CHARACTERISTICS OF SLOP FAILURES AND LANDSLIDE DAMS CAUSED BY THE 2008 IWATE-MIYAGI NAIRIKU EARTHQUAKE

Yoshiharu Ishikawa[1] and Takayuki Ishikawa[2]

ABSTRACT

The 2008 Iwate-Miyagi Nairiku Earthquake with a magnitude 7.2 induced numerous slope failures on steep inner valleys along the Ichihasama River, the Nihasama River and the Sanhasama River in Miyagi Prefecture, Japan. The debris mass rushed down the steep slopes and deposited in the valley, resulting in many landslide dams generating along the rivers. The purpose of this study is to clarify the topographic and geological features of slope failures and landslide dams generated by the earthquakes using by the aerial photointerpretaion. There are many failed slopes on acid tuff breccias of pyroclastic rocks. Many landslide dams were generated by occurrence of slope failures near the river courses. Most failed slopes that formed the main landslide dams are at a distance of approximately 250m from the center of the river course.

Keywords: Iwate-Miyagi Nairiku Earthquake, slope failure, landslide dam, aerial photointerpretation

INTRODUCTION

The Iwate-Miyagi Nairiku Earthquake with M = 7.2 occurred at 08:43 on June 14, 2008. A maximum intensity of more than 6 was observed in Kurihara City, Miyagi. Consequently, 23 people died or went missing and 23 houses were demolished, mainly in the city. As the main focus of the earthquake was in a mountain-ringed area, it caused many slope failures that subsequently generated landslide dams. Understanding the characteristics of slope failures and landslide dams caused by earthquakes enables better prediction of these events. The clarified characteristics will provide important data and information necessary for future disaster prevention. This paper describes the topographic and geological features of locations where earthquakes caused slope failures that subsequently generated landslide dams.

OUTLINE OF SURVEYED AREAS

We surveyed the basins of the Ichihasama River, Nihasama River, and Sanhasama River that run through the northwestern part of Miyagi, where the event with a maximum intensity of over 6 was observed (Fig.1, 2). These basins had many slope failures, and subsequently, many landslide dams were formed (Fig.3, 4). The catchment areas are geologically made up of andesites erupting from Mt. Kurikoma and pyroclastic flow sediments from the Onikobe Caldera, or fragile layers.

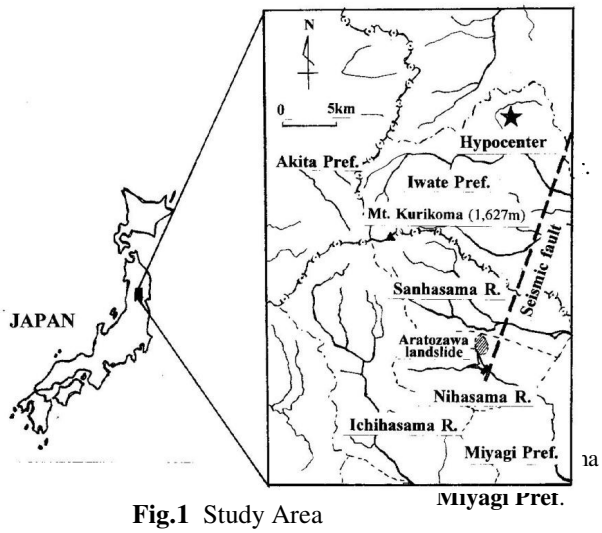

Fig.1 Study Area

[1]Prof. Yoshiharu Ishikawa, Tokyo University of Agriculture and Technology, Saiwaicho 3-5-8, Fuchu, Tokyo, 183-8509, Japan(e-mail: y_ishi@cc.tuat.ac.jp)
[2]Takayuki Ishikawa, Forestry Agency, Japan

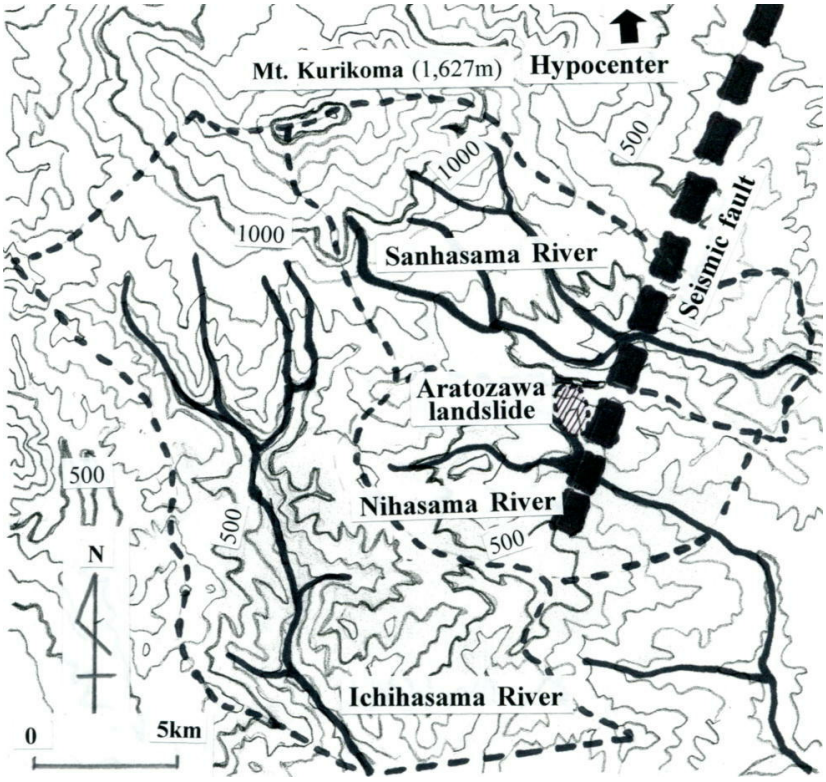

Fig.2 Surveyed basin and Seismic fault

Fig.3 Slope failure and landslide dam at Ogawara, Ichihasama River

Fig.4 Slope failure and landslide dam at Azabu, Ichihasama River

SURVEY METHOD

The results of the analysis of pictures taken at the slope failure locations were reported in "Version 1.2 of the Distribution Map of the Landslides and Slope Failures Caused by the 2008 Iwate-Miyazaki Nairiku Earthquake (Yagi et al., 2008; Fig.5)". Based on this map, the slope failure locations were transferred to a 1:25,000 scale topographic map, using aerial photographs taken after the earthquake (taken by Asia Air Survey Co., Ltd., scale of 1:10,000; Fig.6) and orthophotos (taken by the Geospatial Information Authority of Japan, scale of 1:10,000). The areas, inclinations, geological features, slope directions, distances from valleys, and those from the hypocentral fault (Fig. 5) of the failed slopes that were transferred to the topographic map were measured to examine the characteristics of these elements. The geological features were surveyed based on the special

geological map of the epicentral area on a scale of 1:100,000 that was edited by the Geological Survey of Japan, AIST.

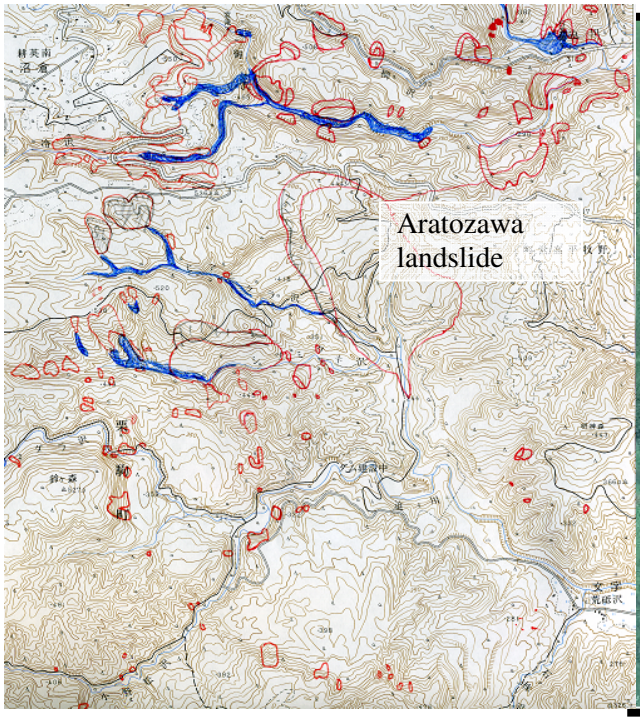

Fig.5 Distribution map of the landslides and slope failures caused by the earthquake (Yagi et al., 2008)

Fig.6 Aerial photograph after the earthquake taken by Asia Air Survey Co. Ltd

SURVEY RESULTS

Slope failures in the basins of the Ichihasama River, Nihasama River, and Sanhasama River were investigated. The results are summarized in Tab. 1. From the table, it is seen that the catchment area of the Ichihasama River is farthest from the hypocentral fault but has the highest population density of failed slopes. Failed slopes with an area of 0.05 ha or less account for 47.5% of all the failed slopes, but only 5% of the total per failed area (Fig. 7 and Fig. 8).

Tab. 1 Area of affected basin, number of failed slopes, and failed area

Prefecture name	Basin	Basin area (ha)	Slope failure		Failures density (number/ha)	Percentage of failed area (%)	Mean distance from fault (km)
			Number of failed slopes	Failed area (ha)			
MIYAGI	Ichihasama	9034.3	630	219.1	0.070	2.4	8.2
	Nihasama	2958.8	105	50.7	0.035	1.7	2.3
	Sanhasama	4757.9	197	100.0	0.041	2.1	4.0
	Total	16751.0	932	369.8			

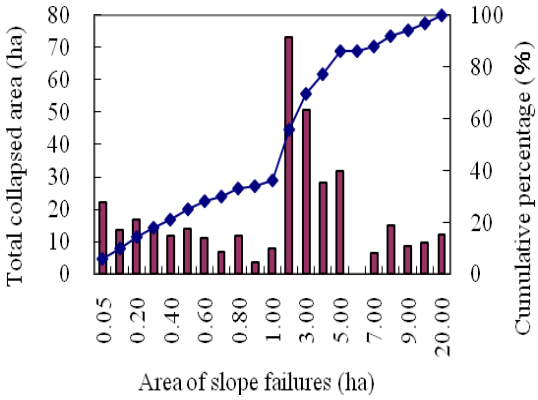

Fig.7 Number of failed slopes and cumulative percentage

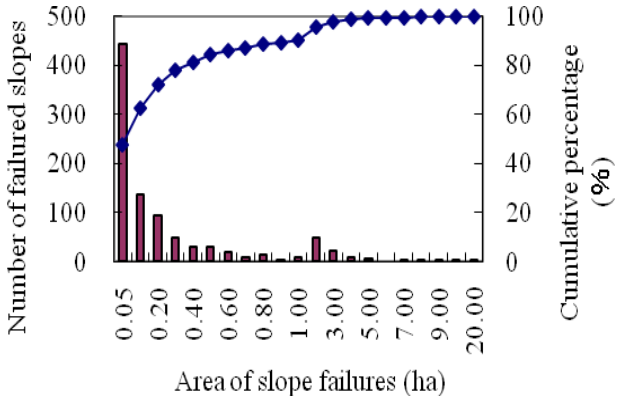

Fig.8 Distribution of collapsed area

The aspects of collapsed slopes in Fig. 9 indicates equilibrium distribution in each direction. The population density of the failed slopes per geological condition shows that there are many failed slopes on acid tuff breccias of pyroclastic rock (Fig. 10).

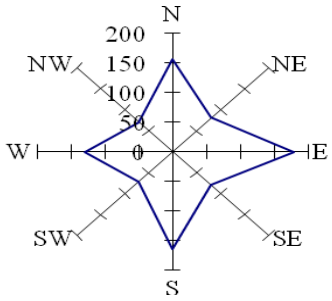

Fig.9 Aspects of slope failures

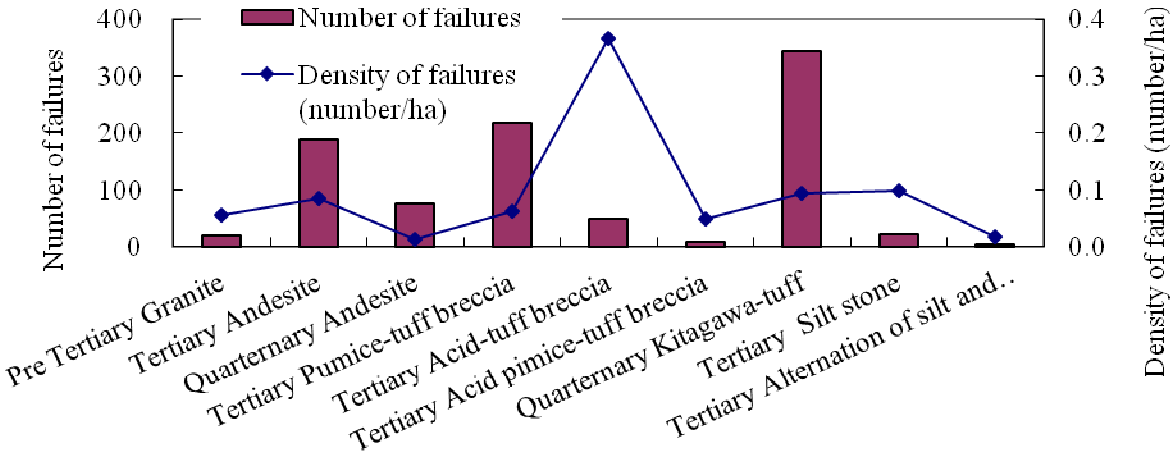

Fig.10 Numbers and density of failures by geology

Figure 11 indicates that the peak of the slope frequency distribution on the acid tuff breccias is the same as or lower than that under the other geological conditions. The tuff breccias are less affected by the slopes.

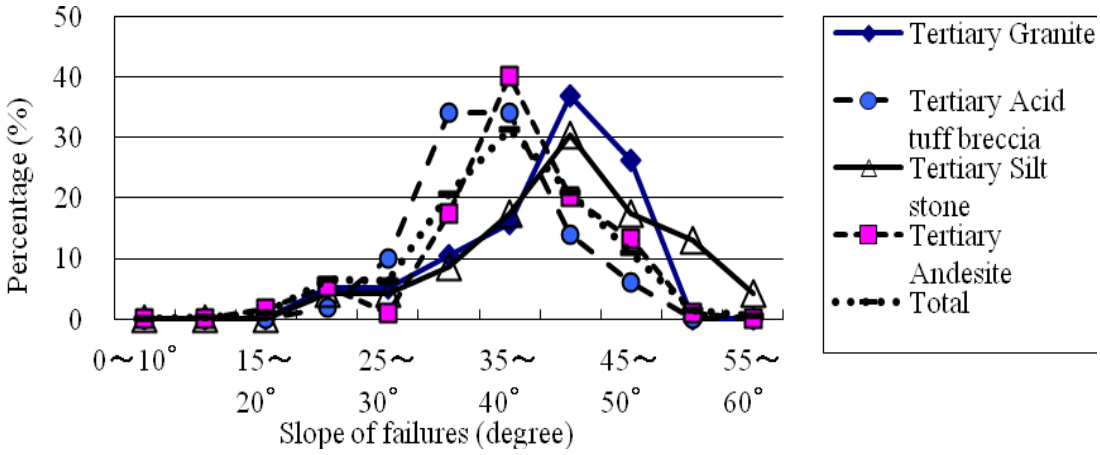

Fig.11 Frequency of slope of failures by geology

Distances between the seismic fault and the failed slopes that were transferred to the topographic map were measured to examine the influence of the seismic fault for the slope failures (Fig. 12). Fig. 13 indicates that the first peak of density of failures related to the failures in the Nihasama River and Sanhasama River and the second peak is derived from the failures in the Ichihasama River. There are not specific relationship between density of slope failures and distance from the seismic fault.

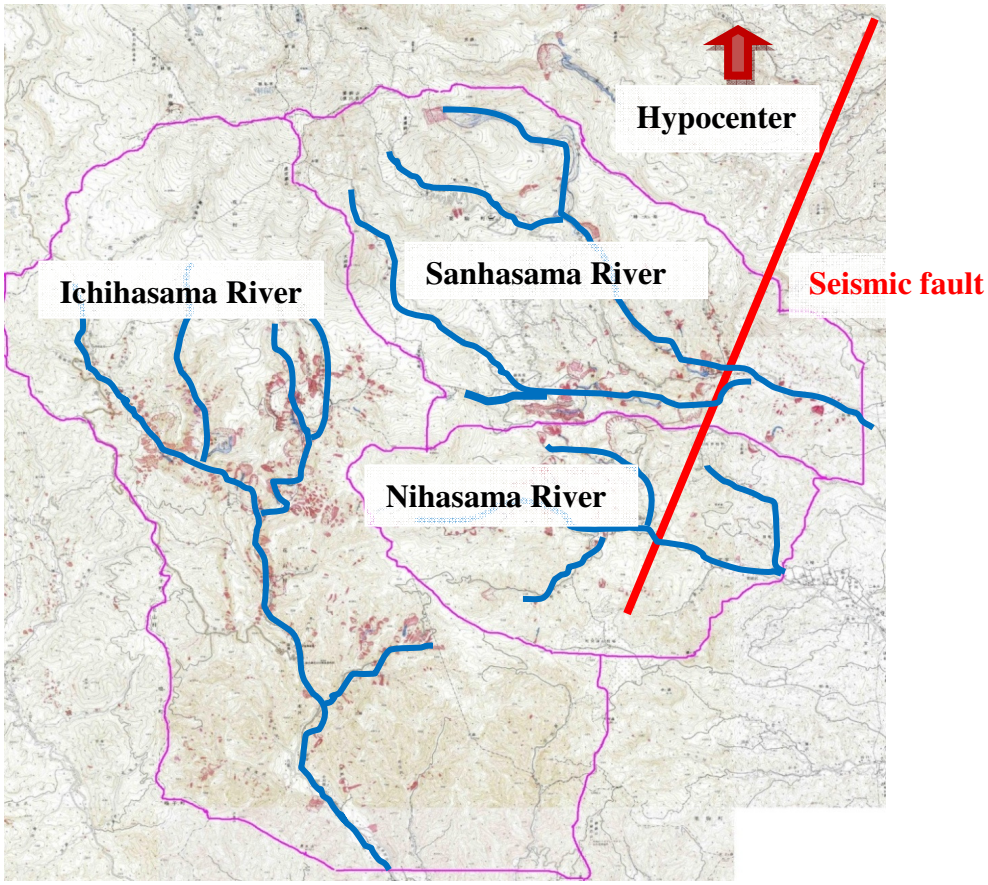

Fig.12 Distances between the seismic fault and the landslides and slope failures caused by the earthquake (Yagi et al.,2008)

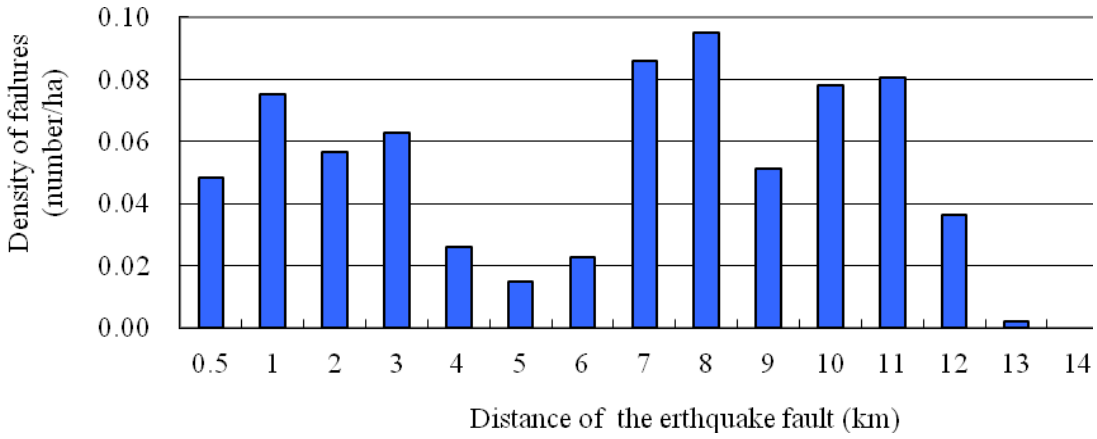

Fig. 13 Density of failures per distance from the earthquake fault

This earthquake created many landslide dams (Fig.3, 4) owing to the fact that many slope failures occurred near the rivers (valleys), as shown in Fig.14 and Fig.15. The surveyed basins were generated after the rivers dissected pyroclastic materials and other thick sedimentary layers. Therefore, the slopes on the riverbanks have a high degree of incline and large elevation differences, resulting in many slope failures occurring on the banks and subsequently many landslide dams. Many slope failures occurred in the third to fifth order valleys, as shown in Fig.16 and Fig. 17. Most failed slopes that formed the main landslide dams are at a distance of approximately 250 m from the center of the river course, as shown in Fig. 18. It is estimated that landslide dams are easily formed in areas where the riverbank slope has a large elevation difference (large distance) and the riverbed has a relatively gentle inclination (third to fifth order valleys).

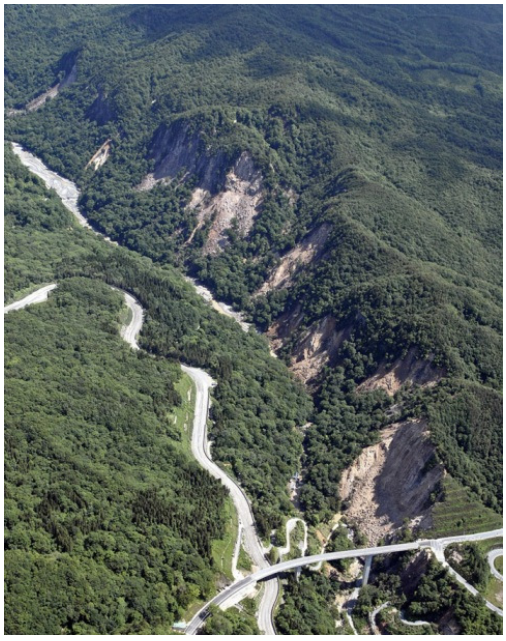

Fig. 14 Slope failures along Ichihasama River

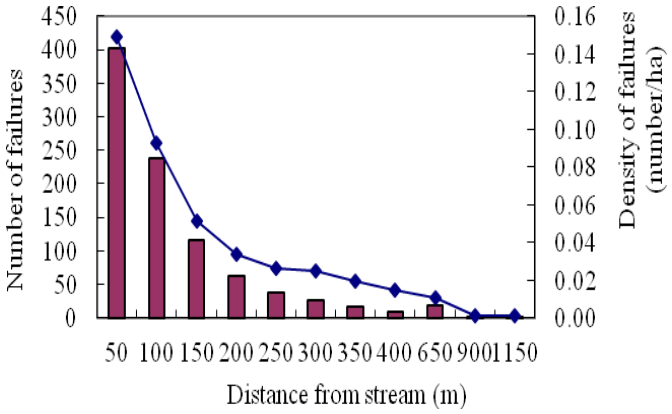

Fig. 15 Distance between failures and stream, number of failures, and density of failures

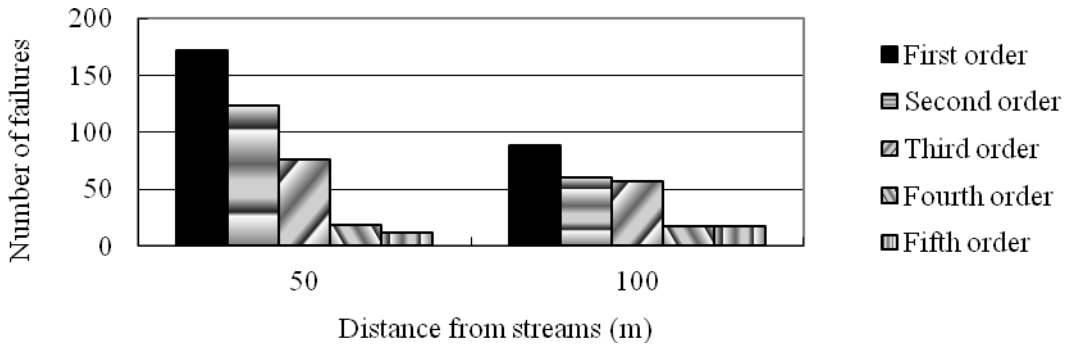

Fig. 16 Number of failures per distance from the streams by each stream order

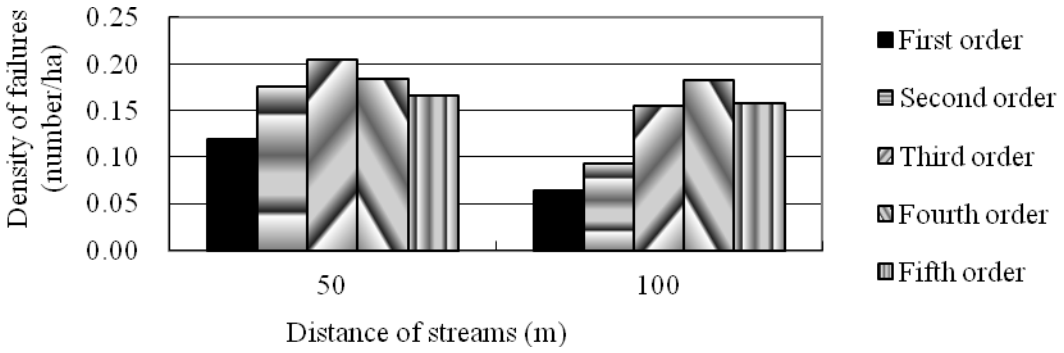

Fig. 17 Density of failures per distance from the streams by each stream order

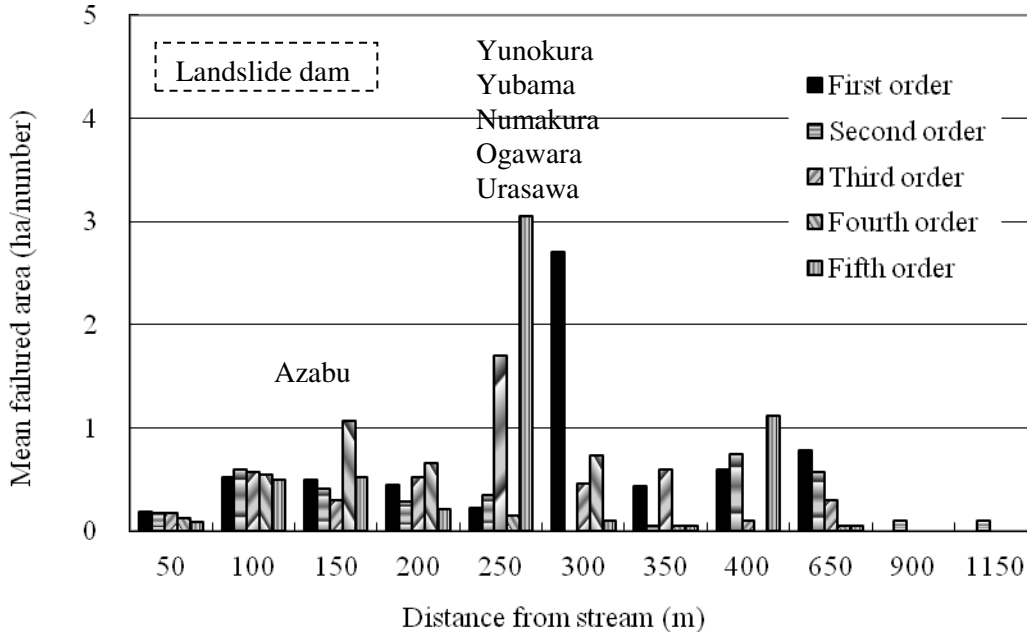

Fig. 18 Mean failed area per order and per distance from streams, and failure generating landslide dams

CONCLUSION

We investigated the topographic and geological features of slope failures and landslide dams generated by the earthquakes using by the aerial photointerpretaion. The following results have been obtained.

(1) Slope failures less than 0.05ha are about 47% in number of total failures, however 5% in area.

(2) Failures tend to occur near streams, especially in third –fourth order streams than first –second order streams within 100m from streams.

(3) Failures tend to occur in acid tuff-breccia.

(4) Many slope failures occur on the slopes about 40° as like past earthquakes.

(5) Landslide dams are easily formed in areas where the riverbank slope has a large elevation difference (large distance) and the riverbed has a relatively gentle inclination (third to fifth order valleys).

It is necessary to further investigate the characteristics of topographic and geological features that cause slope failures and landslide dams in the basins of the three rivers, including the catchment area of the Iwai River in Iwate Prefecture, and to develop ways to predict slope failures and landslide dams caused by earthquakes in areas of volcanic products.

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