INTERNATIONAL INSTITUTE OF SEISMOLOGY AND
EARTHQUAKE ENGINEERING (IISEE)

REPORT OF STUDY TRIP
(Niigata & Miyagi Prefectures)

14 – 17 November 2011

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INTRODUCTION

During this study trip we visited Nagaoka city Hall, Nagaoka Earthquake Disaster Archive center, Ojiya General Hospital, Research Center for Prediction of Earthquakes and Volcanic Eruptions in Tohoku University, Onagawa Town, Tohoku Regional Development Bureau, Senday city Aoba Ward (Ground Failure Area) and Sendai City Wakabayashi Ward (Costal Area). These places are located on Niigata and Tohoku (northeast) Region of Japan.

We had the opportunity to join this study trip to the Tohoku Region between 14 and 17 November in 2011, eight month after the great earthquake and tsunami. The purpose of this study trip was a closer site survey of an effected region caused by huge earthquakes. We were escorted by three supervisors Dr. T. Yokoi, Dr. T. Hara, Dr. Ishihara and one of our coordinators Mr. Ajima.

In this paper, I write about the places and the university we visited during four days in the east part of Japan.

NIIGATA PREFECTURE

On the first day, it was 14th of November, we visited Nagaoka city Hall and Nagaoka Earthquake Disaster Archive Center to observe the damages which was caused by the unpredictable earthquake on October 23, 2004.

The town of Nagaoka and surrounding clan holdings became part of Kashiwazaki Prefecture (now Niigata Prefecture) at the beginning of the Meiji period. The modern municipality of Nagaoka was established on April 1, 1906. Nagaoka city is located in the central part of the Niigata Prefecture, Japan. It is the second largest city in the prefecture, behind the capital city of Niigata and surrounding Chuetsu region.

Japan’s longest river, the Shinano, flows north through the middle of Nagaoka, dividing it into the East Riverside and West Riverside areas. Centering on this river, the city has a vast variation in its climate between the seasons, and is based with beautiful and rich natural surroundings. Nagaoka's summers are hot and humid, while the winters are snowy, influenced by the monsoon.

On October 23, 2004, an earthquake with a magnitude of 6.8 occurred in Niigata Prefecture, which is located about 200 km NNW of Tokyo. According to report issued by the Niigata Prefecture Disaster Prevention Bureau on October 15, 2009, 68 people were killed, 4,795 people

were injured, 3,175 buildings were completely destroyed, approximately 118,000 houses were damaged and at least 1,300 landslides occurred. After the earthquake, Nagaoka City's government built memorial halls and collectively referred to as the Great Chuetsu Earthquake Memorial Corridor.

The Region affected by the earthquake is famous for very heavy snowfall. If the earthquake would have occurred in the middle of winter, the damage could have been much larger due to the potentially high snow loads. The snow in the region is wet and typically accumulates on roofs to more than 2 meters in depth.

At first, Mr. Higuchi, from the Regional Development Strategy Department of Nagoaka City's government officer, gave us a lecture of the 2004 Mid Niigata Prefecture Great Cheutsu Earthquake and Disaster and Recovery. Then he introduced us to reconstruction of Nagaoka City and implementation programs at length. After the lecture, we observed the video and image data of the Great Chuetsu Earthquake Archive Center. In the Hall, the Chuetsu Region's satellite map which almost covered the entire floor attracted our attention. The staff of the center distributed an ipad to each of us. Under their guidance we could identify the specially affected areas on the satellite map through the ipad camera (Fig 1). When we touched and selected some areas on the ipad, we can see some information such as earthquake's information including location, seismic intensity of that area and damage of houses on the display.

Figure1. Getting information of the Chuetsu earthquake disaster area on the detailed the Chuetsu Region's satellite map by using ipad

After leaving the Nagaoka Earthquake Archive Center, we came to the Ojiya General Hospital that is located in Ojiya City, the vicinity of the mainshock, which is one of damaged buildings. Ojiya is small city in the south of Nagaoka City. The Great Chuetsu Earthquake registering an intensity level of upper 6 on the Japanese Seismic scale was recorded in Ojiya City.

Strong ground motion records were observed from the mainshock and its aftershock at the neighboring base-isolation building, Suisen-no-ie (Welfare Nursing Care Center) (Fig 2(a)). Suisen-no-ie, however, is located at the foot of a hill, while the Ojiya General Hospital is located at the edge of a hilltop. It is likely that input ground motions were different between two buildings. Structural engineer Mr. Y. Shinozaki introduced information about the base-isolation system of the building (Fig 2(b)). I understood that it can be against earthquake forces, I mean this base isolation is most powerful tool of earthquake engineering pertaining to the passive structural vibration control technologies.

(a) (b)

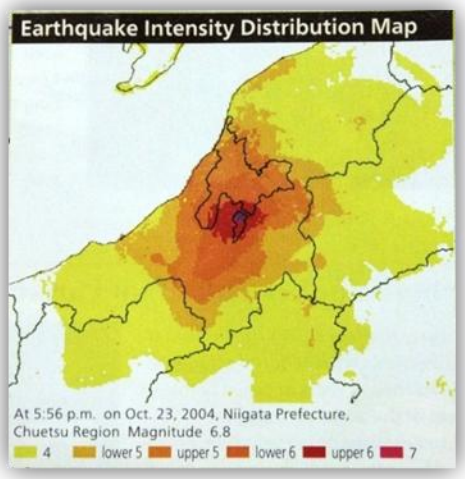
Figure2. (a) Overview of the Welfare Nursing Care Center (Suisen-no-ie) of the Ojiya General Hospital, (b) Base isolation system of Suisen-no-ie

YAMAKOSHI VILLAGE

On the second day, it was 15th of November, we visited Yamakoshi village in Niigata Prefecture to observe the damages which were caused by the earthquake centered in the Chuetsu area of Niigata Prefecture that occurred at 03:59 a.m. on March 12th 2011. Also we observed how the Yamakoshi Village survived and recovered from this earthquake.

First, we visited the Yamakaoshi Branch Office and they introduced the situation of the disaster and recovery work of Yamakoshi village.

Japan is a land where earthquakes happen frequently. A powerful earthquake with a magnitude of 6.8 occurred 13 km beneath the Chuetsu Region Niigata Prefecture at 5:56 p.m. on Saturday, October 23, 2004. The unprecedented earthquake registering an intensity level of 7 on the Japanese Seismic scale was recorded in Kawaguchi Town and intensity level of upper 6 was recorded in Ojiya City, Yamakoshi Village, and Oguni Town. An intensity level of lower 6 was also recorded in Nagaoka City, Tokamachi City, and Tochio City. Strong aftershock measuring a magnitude 6.0 at 6:11 p.m. and 6.5 at 6:34 p.m. occurred on the same day. A maximum level of upper 6 on the Japanese Seismic Scale was recorded during both aftershocks.



The region is geologically folded and consists of thrust faults, which have been formed by compressive stress from the west-northwest and east-southeast.

Figure 3. Intensity map of the Chuetsu Region
(The image is a photo taken at the Yamakoshi Village office.)

The Mid Niigata Prefecture earthquake caused many landslides and slope failures that accumulated in the Chuetsu region of Niigata prefecture, particularly in the Imo River basin. This area is known to be a zone of frequent landslides (Fig 4). Consequently, heavy damage was caused in the entire basin including disruption of roads and inundation of residential areas near rivers (Nakaide*et al.*2004). There were reports of damage to the forest on the mountain ridges, because of the Mid-Niigata Prefecture earthquake which occurred in that mountainous area (Sekiguci, 2006).

Figure 4. Landslide caused by the Chuetsu earthquake in Yamakoshi Village.

In addition to earthquakes, other disasters include floods and snow damage. During heavy rain falls, it is advisable to stay away from rivers. Snow damage is caused by heavy snowfalls. Some people have lost their lives due to avalanches or during snow removal operations. Then we visited the remains of barrier lakes and landslides, the residential houses built by Government and some of history and very unique culture in this area.

MIYAGI PREFECTURE

On the third day, it was 16th of November, we visited Sendai 3rd joint government building, Tohoku University including Research Center for Prediction of Earthquakes and Volcanic Eruptions and Onagawa Town.

Sendai is the capital of Miyagi Prefecture, and is the political and economic center of Tohoku (northeast) Region. Although Sendai is a large city, it is known throughout Japan as a modern city which is in harmony with nature. Sendai is located approximately 300 km-s north of Tokyo on the Pacific coast of Honshu (the largest of Japan's four major islands). Sendai City and the coast of Miyagi are the hardest hit areas of the 2011 off the Pacific coast of Tohoku Earthquake and tsunami. The serious damage in this disaster is the theme of our study trip here.

This morning, we visited Sendai 3rd joint governmental building. This building constructed in 1978 and used as the Tohoku meteorological observatory and the Tohoku defense bureau are important facilities that communicate information after disaster such as large earthquakes. These include Tsunami warnings and the aftershock information.

In 2008, the building was retrofitted and the base isolator system was installed to enhance its seismic resistant (Fig 6). In the basement floor, Mr. Kagaya introduced to the displacement monitoring plate that was installed to record the trace of building movement anytime when an earthquake struck.

Figure 6. Overview of Sendai 3rd joint Governmental building.

The instrument consists of the needle and the plate. He explained that on March 11, 2011 the plate recorded the building movement due to the mainshock of the off Pacific coast of Tohoku Earthquake 2011 with maximum displacement 18 cm from the center point, some needles on the other places were broken during the shaking caused by the power of the shock or the high acceleration of the vertical motion.

(a) (b) (c)

Figure 7. The plastic plate (a), Needle (b), and the trace records of the Tohoku earthquake March 11, 2011

Then we visited Tohoku University and we were separated into 2 groups that Seismology and Earthquake Engineering groups. Our Seismology group went to the Research Center for Prediction of Earthquake and Volcanic Eruption in Tohoku University and the other group went to Motosaka Laboratory and Damaged Building. Prof. N. Umino received our group and he introduced for us about brief history of the Research Center for Prediction of Earthquake and Volcanic Eruption. He gave us some results about the Tsunami disaster and impact due to the 2011 Tohoku earthquake and the tsunami behavior that occurred at affected areas. Then we visited several places in this center. This center has a long history, one that stretches back to 1912, when it was established for monitoring earthquakes. There were many old types of seismometer, such as the one named the Wiechert Seismometer. Then we visited in the tunnel under the center at depth of 45m by using elevator and there were so many kinds of seismometers. For example, water tube tiltmeter, quartz tube strainmeter, quartz pendulum tiltmeter and so on. Prof. Umino explained the principle of these observations.

Onagawa town

Onagawa is a town located in Oshika Dsitrict, Miyagi. Onagawa town is situated in an area where it is most vulnerable to tsunami because of its geographical location. The Onagawa bay and its shallow bathymetry characteristics was a big factor that made the towering height of the tsunami as high as 15 meters. The inundation was as far as 3 km away from the town. The town

had a flat surface with no sufficient embankments. Most residential areas were located few meters away from the shoreline. For these reasons, the town was swept away by the tremendous energy of the tsunami.

There were at least four pile-supported buildings toppled and /or carried over some distances in Onagawa. Buildings were uprooted, floated several meters away from their original positions. A three storey-hotel fronting the pacific was totally inundated. Cars were like papers crumpled and thrown into small pieces with the strong impact of the tsunami. Roads were subsided as well as the port facilities. Besides the massive destruction it brought to the town, 900 people were killed or missing in Onagawa Town. As shown in Figure 8, the hospital was located approximately 14 meters high from the sea level. Based on our observation, the trees were dried up which reveals that the tsunami reached and inundated the hospital 3 which surpassed the height of the wall surrounding the area of the infrastructure.

Most of the buildings located near the seashore were completely destroyed and drifted by the strong tsunami waves. Figure 6 shows one of the examples of building which was drifted by the tsunami about 70 meters. Most of the roads in Onagawa town especially those near the seashore were no longer visible. The roads were subsided by approximately 80 cm as shown which can no longer be used for transportation. Some of the roads were still covered with tsunami debris and covered with sea water. However, many roads were already built by the government to pave for continuous repair and reconstruction of the devastated town. Display of column steel bars was overturned by the backflow of the tsunami wave.

Figure 8. Heavily damaged buildings at Onagawa city

On last day, it was 17 of November, we visited Tohoku Regional Development Bureau, Sendai City Aoba Ward (Ground Failure Area), Wakabayashi Ward (Costal Area) and Tsunami Disaster. We visited some coastal areas in Tohoku region, where tsunamis generated from the 2011 off the

coast of Pacific earthquake (M9.0) caused serious damages. In the devastated area by the tsunami, cleanup work of debris was still undertaken even after 8 months from the disaster.

On the morning, we visited Tohoku Regional Development Bureau in Sendai city and Mr. Kawashima gave us information of the 2011 Tohoku Earthquake and Tsunami as well as Disaster and Recovery.

Then we went to Aoba Ward (Ground Failure Area) and Wakabayashi Ward (Coastal Area). A Ward is a subdivision of one of the cities of Japan that is large enough to have been designated by government ordinance.

Aoba Ward is one of five wards of Sendai, the largest city in the Tohoku Region of Japan. In these areas, also the damage of houses was caused by ground transformation. There were some roads having split and deformed and some walls tilted and collapsed.

Figure 9. Damage of Retaining Wall, House Movement and Tilting by Sliding and Ground Transformation

Wakabayshi Ward was the last destination of our study trip. This ward is located in Sendai in Miyagi, Japan. The total area is 50 km2. In the aftermath of 2011 Tohoku Earthquake and Tsunami, the area was severely damaged, where almost all 2,700 houses were destroyed and swept away by tsunamis. The earthquake and Tsunami caused extensive and severe structural damage in Japan, including heavy damage to roads and railways as well as fires in many areas, and a dam collapse.

CONCLUSION

The power of nature that cannot be underestimated and we cannot easily take it for granted. There is always a high potential of a risk in facing the natural disaster. Thus, preparations on countermeasures of earthquake and tsunami mitigation are important and needed to be taken into account.

During this study trip, I really witnessed the destructive damages caused by this Great Tohoku earthquake. The buildings close to the coastline were seriously damaged by tsunami. However, in this case of Japan, many people live nearby the coastline. So, how to protect their lives and asset safety is a very important and urgent topic. Although great progress has made in technology, we still have great difficulties in disaster mitigation and prevention.

When making disaster mitigation design and decision, we should depend not only on theory which we have learned, but also on their real experiences.

Japan is one of the well prepared countries in the world to deal with a threat of tsunami. They have good tsunami countermeasures. I am very impressed by the Japanese government and disaster mitigation. 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.

In case of our country, the territory of Mongolia lies in the seismic active zone of Central Asia. About 75 percent of urban areas are located in the region which might be hit by earthquakes of intensity VII and more by MSK scale. The 12 settlements are located in the high seismic active zones with the intensity 9 and more. Therefore, the 80 percent of our population live in the seismic active region with the intensity 7 and more. In the last decade, according to the rapid urbanization and development of Ulaanbaatar, the capital of Mongolia, the number of residents of urban areas increased and reached the 60 percent of total number of population. It increases an earthquake risk level in Mongolia. So, we have to learn more and more about disaster mitigation policy from Japanese.

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