INTERNATIONAL INSTITUTE OF SEISMOLOGY AND EARTHQUAKE ENGINEERING (IISEE)

REPORT OF STUDY TRIP (TOHOKU)

10-14 JULY 2011

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TSUNAMI DISASTER MITIGATION

INTRODUCTION

The world was shocked by the catastrophic earthquake and tsunamis that hit Japan on March 11, 2011 at 14:46 JST (5:46 GMT). The Mw9.0 magnitude earthquake that sparked the tsunami and resulting destruction of social infrastructure, housing and corporate facilities would cost between 16 and 25 trillion yen (Cabinet Office's estimate) and 23,000 death and missing (F. Imamura, 2011). Tsunami course participants had the opportunity to join this study trip to the Tohoku District from July 10, 2011 until July 14, 2011. The purpose of this study trip is to look more closely at the effects of the tsunami and action taken to reduce the impact of the tsunami. We were escorted by four supervisors and one coordinator.

1st Day, July 11, 2011 (Monday)

On the first day we had a lecture by Prof. Imamura at Disaster Control Research Center (DCRC), Tohoku University. Prof. Imamura is one of the famous tsunami experts in Japan. Buildings here were also affected by the earthquake on March 11, 2011. Since we arrived earlier, we could review the situation around and see the cracks and sediments around the building. Prof. Imamura briefly described about seismic activities (main shock and aftershocks) of the March 2011 Tohoku earthquake. Tsunamis caused by this earthquake happened continuously up to 2 days. Mutsu, Hachinohe, Miyako, Kamaishi, Ofunato, Ayukawa and Soma are areas heavily damaged. Prof. Imamura also explained the tsunami attacks in Sendai area as well as planning, research in the future and the lessons learned from this earthquake and tsunami.

We continued our study trip in the afternoon to several areas around Sendai accompanied by a tsunami deposit expert, Dr. Sugawara. Dr. Sugawara also shared his research on the Jogan earthquake and tsunami. The Jogan earthquake occurred on July 13, 869 at offshore of Northeast Japan produced a large-scale tsunami that the Low-Lying Damaged coastal zones of Northeast Japan (K. Minoura et. al., 2001). With Dr. Sugawara we looked around Arahama village, Arahama beach and the Natorigawa river that were affected by the tsunami. He also took us to the area where he found Jogan tsunami deposits. Figure 1 shows some photos that I captured at Arahama village and Arahama beach.

Figure 1 (Photo taken by Mazni Azis)

Figure 1(a): Mud layer top of sand truly came from tsunami.

Figure 1(b): Sand from tsunamis about 30cm thickness.

Figure 1(c): A small temple survived from the tsunami probably because of the Heliport and trees around the temple.

Figure 1(d): Signage "Tsunami Hazard zone" falls down by tsunami.

Figure 1(e): Breakwater at Arahama beach not damaged by tsunami.

Figure 1(f): Tsunami sirens fall down.

A study of Tsunami deposit is very important in order to evaluate source and history of earthquakes and tsunamis such as recurrence earthquakes, magnitude and inundation area. Mega thrust tsunami has recurrence with interval of 500-1000 years. Figure 2(d) shows the result of field observation that we did with Dr. Sugawara using a hand auger equipment. The Jogan tsunami deposit from the Jogan earthquake occurred more than 1000 years ago. Source Volcanic ash deposit is about 300km from our observation field. For me, research on tsunami deposit is very interesting and I want to know more about this. In Malaysia research about this is very limited.

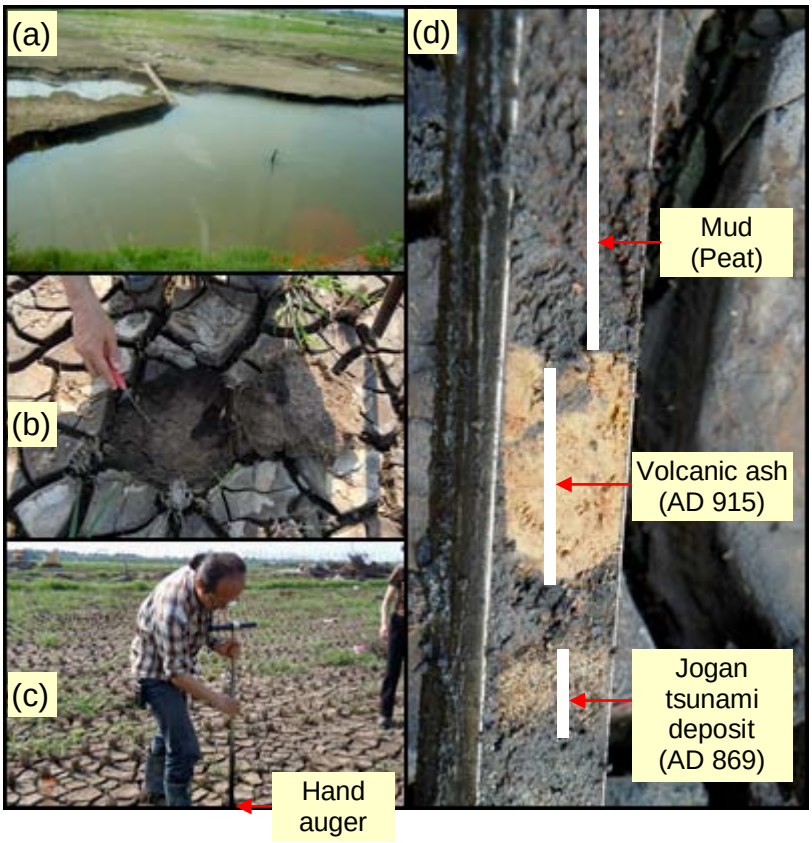

Figure 2(a): The photo shows the effect of combination of liquefaction phenomenon and scouring due to falling flow (hydraulic jump) behind the elevated roadway.

Figure 2(b): Thick mud from tsunami.

Figure 2(c): Dr. Sugawara shows how to observe Jogan Tsunami deposit using a hand auger.

Figure 2(d): The result from the field observation of the Jogan tsunami.

Figure 2 (Photo taken by Mazni Azis)

At the Natorigawa river I asked a question to Dr. Sugawara about the different effect of the tsunami at the left and the right sides of the river, because the right side seemed to be less damaged than the left side. Dr. Sugawara said that it was probably because the river and the dike at the right side of the river is higher compare to the left side (Figure 3 and Figure 4). In addition, he said that the right side was also suffered from the tsunami but it was only the first floor of building.

Figure 3 (Photo taken by Mazni Azis)

Figure 4 (Photo taken by Mazni Azis)

2nd Day, July 12, 2011 (Tuesday)

On the second day, we visited Matsushima and Onagawa. Damages of the two places were very different. Matsushima was not affected so much compared to Onagawa. The tsunami height at Matsushima was about 1-3m and that at Onagawa was about 40m at a maximum and it caused heavy damage. First, we visited Matsushima which has been called one of the most representative places in Japan that can offer the view with many beautiful islands truly brings the splendid and exhilarating time in each season. The small islands help to reduce tsunami height at Matsushima (Figure 5(a)). Although not heavily damaged, this area also experienced inundation and one of the evacuation areas was also inundated.

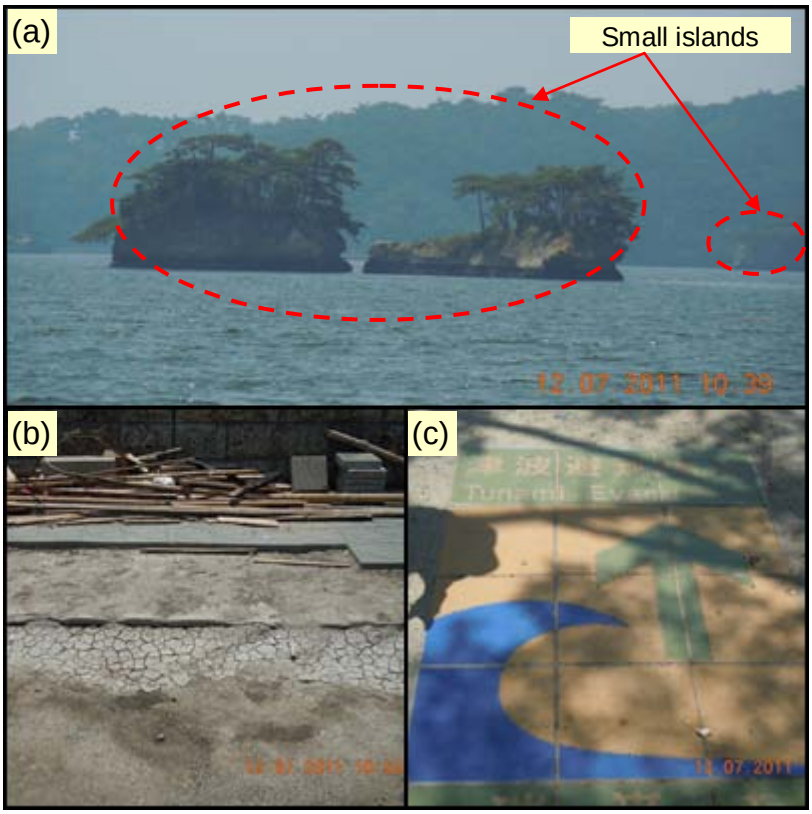

Figure 5(a): Small islands around Matsushima function as natural "break water" which can reduced tsunami wave.

Figure 5(b): Damage by the tsunami at Matsushima.

Figure 5(c): Signage "Tsunami Evacuation" shows 400m to "Zuiganji Temple" which is tsunami evacuation area. Unfortunately this temple was also inundated by tsunami.

Figure 5 (Photo taken by Mazni Azis)

After visiting Matsushima, we moved to Onagawa through Ishinomaki. Ishinomaki is one of the areas that were also badly affected by the Tohoku tsunami 2011. On the left and the right, we saw clearly the buildings collapsed, houses damaged (Figure 6(b)), trees in changed colour to brown leaves as a result of sea water arrived up to there (Figure 6(c)). When we went through the area of the beach connected to the sea, we were able to see the water level very close to the road at the time of high tide (Figure 6(a)). It is because of the subsidence.

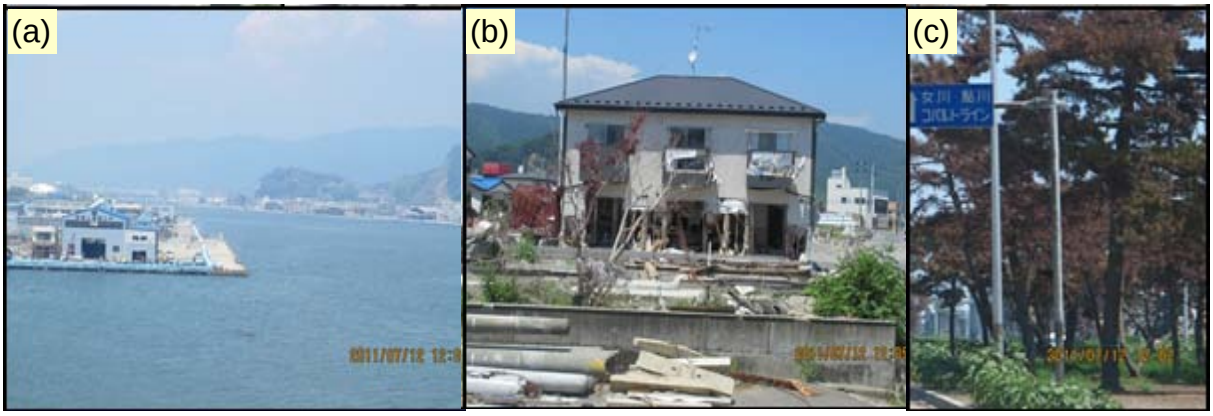

Figure 6 (Photo taken by Fatimah Zaharah Saleh)

Onagawa was heavily damaged and I saw many buildings collapsed and destroyed by the tsunami. According to the witnesses, residing wave was also strong in this area. Many people did not want to live here again because of the trauma of the tsunami. I asked Prof. Okazaki's opinion about the time needed to recover this area. He said it may take 2-3 years to be reinstated as it was very terrible destruction. Onagawa Tsunami Memorial Park and Onagawa Tsunami Memorial Museum will be built to mark the terrible tsunami disaster and to educate people about the impact of the tsunami in this area. Four damaged buildings will remain as the Onagawa Tsunami Memorial Park. Onagawa Tsunami Memorial Museum proposed by Prof. Shuto as a sign of place near to tsunami run-up. For myself, it was very surprising to see the situation in Onagawa in which buildings were destroyed, turned over and some of them moved up to 70m by tsunami wave although they were constructed using the RC structure.

Figure 7: Heavily damaged buildings at Onagawa city (Photo taken by Mazni Azis)

Figure 8: Building moved about 70m (Photo taken by Mazni Azis)

Figure 9: Measurement of tsunami terrace
(Photo taken by Mazni Azis)

Figure 10: Because of subsidence, sea level is only about 35cm from the road.
(Photo taken by Mazni Azis)

3rd Day, July 13, 2011 (Wednesday)

We headed to Rikuzen-Takata, Ofunato and Kamaishi (Iwate Prefecture) accompanied by Mr. Moritsugu KANEKO who explained the effect of the tsunami that occurred in Iwate Prefecture. Along the way in Rikuzen-Takata, the process of cleaning was underway. We stopped at an area to see the destruction there. I found that all debris is collected by type, such as cars, concrete, iron, wood and I asked Mr.Kaneko about the debris management. According to Mr. Kaneko, after the disaster there were some stages in its management. In the first stage, a local government hires a private contractor to clean everything. He added that what we were seeing was the second stage in which collection and transporting of debris underway. Funds for hiring a private contractor are available from the central government. I also asked about the strength of the temporary houses as there was very active seismicity and many aftershocks of magnitude greater than M_w6 occurred. Mr. Kaneko said he did not know much about it, but until now there was no incident of a temporary house collapsed due to the earthquakes. The problem there was a leaking since it was built in a short time.

Figure 11: Damaged flood gate caused by tsunami at Rikuzen-Takata. (Photo taken by Fatimah Zaharah)

Figure 12: All debris is collected by type. (Photo taken by Mazni Azis)

Our next destination was Ofunato city. Ofunato city is a coastal city and suffered from frequent earthquakes of various scales for example the 1896 Meiji-Sanriku earthquake, the 1933 Showa-Sanriku earthquake and the 1960 Chile earthquake. In Ofonato, our arrival was greeted by Mr. Taiji Iwaki. He was a chairman of a nonprofits organization (NPO) called Yume-net Ofunato. He told Ofunato had many tsunami countermeasures such as break waters, siren system, evacuation buildings and a lot of evacuation signage. They also periodically conducted a drill and just did an evacuation drill before the tsunami attack. Tsunamis occurred this time was two times more excruciating than the tsunami that hit the Ofunato city in 1960 (the Chile earthquake).

Railway station was also heavily damaged. Mr. Taiji Iwaki told us that the area might require 10 or more years to completely recover as well as a very high expense. As of July 08, 2011, 325 deaths, 124 people missing, 3,629 houses destroyed or partially destroyed is reported in this area (http://www.city.ofunato.iwate.jp/www/contents/1303015440244/index.html). At Ofunato, I asked the tsunami siren system was working or not during the incident. Mr. Taiji Iwaki told the siren system was working well and tsunami warning was announced less than 0.5m when it was first issued. People did not evacuate immediately and in some cases people went close to the beach to see the

tsunami. When warnings were increased streets were already jammed because the traffic light did not function.

A lesson from this tsunami is to make traffic lights with alternative energy such as solar energy because if the tsunami happens and power supply stops, traffic light cannot function and make a traffic jam. Another lesson is to establish an organization to conduct an emergency shelter community because they did not have an emergency shelter community. In this tsunami, local people conducted the emergency teams after three-day tsunami occurred. Other than that, they want people to evacuate first without thinking about their family because the tsunami comes very fast and some of them do not have ability to move very fast like elderly people.

Figure 12: This pair of before-and-after photos shows the removal of tsunami destruction and debris covering the road in Ofunato city, Iwate prefecture on March 14, 2011, three-days after the tsunami disaster and after the road was cleaned of debris, on April 15, 2011. (Toshifumi Kitamura/AFP/Getty Images) http://www.theatlantic.com/infocus/2011/04/japan-earthquake-the-long-road-to-recovery/100047/#img24

Figure 13: Damaged railway. This is very important transport in Ofunato city.
(Photo taken by Mazni Azis)

We proceeded our journey to Kamaishi port. Kamaishi is a historic city located on the Sanriku coast of Iwate Prefecture, Japan. It is famous in modern times for its steel production and most recently for its promotion of eco-tourism. Fishing and shellfish production are also important economic activities. Kamaishi was heavily damaged by the 2011 Tohoku earthquake and tsunami. Our arrival was greeted by Mr. Nagao and Mr. Yamada at the temporary office because the port office was destroyed by tsunami. Mr. Nagao presented us about a report of the damage at Kamaishi port and damage of Kamaishi break water. Inundation height in and around Kamaishi port was about 8.1m-11.7m inside the bay while 12.5m-18.3m outside the bay. Many wooden houses drifted away with the tsunami while Reinforced Concrete (RC) buildings were damaged but not collapsed. There was much debris swept into the sea where they needed to carry debris to the ground so that the Kamaishi port can be used. Kamaishi port started temporary operations on March 17, 2011 a week after the 2011Tohoku earthquake and tsunami.

We got the opportunity to board a boat to visit Kamaishi break water that was damaged by the tsunami. The Kamaishi break water, 1.950m (6.400ft) long and 63m (207ft) in depth, was completed in March 2009 after construction work started in 1978 with a cost of $1.5 billion. It was once recognized by the Guinness World Records as the world's deepest Breakwater. Http://community.guinnessworldrecords.com/_DeepestBreakwater/BLOG/2699333/7691.html). Mr. Nagao explained how its constructions worked and it was very interesting for me. We were all interested to know about break water's plan in the future. Mr. Nagao told that at the moment they did not plan to build it back but would probably remove it if the fishermen asked them to do so. Although there are many stories about the failure to break water in the tsunami countermeasure, according to the result from the tsunami simulations conducted by Port and Airport Research Institute (PARI), the break water is able to reduce tsunami run-up to two times. In the result from the simulations, tsunami run-up is about 20.2m if there is no break water while in observation tsunami run-up is 10.0m. Sea wall is also found to delay the tsunami waves for six minutes.

Figure 14 (Photo taken by Fatimah Zaharah Saleh)

Figure 14(a): Temporary Kamaishi Port Office.

Figure 14(b): Damaged at Kamaishi Port.

Figure 14(c), Figure 14(d) Figure 14(e): Damaged of some part at Kamaishi break water.

Figure 14(f): Lighthouse at Kamaishi Break water tilt and damaged caused by tsunami.

Figure 15: Tsunami Course Participants with Supervisor, Coordinator and Mr. Nagao and Mr. Yamada (Kamaishi Port staff) at Kamaishi Break Water. (Photo source: Fujii Sensei)

CONCLUSION

Japan is one of the well-prepared countries in the world to deal with a threat of tsunami. They have good tsunami countermeasures such as sea wall, break water, dike, controlling forest, tsunami warning, evacuation building, education and awareness about the past tsunami monument. The tsunami that occurred on March 11, 2011 was already predicted but seismologist and geologist did not expect its magnitude up to Mw9.0. This caused destructions of break waters, sea walls and evacuation buildings. Many people died because evacuations buildings were also destroyed and washed away by the tsunami. In my opinion, when it comes to natural disaster, it is hard to predict and what can be done is to reduce the consequences. Looking at the effects of tsunami impact on the areas that we visit, I am now completely aware of the strong tsunami wave as it can cause damage to a few kilometers from the beach. Awareness of the disaster should also be kept by the community because we quickly forget as human. For me, in preparing tsunami countermeasures, make a wide area of forest is the best solution for reducing the effect of the tsunami and that it is environmentally friendly. I'm very impressed by the Japanese government in disaster management. Most of the affected areas continue to be well maintained and have their own planning. Hopefully, the Japanese continues to prosper and stay strong in the face of this disaster.

REFERENCES

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