Report on Field Survey of Solomon Islands Earthquake Tsunami in April 2007

by

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ABSTRACT
On 2 April 2007 a tsunami following an M8.1 earthquake caused serious disasters in western islands of the Solomon Islands. The tsunami killed more than fifty people and destroyed some coastal villages. To investigate the characteristics of the tsunami striking the islands and the induced damage, we conducted a field survey around Simbo Island, Ghizo Island, Ranongga Islands, Vella Lavella Island and New Georgia Island near the epicenter. A 9.03 m runup height above the sea level at the event was measured on a hill surface of Simbo Island, another 5.63 m runup height was on a hill along a southern coast of Ghizo Island. The northern village of Tapurai in Simbo Island, and Titiana and Malakerava in Ghizo Island suffered serious damage such as almost houses were swept away. According to inhabitants, many people evacuated after they watched the tsunami coming to coasts where they lived. The reason why they were able to evacuate successfully from the tsunami is that hills to escape from the tsunami are located near the affected low-lying areas. Another mitigation of tsunami disaster is traditional houses on stilts. Almost of these house damaged less by the earthquake remained after the tsunami. Some people escape to such houses from the tsunami flooding.

KEYWORDS: Disaster, Field Survey, Inundation, Rununp, Solomon Islands, Trace Height, Tsunami

1. INTRODUCTION

A big undersea earthquake whose magnitude was 8.1 occurred near the Solomon Islands around 7:40 in the morning on 2 April 2007 in local time (20:40 on 1 April in the coordinated universal time). The earthquake created a tsunami causing serious disasters along coasts of the western islands of the Solomon Islands. The Government of Solomon Island reported on 30 April that 52 people had been confirmed dead by the disaster. In order to investigate the characteristics of the tsunami and the feature of the induced damage, the Port and Airport Research Institute dispatched three researchers to the affected areas for nine days from 9 April 2007, which was one week after the disaster occurrence.

The Solomon Islands lie northeast of Australia in the South Pacific Ocean as shown in Fig. 1, and consist of approximately 1,000 mountainous islands and coral atolls, including the six main islands of New Georgia, Choiseul, Santa Isabel, Guadalcanal, Malaita, and San Cristóbal. Their land area is approximately 29,000 km^2, and the population is estimated to be approximately 480,000 people. The capital is Honiara in Guadalcanal Island. In rural islands, people live in some villages, and there are few hundred residents in a big village. The unity of each village is strong, because such a village is the minimum unit of life.

According to USGS[1], the location of epicenter is 8.481°S and 156.978°E, and is 40 km away from Gizo Town, which is the second largest town of the Solomon Islands, 345 km from Honiara. In the islands near the epicenter, for example, Simbo Island, Ghizo Island, Ranongga Islands, Vella Lavella Island and so on, is felt big ground shaking motion.

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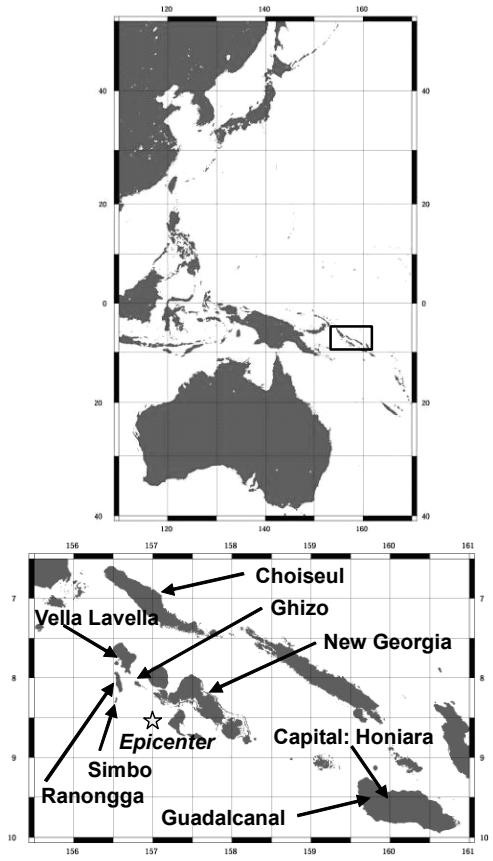


Figure 1: Location of Solomon Islands and epicenter of the earthquake on 2 April 2007.

2. NUMERICAL SIMULATION

Before carried out the field survey on the tsunami, some cases of numerical simulation were conducted to figure out the tsunami in perspective. Figures 2 and 3 show an initial form of the tsunami and a snap shot of the tsunami propagating, respectively. Figure 4 indicates the distribution of the maximum tsunami height. These results are based on the fault data, Version 0.2, by Prof. Yuji Yagi, Tsukuba University [2], which is used to calculate the initial form of tsunami. In his result, earthquake moment M_o is 3.2 x 10**21 Nm, and strike, dip and rake angles are 300^o, 19^o and 72^o, respectively. The location of the epicenter depends on the USGS data in which latitude = -8.481^o, longitude = 156.978^o, and depth = 15 km. Based on other sets of fault model parameters, other numerical simulations of the tsunami are also carried out.

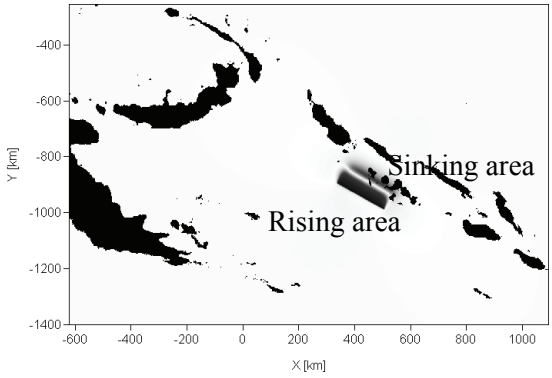


Figure 2: An initial form of the tsunami.

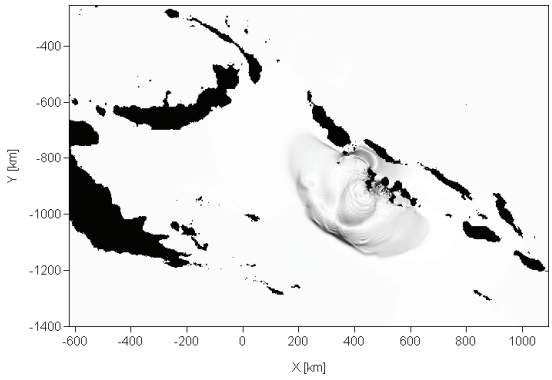


Figure 3: A snap shot of the tsunami propagating 10 minutes after the earthquake occurrence.

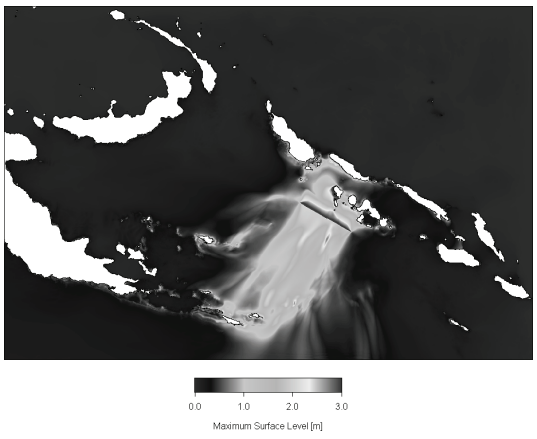


Figure 4: Distribution of the maximum tsunami height.

The numerical simulation of tsunami indicated that a higher tsunami stroke along coasts of the Ghizo, Simbo and Choiseul Islands, since these islands are in a direction perpendicular to the strike of the fault, in which the higher tsunami

energy is radiated. From such simulation results, we estimated that bigger damage was occurred along the coasts of these islands. The simulation result also showed that on the coasts of the islands near the epicenter the tsunami reached within several minutes after the quake occurrence. The other numerical simulations with the different fault parameters also showed similar results.

Actually mass media reported that the Ghizo and Simbo Islands suffered severe damage, and that the Sasamunga Village around the middle of the southern coast of the Choiseul Island was also struck by a destructive tsunami.

3. PROCEDURE OF FIELD SURVEY

Based on the results of numerical simulation and information from media and inhabitants, the locations for the field survey were selected as follows: Gizo, Titiana, New Manra, Marakerava and Sagheraghi in Ghizo Island, Tapurai and Vellaveli in Simbo Islands, Paramata, Reona, Iringgira and Vonunu in Vella Lavella Island, Keara and Pienuna in Ranongga Island, and Munda in New Georgia Island.

In the field survey, tsunami inundation heights as well as runup heights were measured from the sea surface, and then they were converted into the heights above the sea level at the tsunami striking. For the conversion, the astronomical tides at Gizo at the measurements and the event were calculated with harmonic components of tide.

To investigate the feature of the tsunami striking, tsunami arrival time after the quake, the number of tsunami waves, time interval between waves, incident direction of each wave, and tsunami front form were heard from inhabitants.

4. RESULTS OF FIELD SURVEY

4.1 Trace Height

Figure 5 shows the tsunami trace heights measured in the field survey. The trace height is divided into inundation height and runup height. As shown in Figure 6, the inundation height is, for example, the height of the water mark remaining on a wall of house on the ground. The

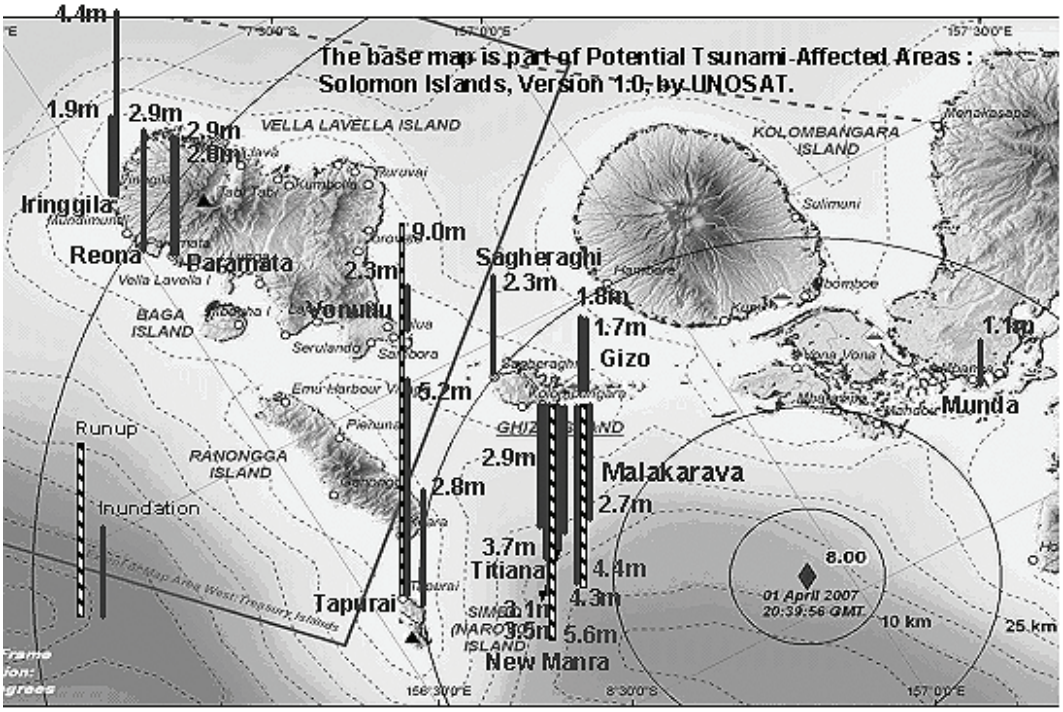


Figure 5: Tsunami trace heights above the sea level at the tsunami striking

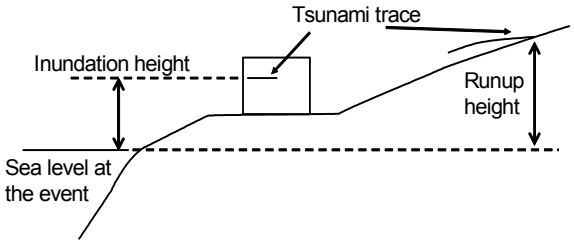


Figure 6: Definitions of inundation height and runup height

runup height is the height of the water mark on a hill.

Form the field survey results, it is confirmed that the higher tsunami struck along coasts of Simbo Island and southern coast of Ghizo Island. The trace heights are more than 5 m locally.

4.2 Tsunami and Damage in Each Island

4.2.1 Ghizo Island

On the southern coasts of Ghizo Island, the tsunami with 4 m approximately struck. At Marakerava on the southern coast, the tsunami climbed up to 5.63 m on a hill surface. According to eyewitness, the first tsunami receded and then the sea water rose in whole, which was not like a water wall. Some inhabitants said that they watched the tsunami coming to the coast and then they evacuated to the hill behind their village. A 14-year-old boy told us that he and his 5-year-old friend were swept by the tsunami in a house, and he helped his friend to escape from a window and then he got out from a breach of a house wall that was made by the tsunami flow. The inundation depth there measured was 1.43 m on the ground. Another person said the first tsunami came a few minutes after the quake and another two tsunamis struck after that. The duration time of three tsunami waves was within 10 minutes. The tsunami destroyed completely houses in the first and second rows from a beach, and the third-row houses remained but suffered severe damage as shown in Picture 1.

In Titiana Village, almost houses were swept by the tsunami higher than 3 m, as shown in Picture 2. However, some houses on stilts remained in the affected area as shown in Picture 3. When we visited there, no persons were in the village because they took refuge on the hill and did not return to the coastal side.

In New Manra, the inundation height of 3.50 m was measured on an inside wall of a house. Beach erosion whose depth was 1 m was found there.

In Sagheraghi Village on the western coast of the Ghizo Island, some houses on stilts were floated away and some main bodies of house sit on the ground and other houses were collapsed.

Picture 1: Swept and remained houses in Marakerava.

Picture 2: Tsunami damage in Titiana.

Picture 3: House on stilts remained after the tsunami in Titiana.

4.2.2 Simbo Island

A runup height of 9.03 m was found on a hill slope as a clear border of dead vegetation by salty water, as shown in Picture 4. In Titiana Village, there were more than 100 houses, and the houses were completely swept by the tsunami as shown in Picture 5, but a house on stilts remained at the innermost part of the village along the hill edge. Since many wrecks of destroyed houses were twined around the stilts of the house, the tsunami inundation depth was lower than the length of the stilts. The inundation height there was 5.20 m. Church on a hill also remained.

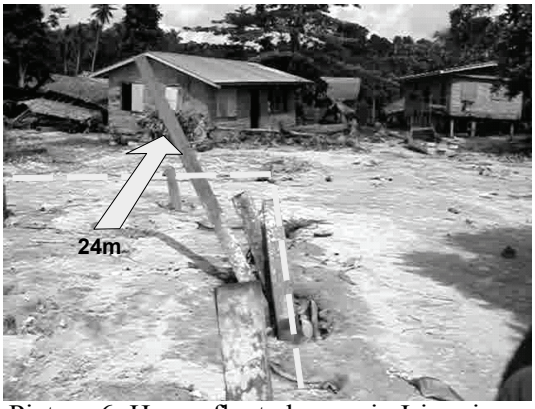
Inhabitants said that the first tsunami came from north and the second tsunami reached from south. They encountered each other in the sea in front of the village and went away from the island. This feature seems the coming of diffracted tsunamis by the island. The diffracted tsunamis by the island encountered each other behind the island resulting in the higher tsunami striking the village.

Picture 4: Tsunami runup in Tapurai.

Picture 5: Tsunami damage in Taprai.

4.2.3 Vella Lavella Island

In Vella Lavella Island, four villages were investigated. Especially in Iringgira on the western coast of the island, higher inundation height of 4.46 m was measured. A local area in the village was struck by the higher tsunami and a lot of houses were swept away, as shown in Picture 6. However, other parts of the village were also inundated by the tsunami but many houses remained. According to eyewitness, firstly the sea in front of a beach of the village was separated into right and left. After that the seawater came reversely from the right and left sides into the area that the seawater retreated and then the tsunami struck the village. Part of the tsunami climbed a river and hit the village from behind. The tsunami striking this village seems to be effected highly by bathymetry, topography and geometry. To understand the tsunami feature there, we should conduct the numerical simulation with detailed bathymetry, topography and geometry data.



Picture 6: House floated away in Iringgira.

4.2.4 Ranongga Island

At locations we visited in Ranongga Island there were less damages by the tsunami. Especially, in Pienuna on the eastern cost of the island, the tsunami did not overflow the land, because the land was raised 2m from the original level by the displacement due to the earthquake. As the result, coral reef appeared above the sea surface as shown in Picture 7.

At other places of the island, landsides were caused by the earthquake motion. An example is shown in Picture 8.

Picture 7: Coral reef appearing above the sea surface in Pienuna.

Picture 8: Landslide in Ranongga Island.

5. DISCUSSIONS

Although the high tsunami whose height was more than 3 m struck coastal low-lying areas in the Solomon Islands, many people could evacuate to save their lives. There are four key points to achieve successful evacuation;

1) The earthquake occurred around 7:40 in the morning. Therefore, many people could recognize the tsunami coming visually.

2) The coming tsunami was not like a wave, and the sea surface was raised like a fast tide. Therefore, the water flow by the tsunami was not as fast as a supercritical flow whose speed is faster than an ordinal tsunami speed of $\sqrt{gh}$. Some people could run in the flow of tsunami

3) There were hills to evacuate from the tsunami near coasts. Therefore, many people could climb the heights to escape from the tsunami as soon as watching the tsunami.

4) A tale in which you should escape to a hill when you see an abnormal low tide helped some people to do quick evacuation. The lessons from the 2004 Indian Ocean Tsunami Disasters was also effective for some persons' evacuation after the earthquake.

Another mitigation of tsunami disaster is traditional houses on stilts. If such a house suffered less damage by the earthquake, almost of them remained. On the other hand, many houses on stilts were broken by the earthquake motion, because such a structure was vulnerable to quake motions. A house on stilts that is strong against quake motion is a good measure against tsunamis as well as earthquakes. Moreover, it is better that such a house is built on a place which is as high as possible.

6. SUMMARY

The field survey on the Solomon Islands Earthquake Tsunami on 2 April 2007 was conducted by PARI. The tsunami trace heights were measured in Ghizo, Simbo, Vella Lavella and New Georgia Islands. The maximum trace height was 9 m on the hill slope of Simbo Island which was the runup height.

Because the hills to escape from the tsunami are near the coasts, many people could climb the hills to save their lives quickly after they watched the tsunami. The traditional houses on stilts are effective for tsunami disaster reduction.

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REFERENCES

1 URL of USGS: http://earthquake.usgs.gov/eqcenter/eqinthenews/2007/us2007aqbk/

2 URL of Prof. Yagi: http://www.geo.tsukuba.ac.jp/press_HP/yagi/EQ/20070401/ (in Japanese).