10. Concluding Remarks

Although more than five months have passed after the earthquake occurred, approximately 90,000 evacuees still live in difficulties and whole damage of the disaster cannot be captured. These facts make us realize that the disaster was unprecedented huge one. It was also the first experience for us that the investigation areas needed to be limited considering the influence of the accident in the Fukushima-dai-ichi nuclear power plant and that we had to be concerned with the safety of staff members against frequent aftershocks including large ones.

This report summarized the survey results described in our quick report already published in Japanese with some additional survey results on the seismically isolated buildings. The outline of each chapter is as follows;

The first chapter forms “Introduction” to briefly figure how NILIM and BRI cooperated to prepare the system (The Joint Survey Team on building damage) in order to respond to the support requests of affected areas and how the team conducted various surveys and researches after occurrence of the earthquake.

The second chapter titled "Outline of Research and Field Survey" describes the outline of the researches and field surveys and the names of the staff members who were in charge of the works.

The third chapter titled as “Overview of Damage” reviews outline of the 2011 Tohoku earthquake, applied situation of enforcement of the laws related to disaster management, data on human and physical damage and situation of provision of temporary houses etc. mainly based on the officially announced data as of April 20 when this report was summarized (if new data becomes available, this report uses updated data indicating new date).

The fourth chapter, “Outline of Earthquake and Tsunami”, provides research results on earthquake source, models of tsunami source and maximum height of tsunami and so on.

The fifth chapter describes “Earthquake Motion Observation and Results” that includes characteristics of earthquake records from BRI strong motion observation network etc. It is noteworthy that the data of above-mentioned BRI earthquake data was referred globally as the first seismic data of the earthquake, since the data network system of the National Research Institute for Earth Science and Disaster Prevention (NIED) that was usually one of the first data resource from earthquake did not work well because damage to network facilities had occurred immediately after the earthquake.

The sixth chapter titled “Damage to Buildings by Earthquake Motions” summarizes the policy of the investigation and the results of damage surveys on wood, steel frame, and reinforced concrete structures, residential land, foundation and non-structural elements. The results are summarized as follows.

1) Wood houses: The damage of upper structure was observed in several areas however the damage to wood houses seemed not so heavy as an impression in Kurihara city where seismic intensity 7 was recorded. Many damage of structure were observed due to deformation of developed residential land in Sendai city, Miyagi prefecture and Yaita city, Tochigi prefecture. The damage to roof tiles could be more observed in both Fukushima and Ibaraki prefectures than in Miyagi prefecture where major earthquakes frequently occurred since the 1978 Miyagi-ken-oki Earthquake. The damage types are similar to those of the past earthquakes.

2) Steel frame structures: There was almost no damage to main steel structure members such as columns and beams. Damage of vertical braces’ rupture etc. was observed in the school gymnasium that was constructed in the years of old seismic code (before 1981) however the damage ratio was smaller than the case of the 2004 Niigata-ken Chuetsu Earthquake. On the other hand, damage to non-structural elements including falling of ceilings was observed comparatively more than the past cases.

3) Reinforced concrete structures: Most of structural damage to reinforced concrete structure was observed in the buildings designed with the previous seismic code. The number of damaged reinforced concrete buildings was not so large as considered with the seismic intensity observed nearby. The damage types were mostly similar to the past seismic damages that included severe damage such as loss of axial force bearing capacity due to shear failure of columns.

4) Residential land, Foundation: Liquefaction occurred in so wide areas that could not be seen during the past earthquakes in Japan. Research on the mechanism and considerations of counter-measures will be necessary not only for individual buildings but also for infrastructure like roadway structures, water supply and sewage systems. In some residential lands, heavy damage such as ground failure was observed similar to the damaging earthquakes in the past.

5) Damage to non-structural elements of buildings of comparatively old construction types was confirmed in many cases. In addition, break and falling of non-structural elements at rather higher parts were also confirmed.

The seventh chapter describes “Damage to Buildings in Inundation Areas Induced by Tsunami” that includes research on the existing guidelines regarding the building design methodologies against tsunami. This chapter introduces conducted surveys on remaining, collapsed or washed away buildings in the major tsunami affected areas from the north in Yamada town, Iwate prefecture to the south in Yamamoto town, Miyagi prefecture. The surveys included measuring damage of buildings, depth of

tsunami and structural element data for calculating horizontal load bearing capacity and other values. After verification of existing guidelines, a proposal was prepared in order to make the guidelines more rationalized ones.

The eighth chapter on “Damage of Buildings, etc. due to Fire” summarizes results of field surveys on fires in tsunami affected areas and shake-induced fires in other areas and clarifies the features of damage. The result shows that many usual type of fires due to earthquake happened even though fires in tsunami affected areas were noticed and reported more.

The ninth chapter summarizes “Response of Seismically Isolated Building” including outline of surveyed buildings and the behavior of seismically isolated buildings.

The damage surveys in this report were conducted as carefully as possible, using around 200 person-days (130 persons). However, whole damage of the earthquake may not be covered, considering the damage of wide areas. Further surveys will be continuously carried out.

Recovery and rehabilitation of the affected areas have advanced slowly but steadily, while the introduction (Section 1) of this report says that whole damage cannot be grasped yet. The government set up the Reconstruction Design Council on April 11, which submitted its report of recommendation in June, 2011. The MLIT also established various working committees. In the field of buildings, the Building Structural Code Committee (chaired by Prof. Tetsuo Kubo, the University of Tokyo) that aims to review draft structural code of buildings in the NILIM, is analyzing the damages and promote related technical reviews and so on in cooperation with BRI in order to secure the safety of buildings based on damages caused by the 2011 Tohoku earthquake.

NILIM and BRI would like to contribute to the society through this report and the advanced technical knowledge. It will be very much appreciated if related organizations and individuals will cooperate with us continuously in the future.

Lastly, NILIM and BRI would express deepest condolence to the victims of the tsunami and earthquake and their family members as well as sufferers affected from the disaster. In addition, we would like to express our heartfelt appreciation to people from around the world for their warm support and cordial friendship.

Note 1: A comment via e-mail sent from U.S.A. dated on March 17,
“I learned that the NIED servers were out, so the shaking must have been pretty bad. I was able to see the BRI ground motions and some reports on buildings. Very good and quick work”

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