Disaster Report

The 2016 Kumamoto Earthquakes Landslide Disasters and Response

Kiyohumi MATSUNAGA ¹, Ryuhou MATSUDA ¹, Tatsuya MATSUO ¹ and Isamu WATANABE ¹

¹ Sediment Control Division, Kumamoto Prefectural Government
(6-18-1, Suizenji, Chuo-Ku, Kumamoto City, Kumamoto 8628570, Japan)
E-mail : sabou@pref.kumamoto.lg.jp

The earthquake with a seismic intensity of seven hit Kumamoto Prefecture twice in April 2016, and caused immense damage in the prefecture. It brought about 158 sediment disasters which included slope failure and landslides, and 246 people died, (which includes the number of those who died of disaster related-death). Furthermore, as the slope in the affected area was loosened, the secondary disasters which might be caused by a rain were likely to occur. Therefore, Kumamoto Prefectural Government adopted various measures, and applied the Provisional Sediment Disaster Warning Standard, for instance, to prevent and mitigate damage from secondary disasters. Kumamoto Prefectural Government is now providing permanent measures to the affected locations to accelerate the recovery to ensure safety and security of the residents.

Key words: Kumamoto Earthquake, landslide disaster, secondary disaster, emergency measure, permanent measure

1. INTRODUCTION

The unprecedented earthquakes with a seismic intensity of seven hit Kumamoto prefecture twice in April 2016, and a series of earthquakes (the 2016 Kumamoto Earthquakes) triggered sediment disasters including slope failure and landslides, which caused serious damage to various areas in the prefecture.

Notably, huge slope failures (**Photo 1**) occurred in Tateno district in Minamiaso-village, National Route 57, and National Route 325 were closed due to the collapse of Aso Ohashi Bridge, and JR Hohi Line, railroad line which was running along the area, was completely cut off. Aso, the popular tourist resort in Japan suffered a great deal of damage.

After the earthquake, people in Kumamoto were thankful and realized many aspects of everyday life

Photo 1 The huge slope failure in Tateno District in Minamiaso-village

that people had taken for granted were precious, and the amount of effort to return to the pre-earthquake situation.

This paper focuses on an outline of sediment disasters, among the many other disasters triggered by the 2016 Kumamoto Earthquakes, and how Kumamoto Prefecture coped with them.

2. OUTLINE OF THE EARTHQUAKE

At 21 : 26, 14th April, 2016, the earthquake observed a maximum intensity of 7 (M 6.5) hit Mashiki-town, Kumamoto Prefecture, and at 1 : 25, 16th April, another earthquake observed the maximum intensity of 7 (M 7.3) hit Mashiki-town, and Nishihara-village in Kumamoto Prefecture. From those seismic activities (**Table 1**), Kumamoto Prefecture was suffered from serious damages, with 246 deaths, which includes those who died of disaster related deaths, and 8,664 houses were destroyed. (as of 13th Oct. 2017)

3. OCCURRENCES OF SEDIMENT DISASTERS

Kumamoto Prefecture suffered from 158 sediment disasters by Kumamoto Earthquake, with 10 resultant casualties (**Fig. 1**). The feature of these sediment disasters by the earthquake is that they occurred not only on hillsides, but on the hilltops and ridges as well. In the area by the San'oudani River (**Photo 2**), slope

failure changed into a mudflow, even though there was no rainfall, and in the area at Takanodai (**Photo 3**), a landslide occurred even at gentle slope areas, in which pyroclastic flow deposited. Rock-slides occurred in towns and villages in which seismic intensity of more than 6, were observed while slope failures and

landslides were concentrated in the Aso area. In Mashiki-town, close to the epicenter of the two strong earthquakes with seismic intensity of seven, housing damage was quite conspicuous including the collapse of retaining walls in the housing areas.

Table 1 Frequency of earthquake each maximum intensity level every month

Period	Frequency of earthquake by maximum intensity									Total
	1	2	3	4	Lower5	Upper5	Lower6	Upper6	7	
Apr. 14, 2016~	1722	859	323	98	10	5	3	2	2	3024
May	344	134	43	8						529
Jun	147	51	14	4	1					217
Jul	85	19	8	1						113
Aug	77	28	3	2	1					111
Sep	49	16	7	2						74
Oct	41	10	4							55
Nov	24	16	1	1						42
Dec	31	10	3							44
Jan. 2017	22	8	1	1						32
Feb	13	4	1							18
Mar	15	9	1							25
Apr	19	5	1							25
May	17	8	1	2						28
Jun	6	3	1							10
Jul	11	4	1		1					17
Aug	13	5	1							19
Sep	12	6	1	1						20
Oct	12	9	1							22
Total	2660	1204	416	120	13	5	3	2	2	4425

4. MEASURES AFTER THE EARTHQUAKE

4.1 Provisional application of sediment disaster warning threshold

As the earthquake of seismic intensity more than 5 occurred in Kumamoto, Kumamoto Prefecture Government and Kumamoto Local Meteorological

Photo 2 View of mudflow

Fig.1 Locations of the main sediment disasters in Kumamoto Prefecture

posted on the prefectural government homepage on 25th May (Rank 1: Hazardous places of sediment disasters where there are more than 5 households announced in FY 2002), and on 24th June (Rank 2: Hazardous places of sediment disasters where there are 1~4 households announced in FY 2002), respectively (Table 2).

4.3 Emergent measures provided to the places of sediment disaster

In order to prevent secondary disasters, emergent

countermeasures were provided to places in which experienced sediment disaster occurred (Table 3). In northern Kyushu area, including Kumamoto Prefecture, rainy season begins in June, so the steps had to be completed by then. As the rainy season would occur soon after the earthquake, the measures were provided mainly to prevent loss of lives from the secondary disasters (Photos 4, 5 & 6).

Through a system of using extensometer we established, municipal staff are informed by email when an abnormal level of movement is detected. We

Table 2 Result of urgent inspection

Inspection Implementing Organ	Target of inspection	Number of locations inspected	Period of inspection
Ministry of Land, Infrastructure Transport and Tourism	Rank 1	1,155	4/19~4/27
Kumamoto Prefecture	Rank 1	1,968	4/21~5/6
	Rank 2	3,464	5/1 ~6/7

Table 3 Main emergent measures

No.	Emergent Measures	Number
1	Installation of extensometer and wire sensor	14
2	Removal of slided soil sedimentation	18
3	Installation of large sandbags	10
4	Stretching sheet	56

Fig.3 Result of emergent inspection for hazardous places caused by sediment disaster

also provided facilities using wire sensors, which gave a warning sound, when the sensor detects a debris flood. In this way, we hoped to prevent further loss of lives from these events.

4.4 Support by municipalities for warning and evacuation

There were some questions from municipality participants that when they saw the ground had become loose and risk increased, including when evacuation advisories should be issued and when these

advisories could be lifted, asking for a standard. The prefectural government, therefore, invited experts including university professors and held meetings with similar organizations (**Photo 7**), where participants exchanged opinions about the timing to issue and lift the advisories. The consensus was “As the provisional standard is to be applied based on the weather information, evacuation advisory should also be dependent on the weather information. However, in the hazardous areas such as steep-walled valley where the risk of disasters is quite high, warning should be issued depending on the situation.” The result of discussion in this meeting was reported in “Kumamoto Prefecture Disaster Mitigation Urgent Conference” held on 23rd May, and each participant from municipalities was required to improve warning and evacuation system.

In this meeting, there were some opinions saying that it was important to show the Photos of mountains before the rainy season to the residents and explain them the risk of sediment disasters and how hazardous they were. Therefore, our members participated in the workshops held in Aso City, Minamiaso-village, and Nishihara-village, respectively, where the risk of sediment disasters is quite high and explained the risk to the residents in these areas by showing them the result of our urgent inspections for the hazardous places of sediment disasters (**Photo 8**).

Photo 4 Installation of extensometer

Photo 5 Removal of soil sedimentation

Photo 6 Installation of sandbags

5. PERMANENT MEASURES FOR THE LANDSLIDE SITES

Table 4 shows the project list which have been implemented to prevent landslide-related phenomena.

As for the big-scale slope failure in Tateno district in Minamiaso-village, the national government started the project of rehabilitation quite smoothly from 5th May, 2016.

National Route 57 and JR Hohi Railroad Line are important traffic networks for Aso area and Kumamoto

Photo 7 Meeting with related organizations

Photo 8 Workshop in local community

Prefecture, so their restoration is expected to be completed as soon as possible. The projects planned by prefectural government are also ongoing to help the affected areas recover.

6. CONCLUSION

The sediment disasters caused by the Kumamoto Earthquakes had quite an unprecedented scale that our

Table 4 The number of projects implemented to prevent landslide-related phenomena

Name of project	Affiliated organization	No. of projects
Project for preventing slope failure	National government	1
Project for preventing mudflows	Prefecture	31
Project for preventing landslides		5
Project for preventing slope failure		22
Project for preventing slope failure	Municipalities	271

prefecture had never experienced. Slope failures, debris flow, and landslides occurred in many places, and following rain in June triggered a further increase of hillside failures (**Photo 9**). They brought sediments and aggradation to the Shira-kawa River System (**Photo 10**). Driftwoods were piled up at bridges (**Photo 11**). As a result, the risk for the flood become higher in Kumamoto City located at the middle and lower reaches of the river. Additionally, in the coastal

Photo 9 Photos to show the place of slope failures expanded by the rain in June 2016

Photo 10 Sediment excavation in the middle reaches of the Shira-kawa River

Photo 11 Drift timbers in the lower reaches of the Shira-kawa River, and their removal

area along the Ariake Sea, fishery and environment were impacted by sediment and driftwood.

The Aso area may continue sediment discharge and sediment yield after Kumamoto Earthquakes, and as the area is comprised of fragile volcanic soil, the ground may become looser. It will continue a large amount of sediment discharge for an extended period. Therefore, we need to provide not only for permanent measures for landslides but also strong and immediate measures to control the sediment discharge of soil into the Shira-kawa River System.

Finally, we would like to acknowledge the Ministry of Land, Infrastructure, Transportation and Tourism, and staff from the municipalities, for their cooperation in the recovery from Kumamoto Earthquakes. The

restoration and reconstruction of our prefecture is going to be full-fledged job moving forward. We would appreciate your continued support and cooperation.

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