The Landslide Occurred at Kokugawa Area
Itakura-ku, Joetsu City

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On March 7, 2012, an enormous landslide occurred at Kokugawa area, Itakura-ku, Joetsu City. The landslide reached the residential area and destroyed 4 houses. The movement of the landslide slowed down after it moved 250 m. Evacuation recommendations were given to 83 people in 21 households in the Kokugawa area on the 8th. Emergency measures were Water treatment, house protection measures, and Observation system. The degree of landslide movement was brought under control together with an increase in the total amount of drained water using water drainage boring. Disaster relief project for this landslide was approved by Ministry of Land, Infrastructure, Transport and Tourism on April 6. The main prevention works were groundwater drainage works, soil retaining works, channel works and soil removal works at the top of landslide. Our prevention works were almost finished on April 10, 2013. Then the evacuation recommendation was canceled by Joetsu City that based on the result of the investigation by the experts about the landslide. At present, the countermeasure work is almost completed.

Key words: landslide, emergency measures, snowmelt water, evacuation recommendation

1. THE OUTLINE OF THE LANDSLIDE

On March 7, 2012, an enormous landslide occurred at Kokugawa area, Itakura-ku, Joetsu City, as shown in Fig.1. The landslide reached the residential area and destroyed 4 houses [Fujita, 2012a; Fujita, 2012b]. In this paper, we report initial correspondence and urgent investigation for landslides which is the first case implemented in Japan based on “the Sediment Disaster Countermeasures for Sediment Disaster Prone Areas Act”. This area has much snow coverage and the snow of the about 2m lies every year. However, a big landslide had not occurred in the area here until now.

1.1 The outline and a scale

The movement of the Kokugawa landslide became active from the afternoon on March 7, 2012. The size of the landslide is 150m wide and 500 m long, and there are 20 m deep and 750,000 m3 volume. And the size of the toe of the landslide is about 120m width, 250m length, and 7m the average thickness. And 5 houses (1 vacant), 4 huts, 2 garages were completely destroyed. A prefectural road and an irrigation canal with irrigated area of 2000 ha were cut off (Fig. 2, 3, 4, 5).

Fig. 1 Location of disaster area
1.2 The characteristics of the movement of the landslide

The fundamental geology of this area is composed of the Sugawa tertiary formations. Joetsu City is known as one of the heavy-snow region in Japan. At the time when the landslide occurred, thicker snow cover than usual year remained around the landslide area. It is presumed that much snowmelt water infiltrated into the block of landslide near the sliding cliff induced the landslide.

The movement of the landslide became active since the evening of March 8. Then 1.5m of snow-pack remain at the foot of the slope where the landslide occurred. The snow-pack push by the landslide started to heave and progress. Because the movement of the landslide was very slow and the landslide mass was covered with thick snow-pack, its movement was not readily apparent, as shown in Fig. 6. We could know it by the sound of falling down tree around the landslide area.
1.3 Evacuation recommendation

The movement of the landslide slowed down after it moved 250 m. Evacuation recommendations were given to 83 people in 21 households in the Kokugawa area on March 8 (Fig. 7, 8). On March 13, evacuation preparation information was also given to 20 people in five households in the Arayashiki district located in front of the landslide tip. Further details are as following.

On March 8 at 5:30 PM: evacuation preparation information (39 people in ten households in the Kokugawa area). On March 8 at 10:50 PM: areas under evacuation recommendation extended (44 people in 11 households in the Kokugawa area; a total of 83 people in 21 households). And on March 13 at 8:30 PM: evacuation preparation information (20 people in five households in the Arayashiki district).

1.4 The weather conditions

Fig. 9 shows the change of snow-depth and temperature during the period before and after the landslide occurrence (Fig. 10). The temperature exceeded 10 degrees two days before the occurrence, and the snow-depth decreased rapidly. This result supports the presumption that a lot of snowmelt water was one of the major occurrence factors of the landslide.

2. EMERGENCY MEASURES

2.1 The outline – Emergency response

Emergency measures were taken based on the three following measures. The 1st is Water treatment in order to curtail the landslide movement like an example of Fig. 11. Drainage boring was carried out to drain underground water flowing into the landslide. These works are water drainage boring of 19 groups, and 136 holes Nine trenches. The 2nd is house protection measures. Pre-cast concrete block setup on the side of 240 m, at the end of 48 m, and Training wall setup of 380 m like an example of Fig. 12, 13. The 3rd is Observation system. These works are mobile reference station, GPS movement observation.

The emergency measures were conducted around the clock and therefore were completed earlier. In particular, the water treatment demonstrated a maximum effect and the movement of the landslide was virtually halted two weeks after the occurrence of the disaster, as shown in Fig. 14.
2.2 Water treatment

The degree of landslide movement was brought under control together with an increase in the total amount of drained water using water drainage boring. When analyzing the relationship between the degree of landslide movement on or after the 14th, when the emergency measures began to make good progress, and the total amount of drained water from the use of water drainage boring, it is apparent that the water drainage boring, along with the other emergency measures, had a certain level of effectiveness in suppressing the sediment movement.
With the implementation of the emergency response water drainage boring, a total of 136 holes in 19 groups were made and the total amount of water drainage reached approximately 500 liters per minute. In addition, the side drainage channels for removing the moisture in the soil served as an effective means to dry the surface or eliminate pools of water because the drainage channels at the top did not completely drain the water from the snowmelt water produced by rising temperatures.

2.3 Snow wall removal work

Since the residents were concerned about the possibility that the wall of snow at the tip of the landslide might collapse and move towards their homes, work to remove it was carefully performed to prevent the soil from shifting again, as shown in Fig.15, 16, 17. This work was carried out after taking the peace of mind and safety of the residents into consideration.

Fig.15 A wall of snow moving towards a home March 13, 2012

Fig.16 A wall of snow continuing to move March 13, 2012

Fig.17 Snow wall removal work March 16, 2012

3. THE PERMANENT COUNTER MEASURES

Disaster relief project for this landslide was approved by Ministry of Land, Infrastructure, Transport and Tourism on April 6. The main prevention works were groundwater drainage works, soil retaining works, channel works and soil removal works at the top of landslide, as shown in Fig.18.

The snowmelt season of the following year was the period a landslide was most likely to occur. Therefore, it was necessary to aim for completion before the snowmelt season, in other words, to complete the work for the measures, except for the boring into the water catchment wells. In order to execute the work efficiently, it was decided to place an order for the work by dividing it into 14 work zones and to then proceed with the work in order to make progress.

3.1 Process and safety management

Because the work site was crowded with the 14 work zones, a work liaison and coordination council was established. Together with meticulously coordinating the schedules, the liaison strove to promote mutual reporting of the status of progress each month. In addition, it made efforts for safety management such as implementing a joint safety patrol.

3.2 Soil removal work

From the standpoint of both process management and landslide countermeasures, the status of the progress of soil removal from the top was very crucial and the amount of soil, combined with the slope cutting amount, was enormous, i.e., at 270,000 m³. 40 dump trucks constantly went to and fro
adding up to a total of 1,000 truck trips per day. At its peak, the work continued from 6:00 a.m. until 8:00 p.m. including Saturdays and Sundays, as shown in Fig.19. With virtually no complaints and good weather helping this tenacity, the soil transport was completed earlier than scheduled, i.e., on October 20, 2012.

3.3 Water catchment well work

Progress in the water catchment wells was key to determining the extent of falling water levels, which has the greatest impact on safety factor. Of the six water catchment wells, the three wells in the landslide block were completed in October. The main structure of the three units at the top and in the soil removal area was finished in December. Boring was carried out in the open caisson during the snow season and was completed on February 21, 2013, as shown in Fig.20.

The ground water level in the landslide area decreased by these prevention works, but we suffered from muddy ground after rainfall for a few months. Even though the surface of the ground was dried, the ground remained as soft as it was because of lots of snow lump in the clod of the landslide, as shown in Fig.21. Our prevention works were almost finished on April 10, 2013. Then the evacuation recommendation was canceled by Joetsu City that based on the result of the investigation by the experts about the landslide. At present, the countermeasure work is almost completed (Fig.22, 23, 24, 25).
4. CONCLUSIONS

In this paper, we described the details of many sediment-related disaster occurred in Niigata Prefecture in 2012. Kokugawa area landslide was selected as the main target site.

It was difficult to find out prognostic phenomenon of the sediment-related disaster in winter, especially on snow-covered area. Also, there were some difficulties of constructing prevention works due to snowy areas landslide. We learned from the experience of Kokugawa landslide that the early investigation and correspondence with renewed interests are important. We suggest that establish warning system for evacuation and to check them constantly are most effective for disaster prevention. Furthermore, the initial correspondence for the disaster occurrence is also very important. In Niigata Prefecture, we are planning to prevent the sediment related disaster more safely with preparation at usual and quick response at emergency.

REFERENCES
