The Geographical features of the Hiroshima landslide disaster triggered by heavy rainfall on August 20, 2014

Shoji DOSHIDA(1) and Kiminori ARAIBA(1)

(1) National Research Institute of Fire and Disaster, Japan
E-mail:sdoshida@fri.go.jp

Abstract

On August 20, 2014, the landslide disaster occurred at 166 or more places in Asa-minami ward and Asa-kita ward, Hiroshima city, Hiroshima prefecture, Japan by the heavy rain. In this research, we aimed at clarifying the geographical features of landslide by field survey and analyzing LiDAR data measured before and after the disaster. It is surmised that the features of the landslide were the following phenomena. First, a strongly weathered rock and soil (about 1m-deepth from the surface) causes shallow landslide by short-time heavy rain. Next, the collapsed rocks and soils flow and go down along a valley. At that time, the rocks shaves a valley deeply, joins the sediment of a valley, and become large debris flow. Finally, a lot of debris flows attack the downstream housing area. The analysis of LiDAR data showed that there are an area which is easy to do erosion, and an area which is hard to do erosion in a valley. As two of various causes, we consider a gentle slope and valley junctions.

Keywords: heavy rainfall, shallow landslide, debris flow, LiDAR, geographical features

1. Introduction

On August 20, 2014, the landslide disaster occurred in Asa-minami ward and Asa-kita ward, Hiroshima city, Hiroshima prefecture, Japan at more than 166 places by the heavy rain. The serious damage caused by this heavy rain was 74 dead persons, 44 injured persons, and 3,562 material damage, etc (Fire and Disaster Management Agency, 2014). The landslide distribution map shown in Fig.1 quoted and corrected the data of the Geospatial Information Authority of Japan (2014), and the geological map quoted the seamless digital geological map of Japan (1:200.000) (Geological Survey of Japan, 2014). The geological units which the landslide disaster occurred are Late Cretaceous granite (Younger Ryoke Granite), mélange matrix of Middle to Late Jurassic accretionary complex and Triassic to Middle Jurassic chert block of Middle to Late Jurassic accretionary complex in Asa-minami ward, and Late Cretaceous granite and Late Cretaceous non-alkaline felsic volcanic rocks in Asa-kita ward. At the AMeDAS Miiri observatory, Asa-kita ward, Hiroshima city, adjacent to the area where landslide disasters occurred frequently, hourly-maximum precipitation is 101.0 mm, 3-hour-maximum precipitation is 217.5 mm and 24-hour-maximum precipitation is 257.0 mm are observed (Fig.2) (Japan Meteorological Agency, 2014a; Japan Metrological Agency, 2014b). These precipitations were the heaviest on the records at the observatory. In this research, We considered the geographical features of two landslides in the disaster by analyzing the LiDAR (Light Detection and Ranging) data acquired before and after the disaster and field survey.

2. LiDAR data and Research area

The LiDAR data which analyzed in the research were offered from Aero Asahi Corporation, Inc. and Otagawa River Office, Chugoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism. The data before the disaster acquired in December, 2009 – March, 2010, and the data after the disaster measured on August 25, 2014 (5 days after the disaster). The

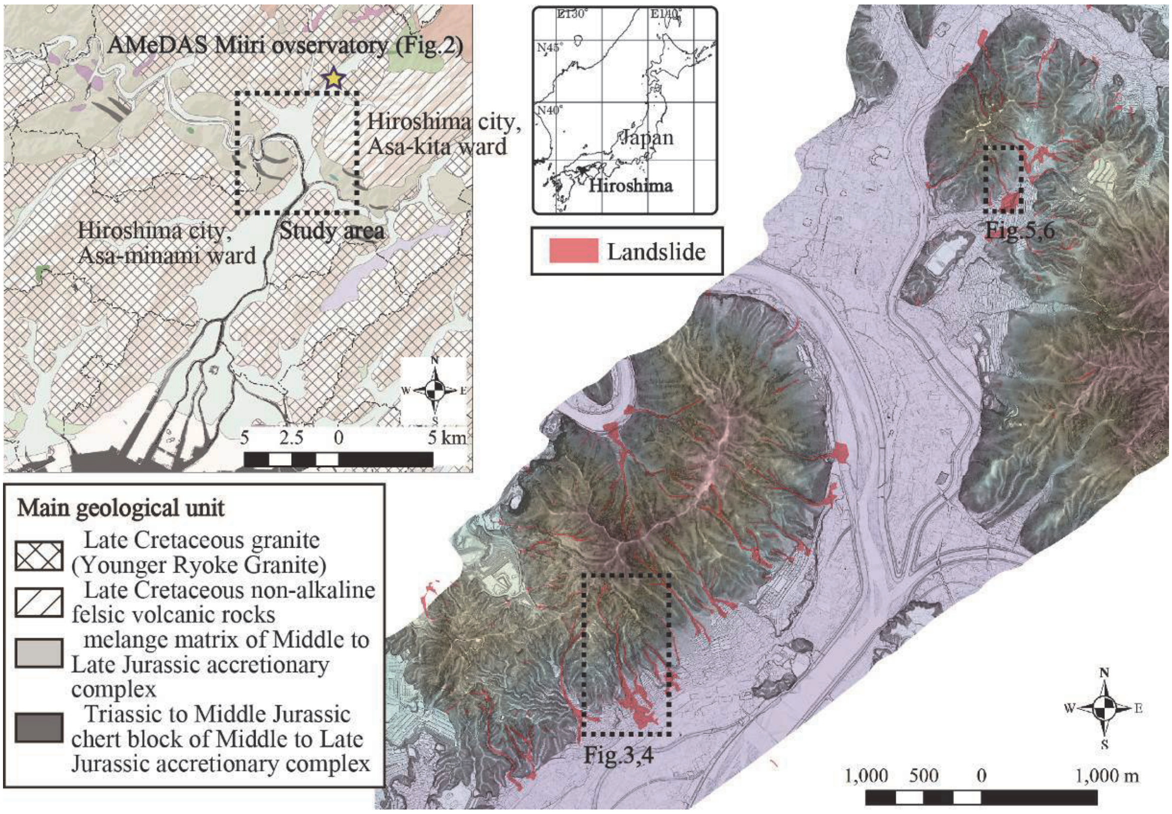


Fig.1 Index map in this research (geological map and geographical map)

resolution of both data are 1-m mesh size.

We set the two landslide as the target of the research, and clarified the geographical features of landslides by analyzing LiDAR data. One is the landslide at the Midorioka municipal housing, Asa-minami ward (Midorioka landslide) which damage was the most serious in the disaster, and another is the landslide in 6-chome, Kabe-higashi, Asa-kita ward which the accident in which the fire-fighting staff are killed during a rescue effort occurred (Kabe-higashi landslide). Chapter 3 and 4 explains the method of analysis and results in detail.

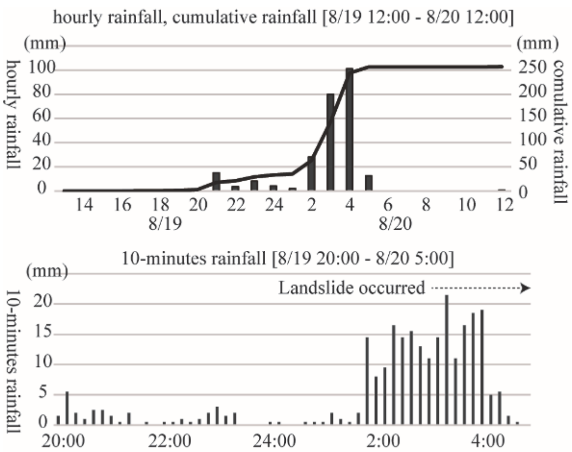
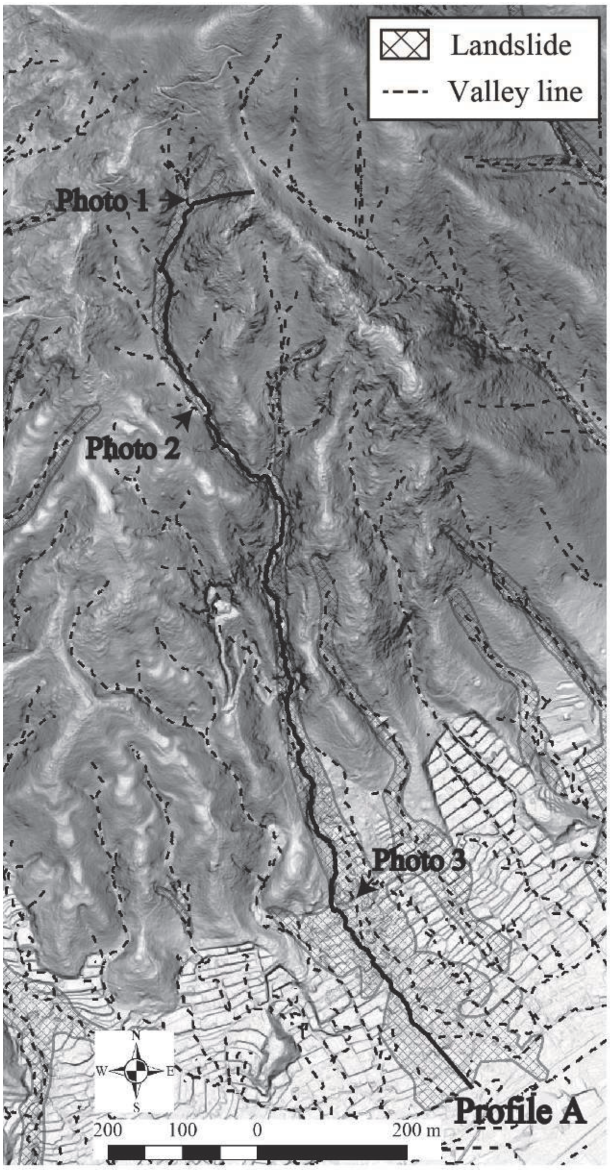


Fig.2 Histograms of hourly rainfall, cumulative rainfall and 10-minutes rainfall.

3. The geographical features of landslide - Midorioka landslidg

3.1 Field survey

The topographical map (left figure) and photographs (right figures) around the landslide at the Midorioka municipal housing, Asa-minami ward (Midorioka landslide) are shown in Fig.3. In Fig.3 left, we illustrate the landslide distribution, valley lines (flow accumulation more than 1,000 m^2) and the line of Profile A (Fig.4) with topographic map. Overlapping of the landslide distribution and valley lines shows that landslides which occurred in the disaster are mostly distributed on valley lines. Right photographs show the result of a field survey. The photo 1 shows the head of landslide. The depth of the landslide was about 1 m and the landslide was shallow landslide. The dike (rhyolite) was exposed at



Landslide at Midorioka municipal housing, Asa-Minami

Photo 1.Top of landslide

Photo 2. Erosion area of landslide

Photo 3.Sediment area of landslide

Fig.3 Landslide distribution and photographs at Midorioka municipal housing, Asa-Minami

this place. The photo 2 shows the large-scale side erosion of landslide. The side erosion is considered to be one of the causes by which the debris flow became large-scale. The photo 3 shows the huge boulders distributed with a debris flow sediment. Judging from the size of huge boulders, it seems that they were supplied from not a head of landslide but eroded area of landslide (Doshida et al., 2014; Doshida and Araiba, 2015).

3.2 Numerical geographical feature analysis

Fig.4 shows the different of elevation map (LiDAR data before the disaster – after the disaster) (left figure) and the graphs which calculated the fromProfile A is a profile in alignment with the main valley line of the Midorioka landslide. We displayed four parameters in the graphs as geographical features of Profile A. The horizontal axis of the graphs show the distance from ridge. The vertical axes of the graphs show the elevation after the disaster (graph A), the difference of elevations (before – after) (graph B), Slope before the disaster (graph C), and flow accumulation after the disaster (graph D). Each data is calculated the whole mesh (1-m resolution). The data of B and C also expresses a 50-m moving average deviation as the dotted line respectively.

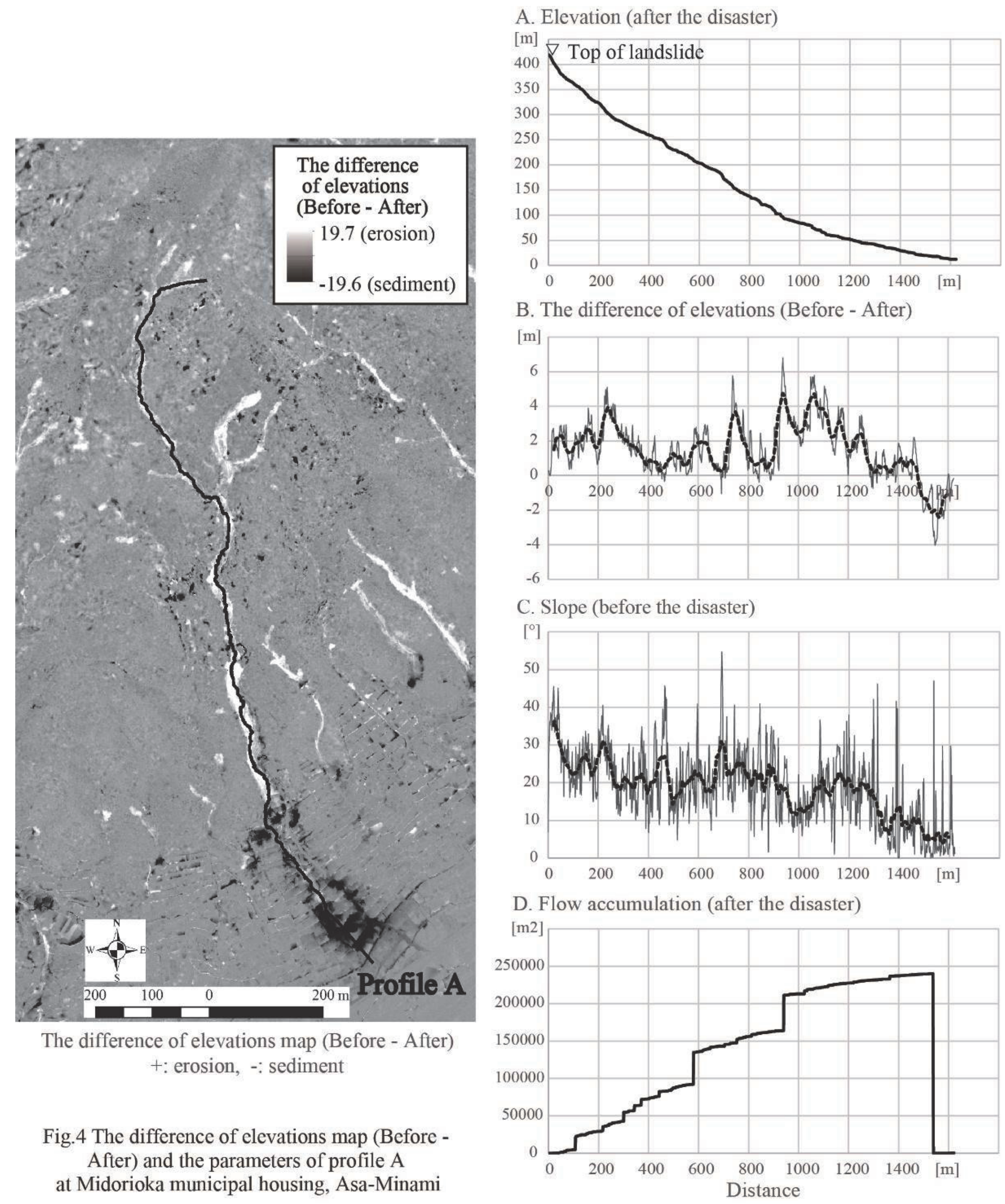
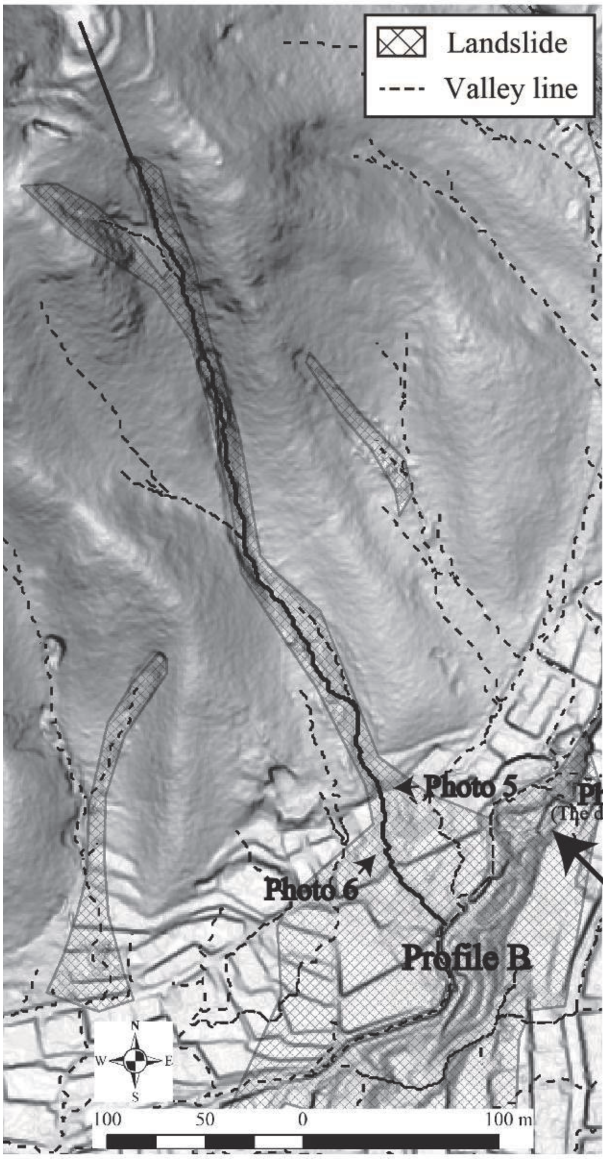


Fig.4 The difference of elevations map (Before - After) and the parameters of profile A at Midorioka municipal housing, Asa-Minami

In B graph, the value is changing a lot. The whole tendency shows that there are an area which is easy to do erosion, and an area which is hard to do erosion in Profile A. In order to clarify the geographical features of the easy to do erosion area, we compared the difference of elevations (graph B) and slope before the disaster (graph C). The comparatively large amount of erosion was observed in the area of 20 degrees or less of slopes, especially near 900 – 1100 m (the distance from ridge). However, overall variation is large and it is difficult to explain all only from the slope before the disaster. Next, we compared the difference of elevations (graph B) and flow accumulation (graph D). In the flow accumulation graph, the part where a value becomes high suddenly show the point where a branch joins a main valley. As a result of comparing, the increase of the erosion was seen in the valley junction (near the point of 580 m and 950 m). However, overall variation is large and it is difficult



Landslide at Kabe-Higashi, Asa-Kita

Photo 4.The distant view of landslide

Photo 5. Erosion and sediment area of landslide

Photo 6.Sediment area of landslide

Fig.5 Landslide distribution and photographs at Kabe-Higashi, Asa-Kita

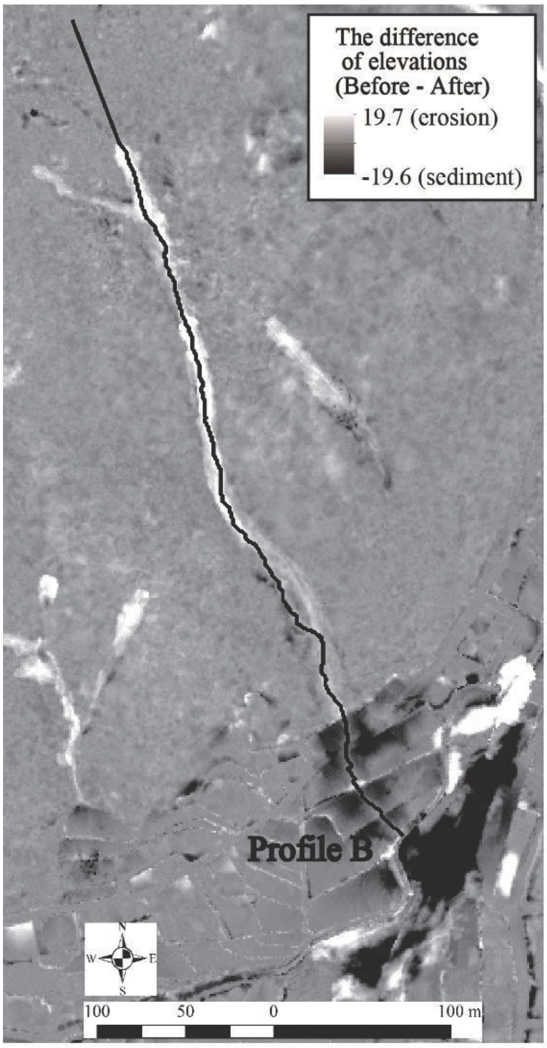
to explain all only from the flow accumulation too. As mentioned above, the area where a slope before the disaster is gentle and a valley junction are easy erosion. However, it seems that there are other causes.

4. The geographical feature of landslide – Kabe-higashi landslide

4.1 Field survey

We analyzed the landslide in 6-chome, Kabe-higashi, Asa-kita (Kabe-higashi landslide) as well as Chapter 3. The topographical map (left figure) and photographs (right figures) around the Kabe-higashi landslide are shown in Fig.5. In Fig.5 left, we illustrate the landslide distribution, valley lines (flow accumulation more than 1,000 m^2) and the line of Profile B (Fig.6) with topographic map. The photo 4 shows the distant view of the Kabe-higashi landslide. The landslide occurred near the ridge, flowed straight along the valley line, and hit two or more houses directly. The photo 5 shows the erosion and sediment area, and the photo 6 shows the sediment area of the landslide. With these photographs, the sedimentation structure which two or more times of debris flows reached is seen. The sediment consisted of the sand and the rock of the granite, and the decomposed granite. (Doshida et al., 2014; Doshida and Araiba, 2015)

4.2 Numerical geographical feature analysis



The difference of elevations map (Before - After)
+: erosion, -: sediment

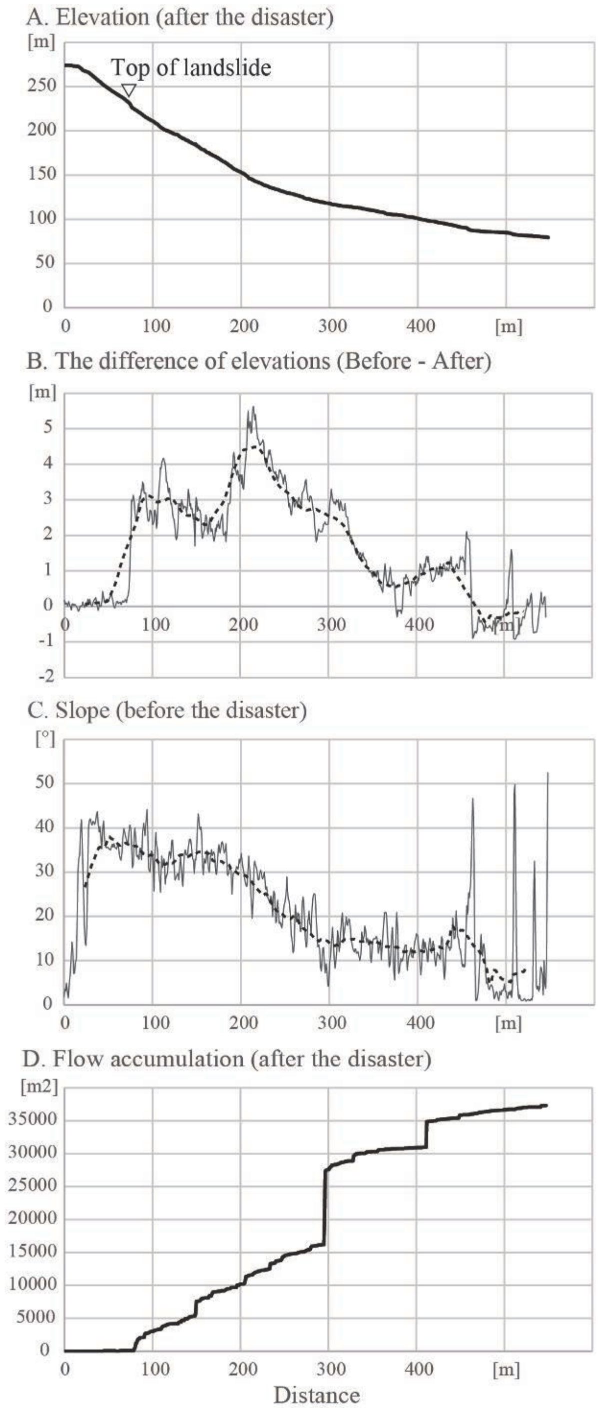


Fig.6 The difference of elevations map (Before - After) and the parameters of profile B at Kabe-Higashi, Asa-Kita

Fig.6 shows the different of elevation map (LiDAR data before the disaster – after the disaster) (left figure) and the graphs which calculated the geographical features in Profile B (right figures). Profile B is a profile in alignment with the main valley line of the Kabe-higashi landslide. We displayed four parameters in the graphs as geographical features of Profile B, there are the same as that of Chapter 3. In B graph, the value is changing a lot too. The whole tendency shows that there are an area which is easy to do erosion, and an area which is hard to do erosion in Profile B. We compared the difference of elevations (graph B) and slope before the disaster (graph C), the amount of erosion was large in the area where a slope becomes gentle (200 – 300 m). And we compared the difference of elevations (graph B) and flow accumulation after the disaster (graph D), the amount of erosion which was decreasing was maintained in near 295 m, and the amount of erosion was increasing in near 410 m. In profile B, the area where a slope before the disaster is gentle and valley junctions are easy to do erosion as well as the area in profile A. However, it seems that there are other causes too.

5. Conclusions

It is surmised that the geographical features of the landslide in the Hiroshima landslide disaster on August 20, 2014 were the following phenomena. First, a strongly weathered rock and soil (about 1m-deepth from the surface) causes shallow landslide by short-time heavy rain. Next, the collapsed rocks and soils flow and go down along a valley. At that time, the rocks shaves a valley deeply, joins the sediment of a valley, and become large debris flow. Finally, a lot of debris flows attack the downstream housing area.

The debris flow damage become large has the great influence by the erosion of a valley. Therefore, we considered the geographical features of erosion from the geographical analysis used by LiDAR data measured before and after the disaster. The analysis of LiDAR data showed that there are an area which is easy to do erosion, and an area which is hard to do erosion in a valley. As two of various causes, we consider a gentle slope and valley junctions. However, it seems that there are other causes.

Acknowledgements

The LiDAR data which analyzed in this research were offered from Aero Asahi Corporation, Inc. and Otagawa River Office, Chugoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism.

References

Fire and Disaster Management Agency (2014): A bout activity of fire-fighting and the damage sit uation in Hiroshima Prefecture by the heavy rai n from August 19 (The 43rd report) (in Japanes e), http://www.fdma.go.jp/bn/2014/ (accessed Nov. 21th, 2014).

Geospatial Information Authority of Japan (2014): Information about the damage situation by the heavy rain in August, Heisei 26(2014) (in Jap anese), http://www.gsi.go.jp/BOUSAI/h26-0816he avyrain-index.html (accessed Nov. 4th, 2014)

Geological Survey of Japan (2014): Seamless Digital Geological Map of Japan, Jan. 14th.

Japan Meteorological Agency (2014a): A Hiroshi ma-related weather bulletin, Heavy rain of Hiros hima Prefecture in August 19 to 20, Heisei 26 (2014) (in Japanese), http://www.jma.go.jp/jma/m enu/h26hiroshima-menu.html (accessed Nov. 4th, 2014)

Japan Meteorological Agency (2014b): The past meteorological data search (in Japanese), http://w ww.data.jma.go.jp/obd/stats/etrn/index.php.

Shoji DOSHIDA, Kiminori ARAIBA, Makoto SA ITO, Daisaku KAWABATA (2014): Landslide of Hiroshima city occurred by the heavy rain on August 20th, 2014 (in Japanese), Journal of the Japan Landslide Society, No.51, No.6, 256-259.

Shoji DOSHIDA, Kiminori ARAIBA (2015): The damage situation and its feature of the debris f low disaster of Hiroshima city by the heavy rai n on August 20th 2014 (in Japanese), Fire-fighti ng science and disaster prevention (Shoubou kag aku to Bousai), No.119, 39-45.