Analysis of the Building Damage Evaluation for the 2011 Great East Japan Earthquake

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SUMMARY:
This paper presents an analysis of the building damage evaluation for the 2011 Great East Japan earthquake and the development of the damage evaluation training system for the post-earthquake management. The building damage evaluations were carried out by many organizations. Among them, the damage evaluation conducted by the local governments is recognized as the only damage inspection that covers whole disaster area. The uniform inspection guideline was developed by the cabinet office of Japan, however, many local governments modified it by themselves. As the result, the damage evaluation criterion of a local government does not correspond to others. This paper presents an analysis of such inspection results for many impacted local governments and the development of a training system for the building damage inspection.

Keywords: 2011 Great East Japan Earthquake, Building Damage Evaluation, Inspection Training System

1. INTRODUCTION

The 2011 Great East Japan earthquake occurred at March 11, 2011 had severe impacts on eastern part of Japan. More than 1 million buildings were damaged by tsunami, earthquake ground motion, liquefaction, and landslide. The building damage inspection is one of the important issues for estimating the size of damage by the disaster. Several damage inspections were carried out, such as for safety, insurance reimbursement, loss evaluation, etc. Among them, the loss evaluation is one of the most important inspections in Japan, since most of the victim support programs, which include the apportionment of monetary donations, allotment of temporary housings, and other recovery-related benefits, are based on the inspection result of the loss evaluation. For this reason, it is carried out at every local government in the disaster area, so that it is recognized as the only damage inspection that covers whole disaster area. From the post-disaster management viewpoint, this result is also useful as a damage index to overview the damage situation.

The inspection guideline and procedure are developed by the Japanese government cabinet office for conducting post-earthquake, post-floods, and post-windstorm building loss evaluation. According to the manual, the guideline for floods is applied to the tsunami disaster. The floods inspection procedure required to evaluate both external and internal damages of a building, which usually takes at least 30-60 minutes per building. Since the tsunamis and earthquake ground motions generated a huge number of damaged buildings and those buildings were widely distributed, significant delays of the inspection were expected. Assuming such situation, the authors developed a simplified guideline to prompt the inspection of the tsunami damaged buildings, and proposed it to the cabinet office. Finally, with some revision by the cabinet office, it was adopted to the cabinet office guideline. In this paper, this new guideline is described in Chapter 2.

The inspections were conducted by the local governments in the disaster area. Basically, all local governments had been assumed to comply with the cabinet guideline. However, many local governments modified it by themselves for reflecting their victim support policies and damage

situations. As the result, the damage evaluation criterion of a local government does not correspond to others. In this study, the interview surveys were carried out to the key persons of the each local government to identify the difference of the damage evaluation criteria. The inspection processes are discussed in Chapter 3.

Finally, to improve the inspection activity, a new damage inspection training system is proposed in this paper. Utilizing iPad, inspectors could easily understand the whole picture of the damage inspection without field experiences.

2. BUILDING DAMAGE INSPECTION GUIDELINE

The inspection guideline and procedure are developed by the Japanese government cabinet office for conducting post-earthquake, post-floods, and post-windstorm building loss evaluation (cabinet guidelines). The inspection is a visual inspection that estimates damage visually observable, but not for structural damage which is not visually observable. The cabinet guidelines establish the damage estimation procedure which set building component ratio (Table 1) to find damage rates for each component by multiplying the damaged component ratio by the damage level.

Table 2.1. Component Ratio of Each Building Element

	Roof	Exterior Wall	Foundation	Column	Interior Wall	Floor	Ceiling	Fittings	Equipments
Component Ratio	10	10	10	20	15	10	5	10	10

The overall building damage ratio (%) is found by summing up the damage rates. The inspection by local government normally uses a point system rather than a percentage system (100 points correspond to 100%) for representing damage. The damage categories are based on the following standards: 50+: major damage, 40-49: major-moderate damage, 20-39: minor-moderate damage, 1-19: minor damage. The concept is similar to that for fixed asset taxation, in that it estimates economic loss rather than building safety or repairability.

The post-floods damage inspection procedure, which is applied to the tsunami damage inspection, requires the inspection for all the components. The inspector needs to enter the building and takes about at least 30-60 minutes per building. However, a huge number of damaged buildings were widely distributed in the disaster area, so that significant delays of the inspection were expected.

To prompt the inspection, the authors developed a new guideline. The preliminary reconnaissance survey was carried out to identify the building damage types, and the damage point of each damage type was calculated as follows:
If the flood water is below the floor level, the damage point is below 20, which is classified as minor damage. Even though there are some damages to the foundation, it is not a serious impact to the building functions.
If the water level reached above the floor level, there are some damage to the interior, floor, and foundation. The lower half of the drywall and insulation required replacement. The calculated damage point is 28, which is classified as moderate-minor damage.
In buildings where the water level had reached about 1m or over above the floor level, the drywalls, insulations, floors have to be completely replaced. In addition, the tsunami water flow carried debris into a building, and it can cause extensive building damage, such as penetrating the external wall, or breaking columns. Assuming such damages of a house, the damage point is 42, which is classified as moderate-major damage.
If the water level reached the ceiling of the first floor, the building is assumed to be severely damaged, which damage is not only to the exterior and interior, but also to the structural components. This type of damage is classified as major damage. And if the buildings were swept off the foundation, it is also classified as major damage.

Based on the discussion above, the authors proposed a new guideline and evaluation sheet to the cabinet office. After the minor revision, the new inspection guideline and evaluation sheet were announced on March 31, 2011 as the cabinet office guideline (Fig. 2.1).

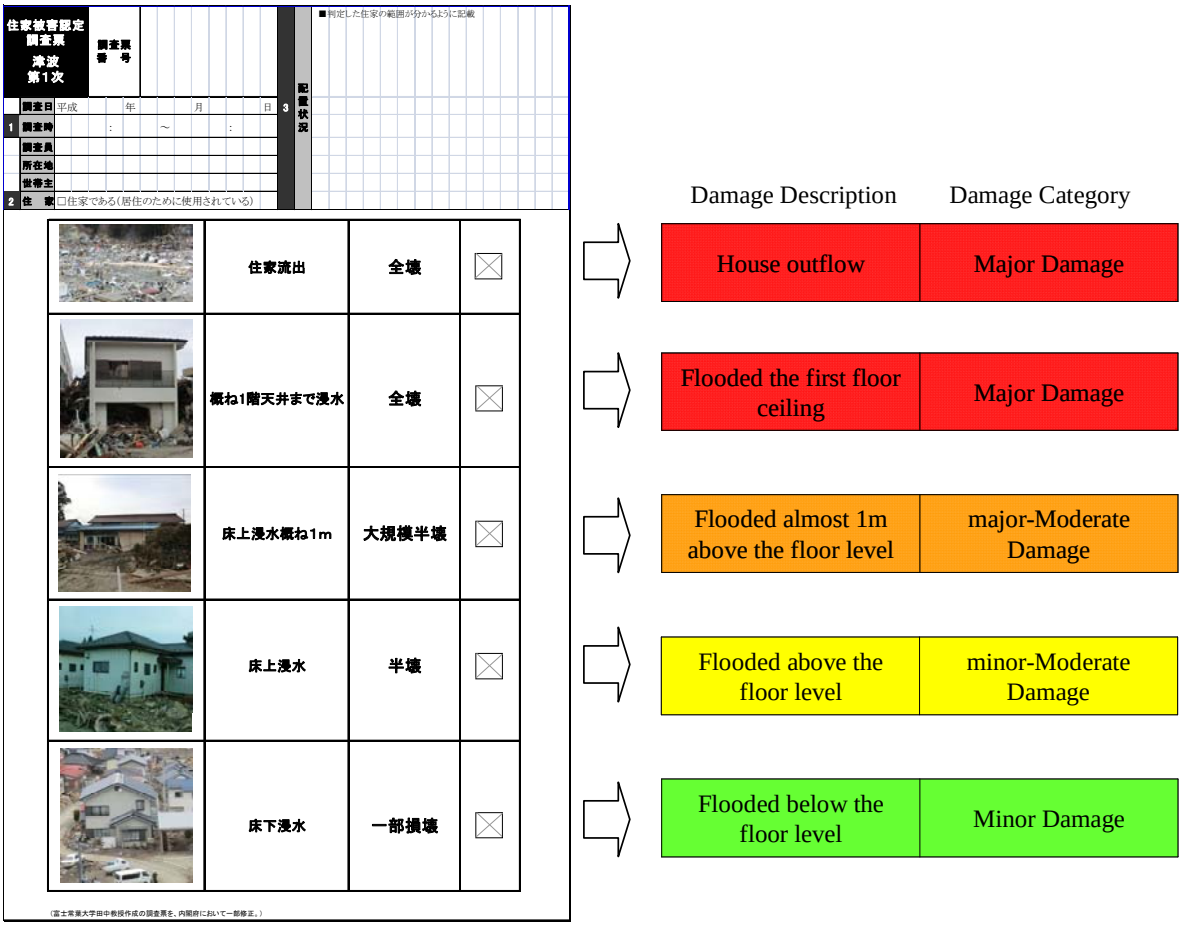


Figure 2.1. Tsunami Damage Evaluation Sheet

3. LOCAL GOVERNMENT BUILDING DAMAGE INSPECTION

The inspections were carried out by the local governments based on the cabinet guideline shown in Fig. 2.1. However, as the damage situation is different in each jurisdiction significantly, some local governments revised the guideline by themselves according to their victim support policies. Some of them made documentations about it, but some of them were not. In this study, the authors selected 11 cities in the damage area and conducted the interview surveys to the key persons who are in charge of the inspection in each local government to obtain the detailed information on the inspection policies and processes. In this paper, 4 typical cities are picked up and described their policies.

3.1. Tagajo City

Tagajo city is located northern part of Sendai city in Miyagi prefecture. As of Feb. 11, 2012, number of deaths rises to 188, and 11,382 buildings were damaged (Fire and Disaster Management Agency). The Tagajo city government revised the inspection guideline and explained it to the citizen by their homepage. They started the inspection activity from March 17. Based on 2 days preliminary reconnaissance survey, they established their inspection policy. Comparing with the cabinet office guideline, their policy is more focusing on the degradation of the wall function by the inundation. As a

result, it is identified that the evaluation criterion of the major-moderate damage is different from the cabinet guideline.

3.2. Ishinomaki City

Ishinomaki city is the one of the most devastative damaged city by this disaster. As of Feb. 11, 2012, number of deaths rises to 3,182, and 53,742 buildings were damaged (Fire and Disaster Management Agency). Ishinomaki city government also revised the inspection guideline and explained it in the damage certificate application form. They started the preliminary damage survey about one week later to identify the major damaged area. In their policy, inundation above floor level is evaluated as major-moderate damage. In addition, it is focusing on the debris which flowed into a house. If the debris flowed into a house by tsunami, the house is evaluated as major damage. As a result, it is identified that the evaluation criterion of both major and major-moderate damage are different from the cabinet guideline.

3.3. Sendai City

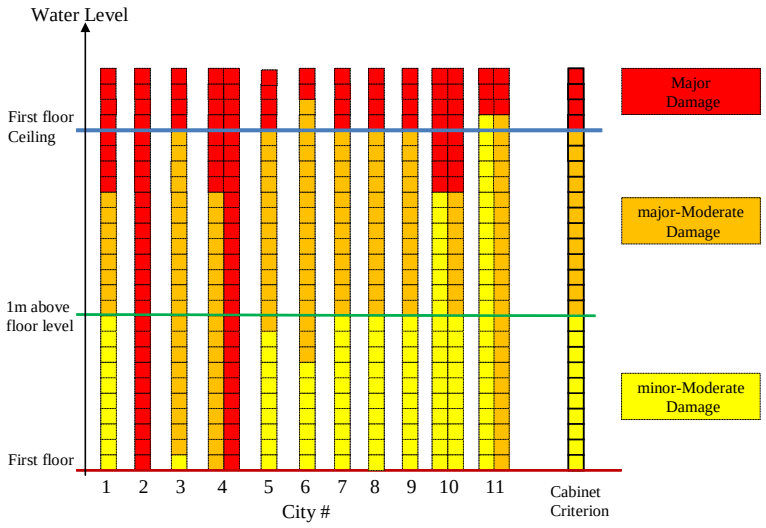
Sendai city is the biggest city among the damaged cities. As of Feb. 11, 2012, number of deaths rises to 704, and 235,278 buildings were damaged (Fire and Disaster Management Agency). Sendai city government also revised the inspection guideline, and we could find it in their evaluation sheet. They consider the damage criterion of the cabinet guideline as the damage criterion of foundation. It means that the basic concept of their guideline is different from the cabinet one fundamentally.

3.4. Rikuzen-Takada City

Rikuzen-Takada city is one of the severely damaged cites in Iwate prefecture. As of Feb. 11, 2012, number of deaths rises to 1,555, and 3,368 buildings were damaged (Fire and Disaster Management Agency). The Rikuzen-Takada city government started the preliminary reconnaissance survey about 3 days later with their own guideline. However, as a result, their guideline fit the cabinet one. Since most of the buildings in the city were flowed out, 90% of the building is classified as major damage.

3.5. Comparison of the Evaluation Criterion

The comparison of the evaluation criterion of the tsunami damage in 11 cities is shown in Fig. 3.1. Although the authors decided not to disclose the city names in Fig. 3.1 due to the political reasons, it is still important information for using the inspection result as a damage index.



(Left column of #4, #10, #11, indicates the case of debris flows in a house)

Figure 3.1. Comparison of the Evaluation Criterion

There are several reasons why the guidelines varied by a local government. Most of the local governments started their inspection for tsunami within a week or two. Meanwhile, the cabinet office announced the new guideline on March 31. This time lag is regarded as a key factor for setting up the independent guideline at each local government, because once the local governments started the inspection, it is impossible to change the criterion later, since it is too much work to inspect the same buildings again, especially for the big cities. Another reason is lack of the official training system. There is no training system for the local government inspectors, who are not building specialists such as engineer or architect. The manuals or power point sets provided by the cabinet office are the only training material. Therefore, each local government had to train the inspectors by their own efforts. Since the damage inspection is the first experience to the local government officials, they do not have enough information for setting up their own inspection procedure and training system. This implies that the evaluation criterion had been modified by a local government.

4. BUILDING DAMAGE INSPECTION TRAINING SYSTEM

In this study, a new building damage inspection training system is presented. The system is designed to acquire the damage inspection knowledge and skills through the simulated field experience by iPad. The system consists of two parts, learning and drill. The content of the learning part is the text and video to explain the concept and method of the inspection. The drill provides the simulated field experience of the inspection. The schematic diagram of the system is shown in Fig. 4.1. The feature of the system is to utilize an actual damaged housing data and learn a series of inspection process interactively. Collecting whole data set for a model house, which is damaged by the 2004 Niitgata-ken Chuetsu earthquake, we reconstruct the house in iPad. To have the correct and authorized answer, the damage inspection was conducted by the government official who was in charge of the damage inspection of the cabinet office. The building photos and the damage inspection results are stored and assigned to the corresponding components of the plan and elevation in iPad Using this system, user could easily understand the whole picture of the damage inspection without the field experiences

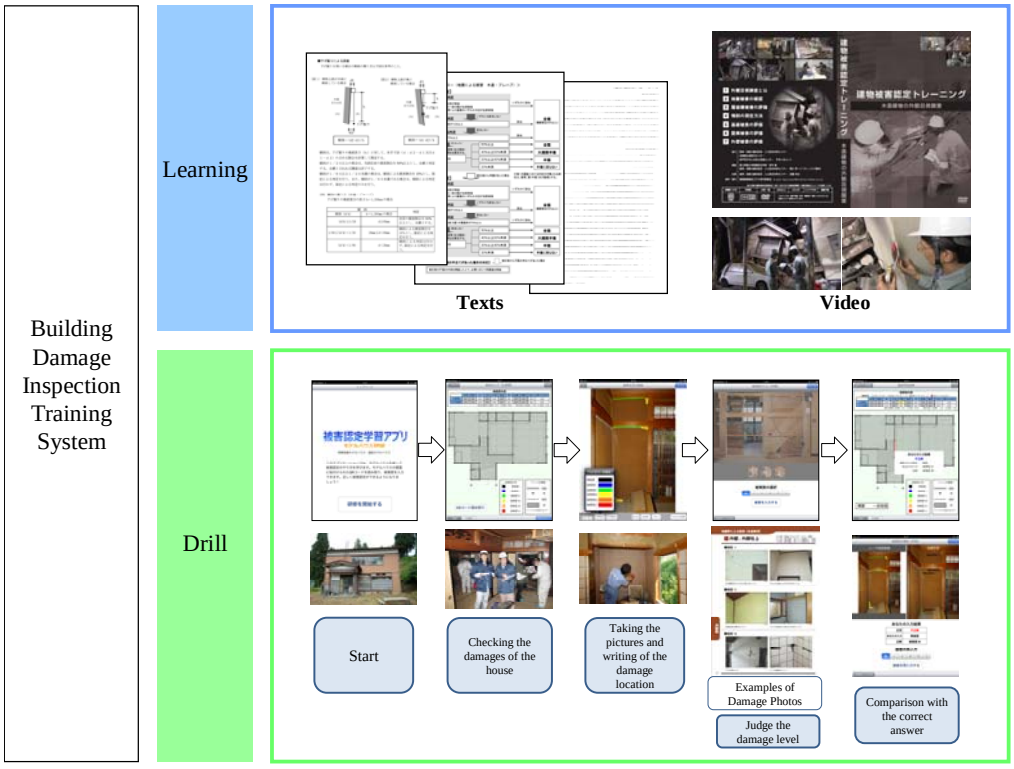


Figure 4.1. Building Damage Inspection Training System

5. CONCLUDING REMARKS

This paper analyzed the building damage inspection processes for the 2011 Great East Japan earthquake and identified that some local governments took the different damage criterion from the cabinet guideline. Although the analysis is still tentative, it is useful information for making a damage indexes or fragility functions using this inspection results. In addition, to acquire the knowledge and skills of the inspection, the new training system is presented. Integrating all information to iPad, user could easily access the standard procedure interactively.

AKCNOWLEDGEMENT
This research was partially supported by the Japan Science and Technology Agency grant program.

REFERENCES

Takana, S. (2008). Building Damage Inspection Analysis in the 2007 Niigata Chuetsu-Oki Earthquake, Kashiwazaki: Self-Inspection Analysis for Damage Evaluation. *Journal of Disaster Research.* **Vol. 3: No.6**, 372-380.

Applied Technology Council. (2004). ATC-45 Field Manual: Safety Evaluation of Buildings after Windstorms and Floods, Applied Technology Councial, USA.

Cabinet Office, Government of Japan. (2011). Damage Evaluation for Disaster Damaged Houses (in Jpapnese). http://www.bousai.go.jp/hou/unyou.html

Fire and Disaster Management Agency. (2012)., Disaster Report for the 2011 Great East Japan Earthquake (in Japanese). **No. 145**, http://www.fdma.go.jp/bn/2012/detail/691.html