotite-hornblende andesite
	Nakanoyu Pyroclastic Rocks	Pn	Pyroxene-hornblende andesite pyroclasts
Paleogene	Pyroclastic dike	Tb	Volcanic breccia, tuff breccia and lapilli tuff
	Senjozawa Breccia	Sj	Breccia
	Okumatashiro Granite	Go	Hornblende-bearing biotite granite and biotite granite
Triassic to Jurassic	Mesozoic strata of Sawando Complex	Sas	Sandstone and alternating beds of sandstone and mudstone (sandsotone dominant)
	Mesozoic strata of Hirayu Complex	Hm	Melange (muddy matrices and blocks of sandstone, chart, basalt and limestone)

Fig.3 Geological map（1:50,000）

Table.1 Various factors of catchment basin

Basin name	Ubuyazawa
Drainage area	1,200 m^2
Watercource length	2,000 m
Source	el. 2520m
Average bed slope	1 / 2.5
stream-order	2nd

unstable slope and is eroding. Around Ubuyazawa and Warabizawa, where this disaster of debris flow happened, is composed of igneous rocks such as granite then it makes topography steep.

There are sediment of talus and fluvial deposits in Ubuyazawa. Outcrop of granite is found underneath the sediment. This granite, massive rock mass which is relatively few cracks and alteration, is class CM-CH. Huge brock of breccia, which form north side ridge, are studded at riverbed.

Outcrop of granite can be seen at the upper Warabizawa and alternation of sandstone and mudstone can be seen at the lower stream. Several faults are intricate and there are volcanic dyke, which has hydrothermal altered fragile parts. Hot springs has

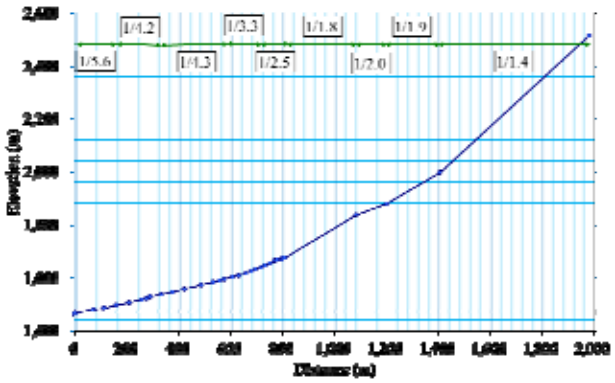


Fig.5 Longitudinal slope of river bed of Ubuyazawa

Fig.6 Desolation of Ubuyazawa

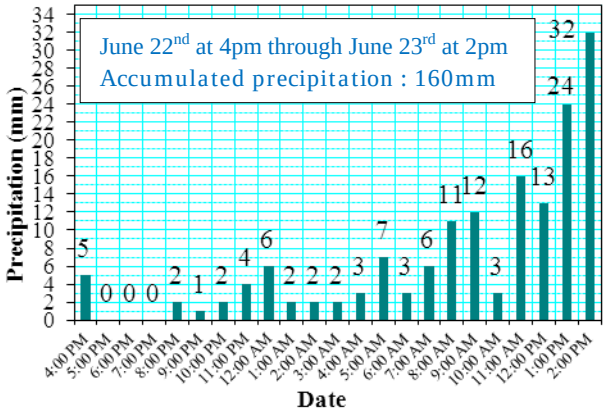


Fig.7 Precipitation of pre-debris flow

found in two places.

There is Abou tunnel (4,370m in length, for cars only). When the tunnel was excavated, advancing drift could not excavate because of large amount of spring water gushing (more than 2000L/min) originated from underwater of Abou moor. Four workers were suffered by phreatic explosion contained of volcanic gas around the road led to the Nakanoyu hot spring. Moreover slope failure and snow avalanche, which occured by the explosion, brought as much as 6,000m^3 of debris to Azusa River.

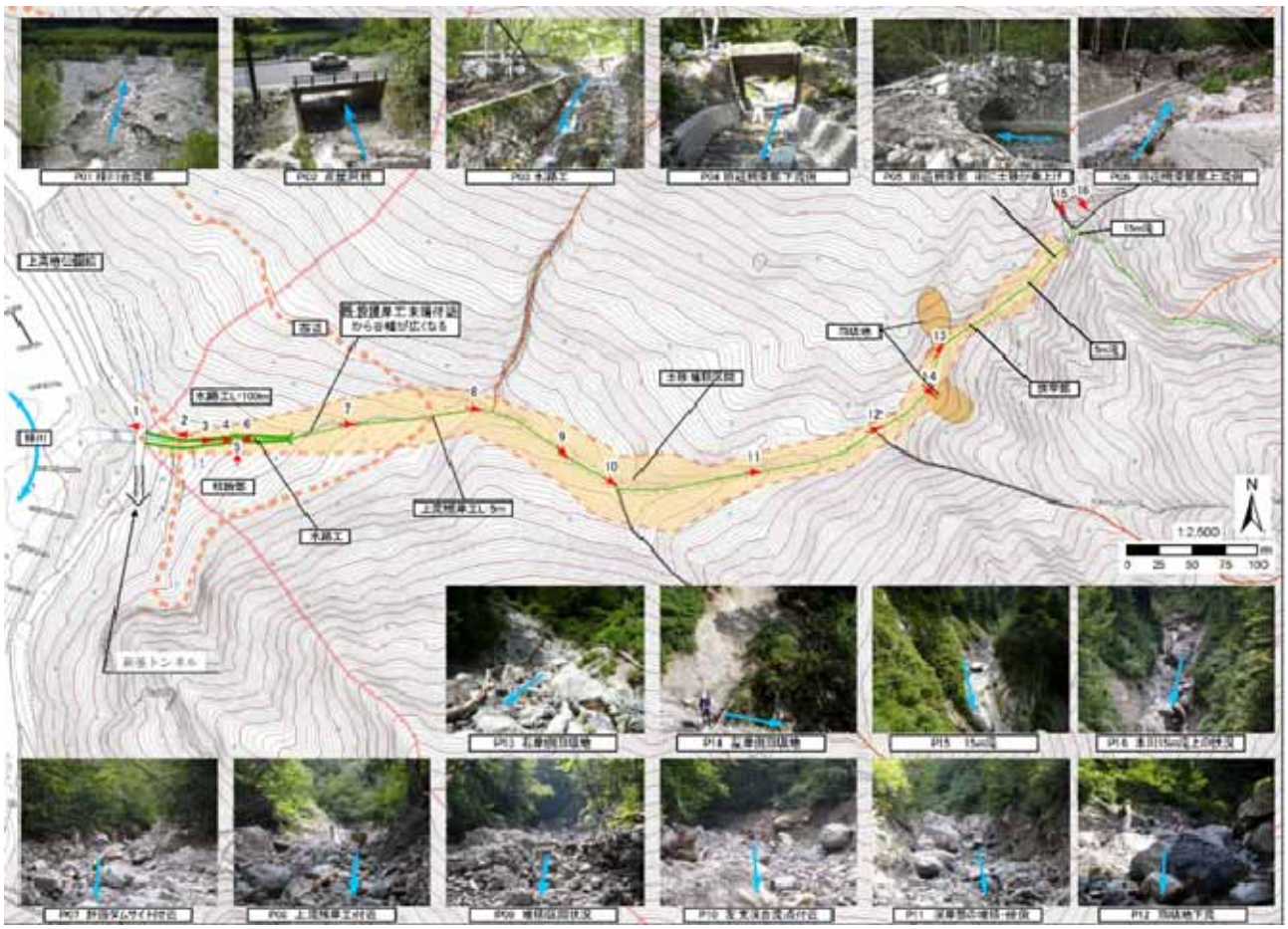


Fig.4 Result of investigation around catchment basin before debris flow happens (2008)

DEBRIS FLOW DISASTER OCCURRED AT UBUYAZAWA

Table.1 shows various factors of catchment basin of Ubuyazawa, Fig.4 shows the results of survey of catchment basin that carried out before the debris flow happned. Fig.5 shows longitudinal slope of river bed of Ubuyazawa.

Ubuyazawa has very steep stream; an inclination of 1/1.4 at headwaters and 1/5.6 at its downstream. Although no records had been kept, the debris flow happened on 2008 and there are still great amount of sedimentation of outflew debris at the riverbed and around its junction to Azusa River. As it shows in Fig.6, there are lots of slope failures that supply debris at the upstream. As it shows in Fig.4, a lot of slope failures which supply debris exist, and there are great amount of sedimentation in the river bed including boulders, which has been supplied by slope failure, in river bed. Although knick point of topography, there is no buffer zone from headwaters and Ubuyazawa bridge. Therefore debris flow that has happened at the upper stream catches sediments and get to the prefecture road as it grows the volume.

Since both of the cross-sectional areas of under bridge and waterway of upstream are small, flow route was blocked and overflow happened by great volume of debris flow like this time. Despite, it had been concerned that debris flow change its flow direction to Kama tunnel and it goes into the tunnel as the flow route blocked; it is related to the inclination of the road, and it actually happened. Although worst situation could be prevented by their advanced management this time, Sabo facilities are urgently needed, because a lot of tourists and cars were held up for a long period of time at the debris flow disaster.

Fig.7 shows the precipitation at Mt. Yakedake observation point, before the debris flow happens (June 22nd at 4pm through June 23rd at 2pm). It started raining at about 18hours before the debris flow occurred and accumulated precipitation reached up to 150mm.

Around Ubuyazawa bridge, back of abutment on the left bank and foundation were washed away in the debris flow; as it shows in fig.8. Slab of bridge grider on the mountain side is worn away and boulder with over 3m in the major axis blocked cross-sectional area of under bridge, as it shows in fig.9.

The debris flow, which has overflew and changed its flow direction by blockage of areas of under bridge, flew into Kama tunnel as it shows in Fig.10. Fig.11 shows the debris flow deposits in the tunnel. It outflew from the other side of the tunnel as it shows in Fig.12. Debris flow deposits include much rock fraction at about 0.3-0.1m, it can be about 3m in the major axis at the biggest. Fig.13 shows the panoramic view of

Fig.8 back of abutment and foundation

Fig.9 boulder reduced the cross-sectional area of river

Fig.10 Trace of debris flow flew down Kama Tunnel

neighborhood of Ubuyazawa bridge after the debris flow happened.

MECHANISM OF DEBRIS FLOW BROKE OUT AT UBUYAZAWA

Debris flow is a phenomenon that mixture of debris and water flows as continuum by the force of gravity. Spaces between granules are filled with water and slurry, and it has strong fluidity and big destructing power. It is not easy to observe the occurring process and fluidity mechanism of the

Fig.11 Debris flow deposit in Kama tunnel

Fig.12 Trace of debris flow flow out from Kama tunnel

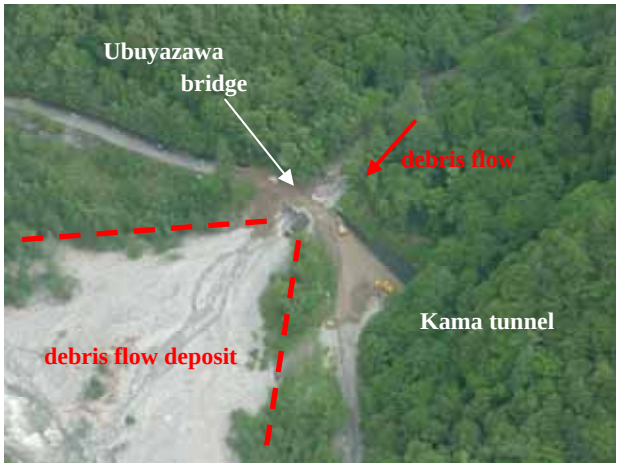


Fig.13 Around Ubuyazawa bridge after the debris flow

debris flow. Since there are no sensors on flow route at Ubuyazawa, it is difficult to analyze the details. The followings are the situations of the site when the debris flow happened.

- Flow in the stream before the debris flow happens was heavily turbid.
- The debris flow flew down as surge happened.
- There was metallic sound “can-can” as debris flow flew down. (it is assumed as boulders hit the metallic handrail of Ubuyazawa bridge)

- Slab of bridge girder on the mountain side is worn away and handrails were destroyed by the debris flow flew down.
- As it shows in Fig.9, debris flow include boulders with more than 3-2m in the major axis.
- The debris flow flew down not only debris and water, it also caught trees.
- It seemed that the flow speed of its surface was over 5m/s around Ubuyazawa bridge.
- It seemed that more than 3 surges led blockage of areas of under bridge and outflow.
- More than 2m thick debris flow deposits on top of Ubuyazawa bridge, the debris flow flew down to Kama tunnel direction which has lower road inclination.
- Debris flow deposits in Kama tunnel include boulders with 1m in the major axis, rock fraction, coarse fraction and fine fraction as shown in Fig.11.
- Scour happened on the back of Ubuyazawa bridge by outflow, shown in Fig.8.
- Since there are no banks at the downstream of Ubuyazawa bridge, it gradually expand the width, not suddenly spreading out.
- Debris flow deposits made alluvial fan shape, as shown in Fig.13.
- Slope failure which cause forming of natural dam cannot be found from aerial photograph taken on the next day of the debris flow happened (Fig.14) and reconnaissance survey.

The followings are occurrence, fluidity and stop mechanism assumed by the situation of the site, stated above.

Fig.14 Around Ubuyazawa after the debris flow

i) Big amount of water accumulate in valley because of continuous rainfall.

ii) Surface current occur (it is possible that saturated seepage flow was happening at the channel deposit, by the continuous rainfall)

iii) Sedimentary layer become unstable, and semi steady turbid flow happens as it catches debris that has accumulated. It does not form non-stationary surge or another wavy surface.

iv) Turbid flow that has increased its concentration flows down as it forms group of flow blocks.

v) Debris flow, which is mixture of debris and water has intermittently stored at knick point flows down with certain time intervals

vi) Although detail of surge mechanism is not clear, it has high possibility to flow down as surge with collapsed debris as surface failure at its flow origin.

vii) Debris flow deposits stopped its flow as it forms relatively depressed depositional landforms with alluvial fan shape.

SITUATION AFTER DBRIS FLOW HAPPENS AT UBUYAZAWA

The followings are result of reconnaissance survey at Ubuyazawa after the debris flow happened.

Debris flow deposits are accumulated at the downstream of Ubuyazawa bridge. Debris flow tends to form bumps (lobes) of debris blocks with long and thin shaped toward its flow direction. However obvious lobes cannot be found at the sedimentation point in the downstream of Ubuyazawa bridge. Fig.15 shows panoramic view of debris flow deposits that has accumulated in alluvial fun shape.

Fig.16 shows debris flow deposits, which include various granule size mainly rock fraction and coarse fraction. Fig.17 shows vegetation along the stream since scratches on the vegetation can be seen, it is sure that debris flow flew down up to about 5m high with increasing that volume.

Fig.18 shows the situation of flow route at the upstream of Ubuyazawa bridge. Flow route that has maintained by stone masonry was broken by debris flow. Especially, it can be seen that riverbed was scoured about 2m in depth on top of breaking stone masonry. By blockage of areas of under bridge and

Fig.15 panoramic view of debris flow deposits

Fig.16 Debris flow deposits

Fig.17 vegetation along the stream

accumulation of debris flow deposit on the bridge, the flow which has changed its flow direction to Kama tunnel flew down as washing the left bank violently out. Fig.19 shows the situation of 150m upstream of Ubuyazawa bridge. It can be seen that the debris flow flew down as eroding both side of the previous flow route of the retained mason for more than 5m with increasing its volume. It is possible that around 150m upstream of Ubuyazawa bridge was the area that debris was accumulated intermittently, because the area is a knick point and accumulation of boulders. Yet, the boulders which are on the left bank on Fig.19 were not the ones that accumulated by this debris flow.

Fig.20 shows the situation around 400m upstream of Ubuyazawa bridge. It can be seen that the debris flow flew down as eroding both side of the previous flow route for more than 5m with increasing its volume. It is possible that around 400m upstream of Ubuyazawa bridge was also the area that debris was accumulated intermittently, because the area is a knick point and accumulation of boulders.

Therefore, existence of accumulating boulders and relation of knick point almost correspond. These results supported the possibility that around knick point can be a place for debris to intermittently accumulate when debris flow flows down as stated in “MECHANISM OF DEBRIS FLOW BROKE OUT AT UBUYAZAWA”, No. v

Fig.18 Upper site of Ubuyazawa bridge

Fig.19 At 150m upstream of the Ubuyazawa bridge

Fig.20 Erosion situation of both bank (400m upstream of the Ubuyazawa bridge)