PROVISIONAL REPORT OF THE DAMAGE CAUSED BY THE JUNE 14th 2008, IWATE-MIYAGI EARTHQUAKE

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ABSTRACT: A M7.4 Earthquake jolted south of the inland of Iwate Prefecture at 8:43 JST on Saturday morning, June 14. Even though the peak acceleration of 4022 cm/s^2 was the largest on records, damage to dwellings did not seem to be serious. Much more serious issues were about landslides and debris flows. The authors made several field surveys; first from June 15 to 17, second from July 12 to 14 and then from Sept. 8 to 9. The results from these surveys are shown in form of figures in this report. The latest version of this document is available at: http://shake.iis.u-tokyo.ac.jp/home-new/

Key Words: Iwate-Miyagi Earthquake, geotechnical issues, rehabilitations

INTRODUCTION

An earthquake of JMA magnitude 7.2 struck a border area between Iwate and Miyagi prefectures, Japan, on June 14th, 2008. The epicenter was located at 39° 01.7'N, 140° 52.8' beneath mountain terrains with Kurikoma volcano. This earthquake was remarkable in that a number of debris flows were triggered, while less serious damages to dwellings were reported. Ministry of Land, Infrastructures, and Transport made quick estimate of property losses of around 12 million JPY and 2.94 million JPY for Miyagi and Iwate prefectures, respectively. The greater part of the losses was due to geotechnical hazards. The authors were members in the field reconnaissance first one from June 15 to 17, second from July 12 to 14, and then Sept. 8 to 9, have compiled the results in forms of figures shown below. The latest version of this document is available at: http://shake.iis.u-tokyo.ac.jp/home-new/.
At this moment, the drawing reflects the authors own opinions and views, but the figures will be updated with the help of more detailed field information and other experts' opinions.

SLOPE FAILURES

Aratosawa landslide

Fig. 1 shows the bird's eyes view of a largest landslide at Aratosawa with Kurikoma Volcano rising behind. The terrain here is suggestive that similar landslides have been reactivated. A wide-spread and almost horizontal laminar structure of lose volcanic sand and ashes is exposed on the escarpment. When wet, some pieces of light-gray rock fragments taken from the toe of the landslide mass smelled strong hydrogen sulfide (see Fig. 3)

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Fig. 1. Landslide at Aratosawa dam: (Photo by K. Konagai, June 15, 2008)

Fig. 2 shows a digital elevation model (DEM hereafter) of the landslide at Aratosawa. The road locations before (gray) and after the earthquake were drawn upon the DEM by using images from helicopter survey, photos (black lines), and field GPS survey (open circles) etc. The arrows show that Points P_1, P_2, P_3 and P_4 have respectively moved about 200m, 300m, 300m and 500m SSE towards the dam lake. The slide blocks are lined up in a succession. The cross-section A-A' (Figure 2b) shows a gradient of about 3-4 degrees. Even though the base slope was very gentle the soil masses have moved some 200 to 500 meters.

A rock piece from the landslide mass was taken at 38.8942ºN, 140.8545ºE, to determine specific gravities under different conditions (Fig. 3).

Specific gravity immediately after the sample was taken（18:00JST, June 16, 2008） = 1.78 g/cm^3
Specific gravity after the sample was dried for 24 hours at 105º C in oven = 1.18 g/cm^3
Specific gravity after the sample was again soaked up in water for three hours = 1.69 g/cm^3

When soaked in water, the sample smelled hydrogen sulfide which is evidence that the materials were from volcanoes. It is remarkable that the specific gravity of the dried sample is quite small, indicating large volume of voids.

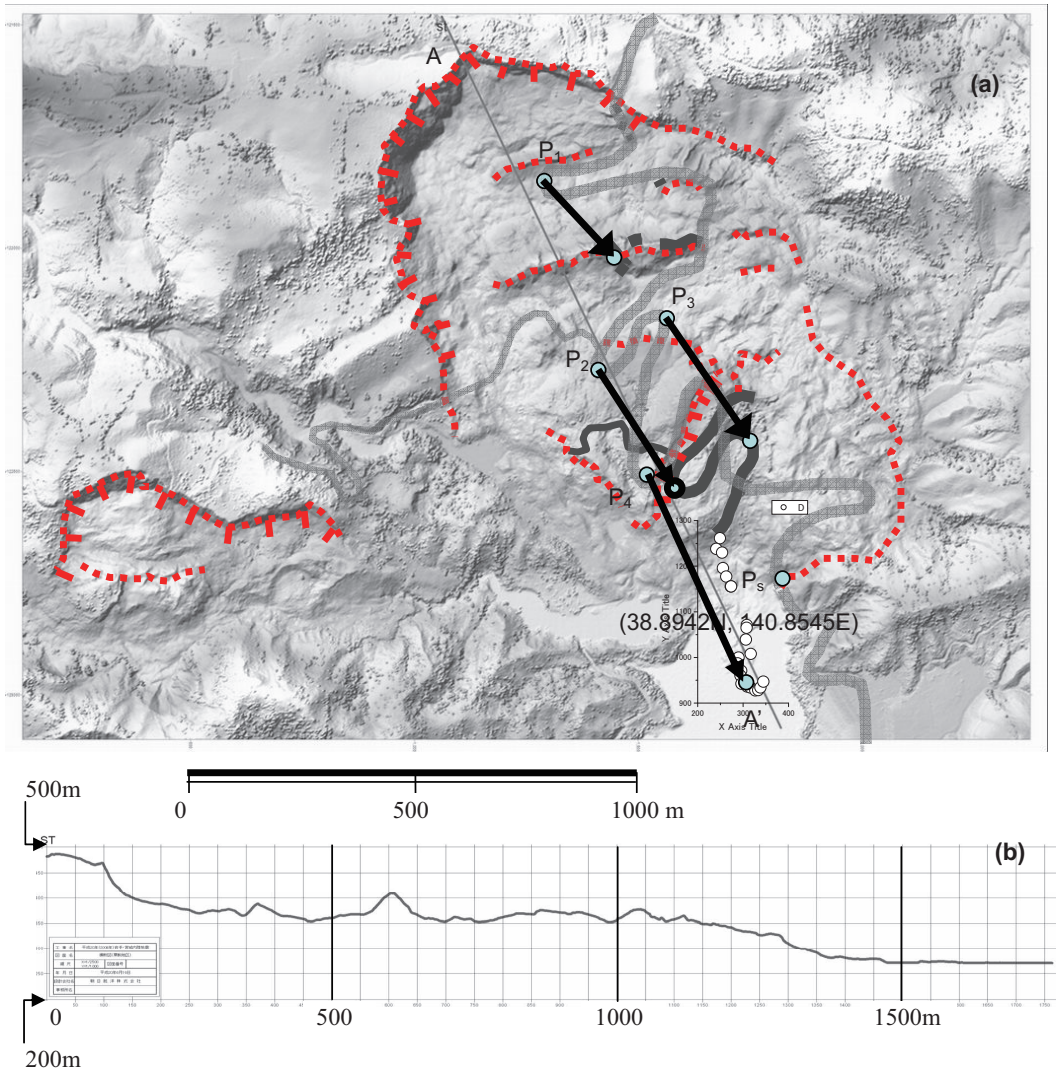
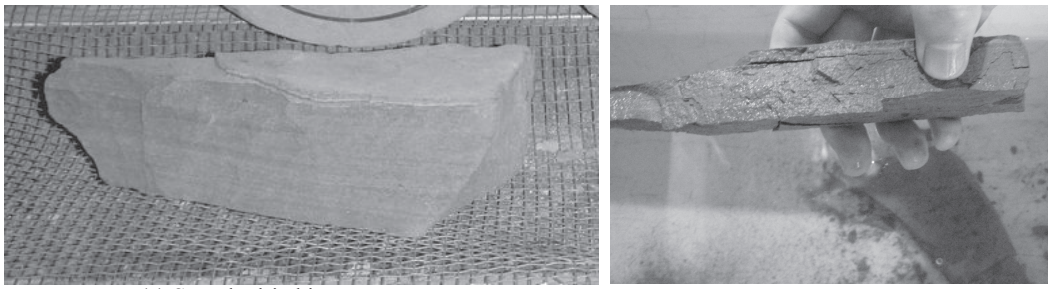


Fig. 2. Landslide behind Aratosawa dam: (Aero Asahi Co. provided the digital elevation model).



(a) Sample dried in oven (b) Sample put again in water

Fig. 3. Rock sample taken for testing specific gravities under different conditions.

Seiche induced in the dam lake

The Aratosawa landslide mass also caused some remarkable seiche in the lake behind the Aratosawa dam. As shown in Table 1, the lake elevation increased from 268.5 m before the earthquake to 270.9 m after the earthquake. This increase in lake elevation is due to the plunge of the landslide mass and possibly also due to some tectonic deformation.

Table 1. Dam Lake elevations measured by Dam Management Office.

Date	Height [m]	Remark
06/14/2008	268.5	Before Earthquake
06/14/2008	270.9	After Earthquake, water level increased due to land-sliding and possibly due to tectonic deformation
07/12/2008	261.4	Reference elevation for measurements on July 12
07/13/2008	261.2	Reference elevation for measurements on July 13 (Lake is being emptied slowly)

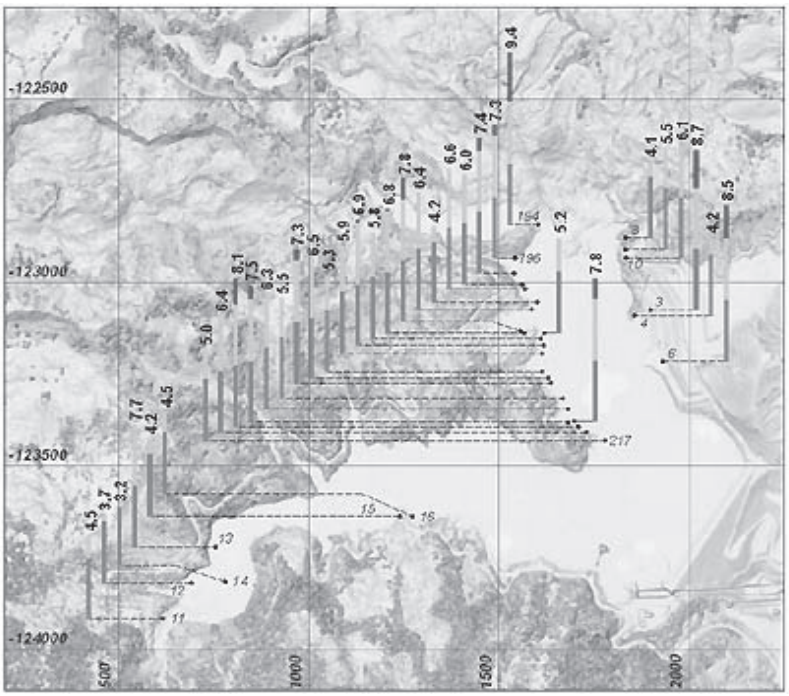


Fig. 4: Seiche hight water marks above the lake elevation of 259.7m on July 12 and 13

DEBRIS FLOWS

Wet debris masses flowed along Dozo and Ura Rivers. A deep scar was created immediately beneath the snow remaining near the eastern peak of Mt. Komagatake (**Photo a**, 38.9584ºN 140.8061ºE). The debris flow from this source swept into Dozo River, and scoured sediment and vegetation from the channel.

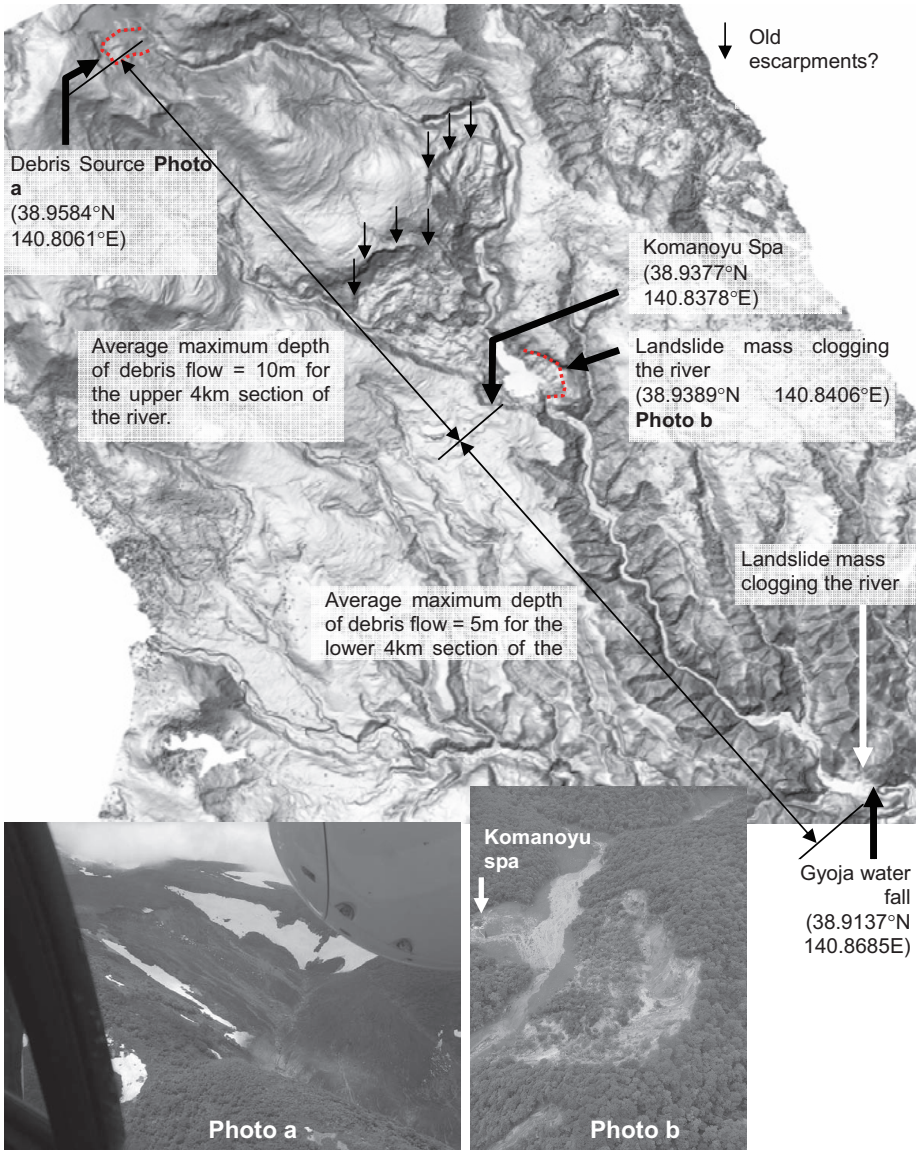


Fig. 5. Debris flow along Dozo and Ura Rivers: (DEM provided by Aero Asahi Co.)

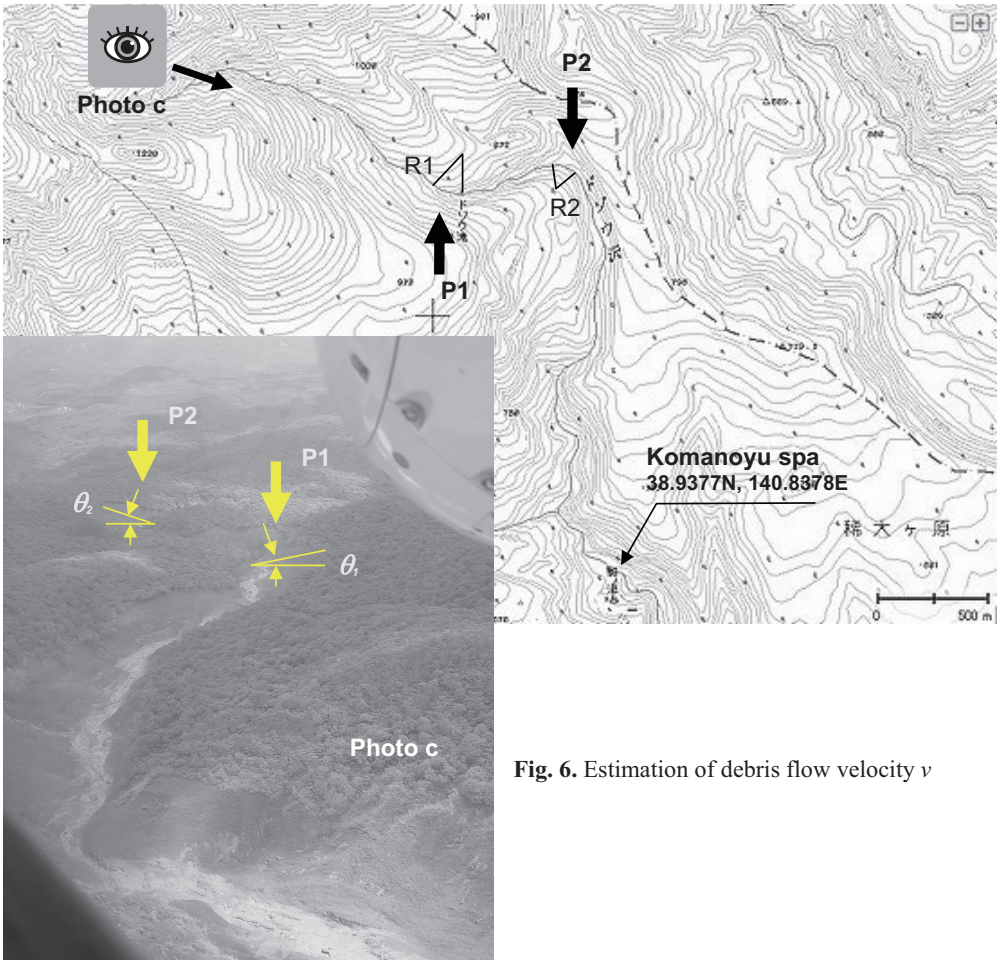


Fig. 6. Estimation of debris flow velocity v

The mud flow, with its channel clogged with another landslide mass (**Photo b**, 38.9389ºN 140.8406ºE, surged up to a hot spa resort "Komano-Yu" (**Photo b**, 38.9377ºN 140.8378ºE), where seven people were trapped in soil and rubble. The average maximum debris flow depth for the 4 km-long upper stream reach of Komanoyu spa was visually estimated to be about 10 m, while it was about half for the lower stream reach probably loosing its momentum. The flow was stopped at Gyoja waterfall (38.9137°N 140.8685°E). (DEM provided by Aero Asahi Co.)

This wet flow along a curved channel had enough momentum to surge up along its outer wall (**Photo c**). Assuming that walls of the channel covered with mud show the inclined mud flow surface, the following equation is obtained.

$$\theta \cong \text{centrifugal force / gravitational force} = \left(\frac{mv^2}{R}\right)/(mg) \tag{1}$$

where, R = curvature radius, and one obtains:

$$v \cong \sqrt{Rg\theta} \tag{2}$$

Necessary parameters for Eq. (2) at Points #1 and #2 are roughly made out from the photo (left) and the topographical map (below) as:

$$\theta_1 \cong 0.12\,, \qquad R_1 \cong 200\,\text{m},$$

$$\theta_2 \cong 0.3\,, \qquad R_2 \cong 120\,\mathrm{m},$$

Substituting these parameters in Eq. (2) yields:

$$v \cong \sqrt{Rg\theta} = 15 \sim 19\mathrm{m/s} \tag{3}$$

This velocity is near to that estimated by Public Works research Institute (PWRI). Sabo Technical Center uses the following equation for estimating debris velocity:

$$v \cong \sqrt{Rg\theta/\alpha} \quad \text{where} \quad \alpha \quad \text{is empirically set at 10} \tag{4}.$$

And the velocity will be:

$$v \cong = 5 \sim 7\mathrm{m/s} \tag{5}$$

CRACKED SHIN-TAMAYAMA TUNNEL

A 36m-long segment at 216m inside the eastern end (38.9006ºN, 140.9230ºE) of the 1220-m-long tunnel was diagonally cracked. Fig. 7 shows projections of the cracked south and north walls on a virtual screen. These cracks were all opened. Black arrows show that the eastern segment moved down with respect to the western segment, while gray ones show the opposite. Numbers in parentheses show these relative displacements in millimeters. If a deep-seated landslide was the cause, long-term monitoring will be a must for rational repairs.

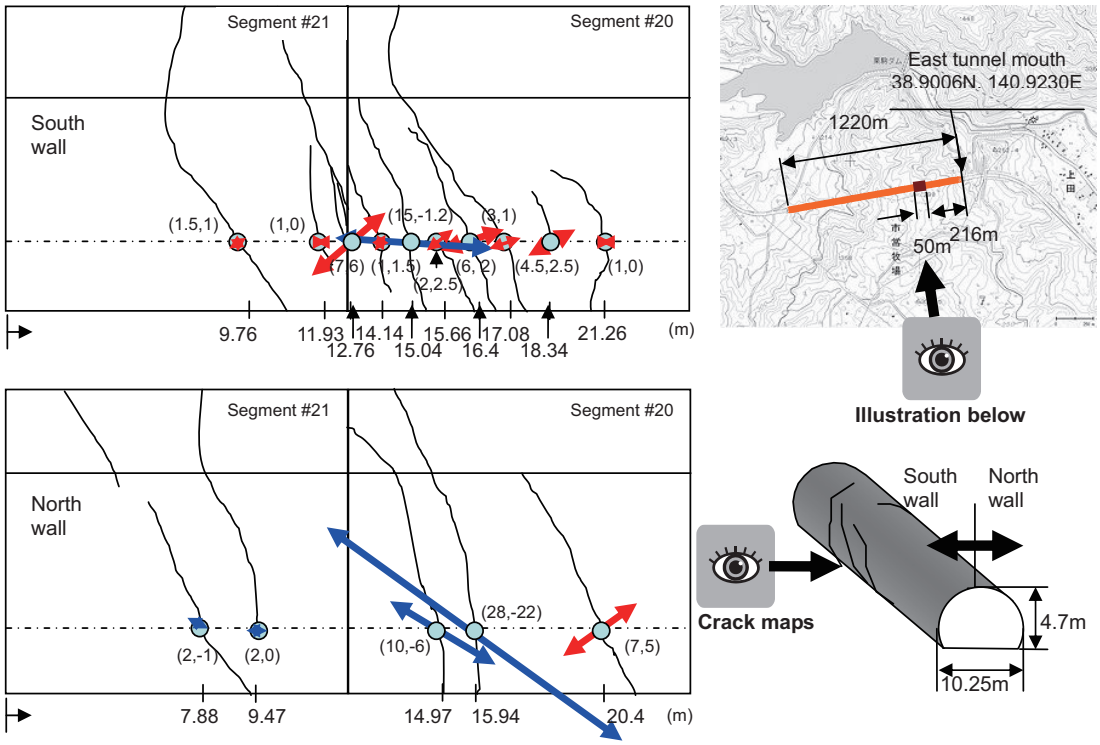


Fig. 7. Cracks in Shin-Tamayama Tunnel:

SUMMARY

This earthquake was remarkable in that a number of debris flows and landslides were triggered, while less serious damages to dwellings were reported. The largest landslide mass at Aratosawa was estimated to be around 50 to 70 million m^3. Although the mass did not cause any loss of human lives luckily, but this volume was certainly extremely large among many recent earthquake-induced landslides. Weakly consolidated rocks of volcanic products were very light, having oven dried specific gravity of 1.18 g/cm^3 indicating large volume of voids. These rocks must have been wet when the earthquake occurred because of the snow melting time, and the increase in excessive pore-water pressure may have accelerated the motion of the huge landslide mass. It is also noted that the landforms around the landslide mass suggest that the landslide may have been reactivated repeatedly.
Among 23 deaths in this earthquake, 5 people were confirmed dead and 2 still missing at a hot spa resort "Komano-Yu". A mud flow along Dozo River from Mt. Komagatake turned around and surged up to the spa because its channel was clogged with another landslide mass just nearby the spa. This wet flow along a curved channel had enough momentum to surge up along its outer walls. The marks that the flow has left on valley walls are to be carefully studied to learn important lessons from this tragedy.

ACKNOWLEDGEMENT

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