DEVELOPMENT OF THE BUILDING DAMAGE SELF-INSPECTION SYSTEM FOR EARTHQUAKE DISASTER

S. Tanaka[1], K. Shigekawa[2], and M. Takashima[2]

[1] *Associate Professor, Graduate School of Environment and Disaster Research, Fuji Tokoha University, Japan*
[2] *Professor, Graduate School of Environment and Disaster Research, Fuji Tokoha University, Japan*
[3] *Associate Professor, Graduate School of Environment and Disaster Research, Fuji Tokoha University, Japan*
Email: tanaka_s@fuji-tokoha-u.ac.jp, shigekawa@fuji-tokoha-u.ac.jp, takashim@fuji-tokoha-u.ac.jp

ABSTRACT :
This paper presents a method for inspecting the building damage, which can be carried out by the disaster victim themselves. It is well known that the building damage survey is one of the important issues for estimating the size of damage by disasters. There are two independent damage surveys in Japan, one is for evaluating the building safety for occupancy, and the other one is for evaluating the losses by the disaster. Local governments have based the apportionment of monetary, donations, allotment of temporary housing, and other recovery related benefits on the loss evaluation. The guidelines for the inspections of loss evaluation are already released, however, from the past earthquake experiences, there are several issues that need to improve from technical and operational points of view. This paper analyzes such building damage inspection processes and proposes a self-inspection system that can be used for a non-expert.

KEYWORDS:
building damage evaluation, Noto earthquake, Niigata Chuetu Oki earthquake, self-inspection system

1. INTRODUCTION

It is well known that the building damage survey is one of the important issues for estimating the size of damage by disasters. There are two independent damage surveys in Japan, one is for evaluating the building safety for occupancy, and the other one is for evaluating the losses by disaster. Under the act on Support for Livelihood Recovery of Disaster Victims, the victim support criterion is based on the result of the loss evaluation of their houses. In addition, local governments have based the apportionment of monetary donations, allotment of temporary housing, and other recovery-related benefits on the loss evaluation. Therefore, accuracy, equity, and rapidness are required for the inspection activity from both technical and operational view points.

For this reason, lots of works have been done by many researchers. For instance, the disaster management division, Cabinet Office of Japan (2001, 2006), has developed and released the guidelines and supplemental manuals for the inspection procedure. Horie et al. (2000, 2002) analyzed the building damage inspection processes for the 1995 Hanshin-Awaji earthquake disaster and developed a simplified inspection system. Horie et al. (2005) presented a case study of the system applied to Ojiya city for the 2004 Niigata Chuetu earthquake. Tanaka et al. (2006) analyzed the damage inspection process for the Ojiya case, and evaluated it from the operational view points. Shigekawa et al. (2005) also analyzed the Ojiya case from the legal and organizational view points. Tanaka et al. (2007) reported the damage inspection process for the 2007 Noto and Nigata Chuetsu Oki earthquakes and discussed the limit of the system.

This paper analyzes such building damage inspection processes from the recent earthquake disasters and proposes self-inspection system that can be used for a non-expert.

2. BUILDING DAMAGE INSPECTION PROCESS

2.1. Damage Inspection Guideline

The documents from the Cabinet Office are the guidelines which describe a general procedure for inspecting the building damage and evaluating its loss due to disasters. The procedure is based on a visual inspection and consists of primary and secondary inspection. The primary inspection is evaluating the damages appeared on the exterior of a building. While, the secondary one is evaluating not only the exterior damage but also the interior damage. The purpose of the secondary inspection is to provide the second opinion for the evaluation when the owner or resident does not accept the result of the primary one. Therefore, the primary inspection is carried out for all the damaged buildings, while the secondary inspection is usually carried out by request.

Depending on the level and size of the damage, the corresponding damage point is assigned for each building element, which is based on the component ratio of a building shown in Table 1. Aggregating the points for a building, the loss for the building is evaluated, which is classified into 4 levels as shown in Table 2.

Table 1 Component Ratio of Each Building Element

	Building Element	Roof	Exterior Wall	Foundation	Column	Interior Wall	Floor	Ceiling	Fittings	Equipments
Component Ratio	Primary Inspection	10	50	10	30	N/A	N/A	N/A	N/A	N/A
	Secondary Inspection	10	15	10	20	15	10	5	10	5

Table 2 Loss Level Chart

Loss Level	Damage Point	Photo (Kashiwazaki)
Major (Zenkai)	$50 \leq x$	
Major-Moderate (Daikibo Hankai)	$40 \leq x < 50$	
Moderate (Hankai)	$30 \leq x < 40$	
Minor (Ichibu Sonkai)	$20 \leq x < 30$	

2.2. Damage Inspection Processes

In the local disaster management plan, the inspection is usually designated to the tax assessor's section of the local government, so the inspector is not a structural engineer. Therefore, the tools used for the inspection, such

as instruction, check sheet, equipment, have to be designed for such non-engineer inspector.
The check sheet shown in Fig.1 is used for the primary inspection of the recent earthquake disasters such as Ojiya city at the 2004 Niigata Chuetu earthquake, Wajima city at the 2007 Noto earthquake, and Kashiwazaki city at 2007 Niitata Chuetu Oki earthquake. It has been developed and modified suitable for non-engineer inspector (Horie et al. 2002).

The inspection teams comprised of two or more local government officers are deployed within the affected area. The primary inspection examines damages appeared on the foundation, roof, and exterior wall of a building. With this check sheet, it takes 10-15 minutes per building on average even for the non-engineer inspector.

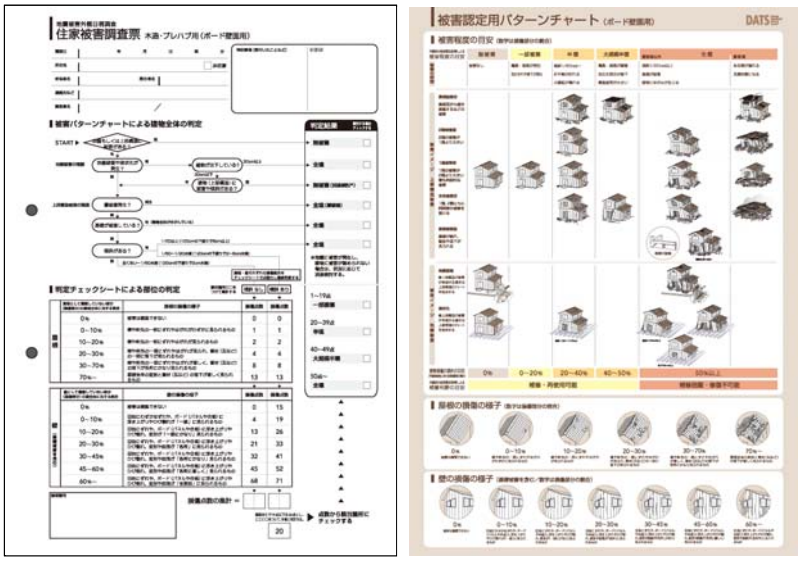

Fig. 1 Check Sheet for the Primary Inspection

The secondary inspection conducts more detailed survey. For example, it evaluates the damages appeared on roof, exterior wall, foundation, column, interior wall, ceiling, floor, fittings such as doors and windows, and equipments such as toilet and sink. The inspector draws the floor plan and plots the location and level of the damage on it (Fig. 2). Taking the similar damage point system, the loss is evaluated in the same manner. If both inspection results do not match, the worse result is taken as the final loss.

As it evaluates the inside of the building, each inspection is carried out by appointment. In addition, it takes about 90 minutes per building on average. Therefore, each inspection team could inspect 4 buildings per day.

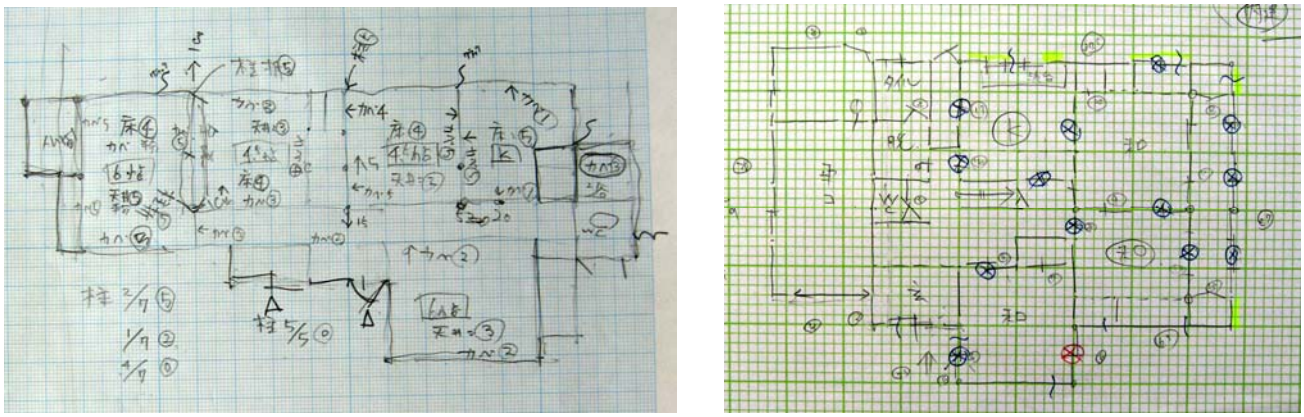

Fig. 2 Plotting the Damage on the Plan by Inspector

3. LESSONS LEARNED FROM THE RECENT EARTHQUAKES

This inspection method is applied to the recent earthquakes in Japan, such as Wajima city at the 2007 Noto earthquake and Kashiwazaki city at the 2007 Niigata Chuetsu Oki earthquake.

As for the primary inspection, it conducted for about 12,000 buildings in 15 days for Wajima city (Fig. 3). While for Kashiwazaki city, it conducted for about 60,000 buildings in a month.

Fig. 3 Primary Inspection Activity at Wajima City

The result of the inspection, loss level, is printed on the damage certificate. Since the recovery support programs that the victim could apply depend on the loss level, the victims are sensitive about it. Therefore, the acceptability of the result to the victims is one of the critical issues.

As the result, about 10 percent of the primary inspection result was not accepted by owner, and the secondary inspection was requested. Several reasons are pointed out; 1) for some buildings, it is only minor damage appeared on the outside, but is severely damaged inside; 2) regarding to the inspection method, only a few information is circulated to the residents, so that if there is an opportunity to have another inspection, they just request it; 3) the building owners insist that the damage appears not only for the outside but for the inside of the building as well. The only outside inspection is not satisfactory to them; 4) since the victim recovery support programs such as apportionment of monetary donations, allotment of temporary housing and other recovery-related benefits are based on the inspection result, they are not satisfied with the programs that they are assigned

4. DEVELOPMENT OF SELF-INSPECTION SYSTEM

Since the inspection is labor intensive and time consuming, it is expected that the delay of the inspection causes to the delay of victim recovery activities. In addition, the shortage of inspector is another issue to concern, especially after catastrophic events in large cities.

To avoid the delay and promote the recovery activities, the authors propose a self damage inspection system for non-expert in this study. With this system, the owners could inspect the damage appeared both outside and inside the building by themselves, and could get the same result as the local government inspector does. In the Kashiwazaki secondary inspection, a self-inspection sheet shown in Fig. 4 was introduced to promote the understanding of the inspection method and help the inspection activity.

This sheet is distributed to the people who request the secondary inspection. The damage level of each building element is referring to the supplemental manual (Cabinet Office of Japan, 2006). It prompts the owners to draw the plan of your building and plots the location and level of the damage in it as shown in Fig. 5.

As a result, about a half of the residents and owners who request the secondary inspection filled in the sheet. And most of the inspectors point out that it is useful for saving the inspection time. Analyzing the sheets, a standard procedure for plotting the damage on the sheet has to be developed.

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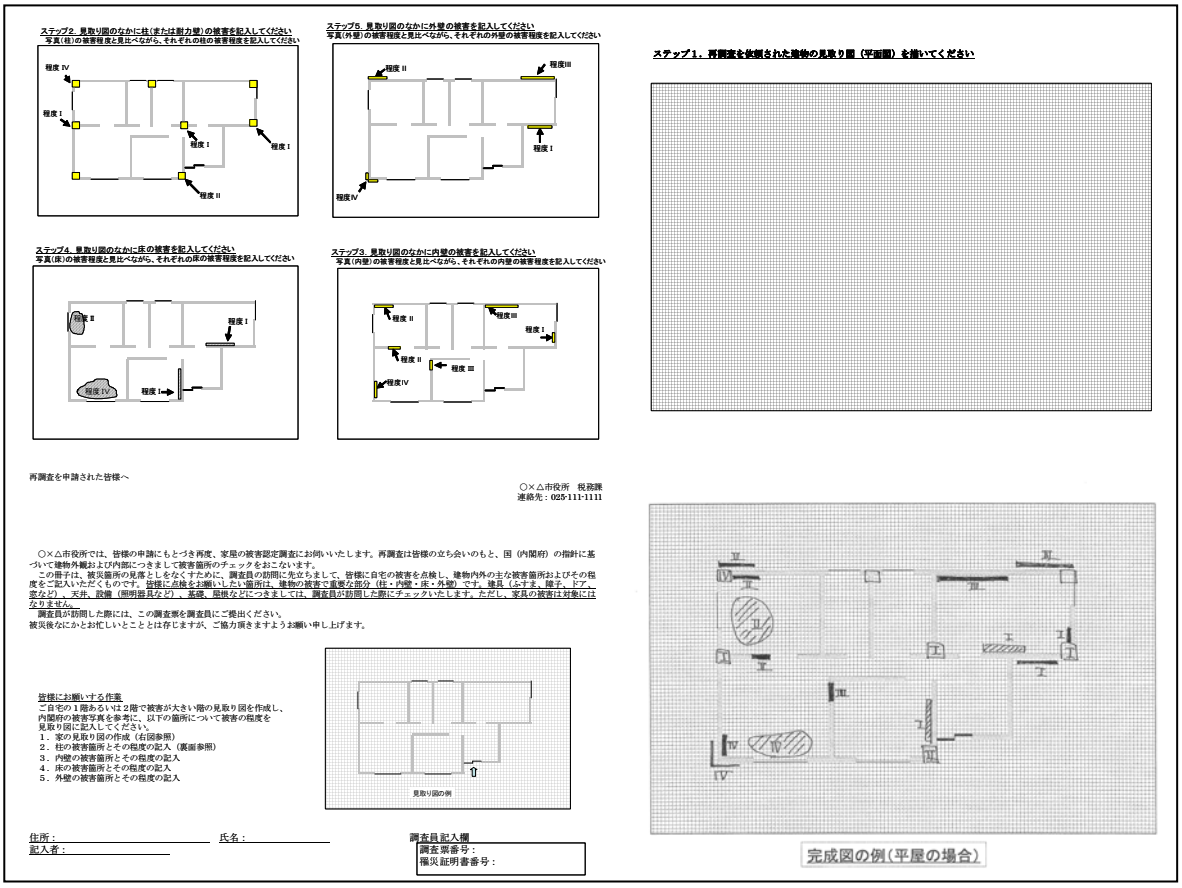

Fig. 4 Self-inspection Sheet distributed at Kashiwazaki city

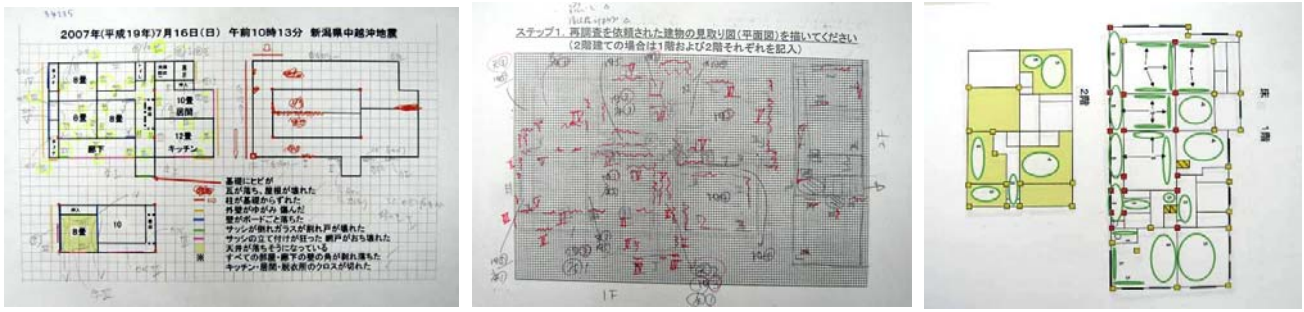

Fig. 5　Examples of Self-inspection Result Drawn by Residents

4. CONCLUDING REMARKS

This paper discusses the building damage inspection process for loss evaluation from the recent earthquake disasters. Introducing the Wajima and Kashiwazaki inspection processes, key factors to recognize and evaluate the damage are identified. Based on the analysis of the inspection processes, the authors propose to develop the self damage inspection method which can be used by the disaster victim themselves. Although the inspection method here still tentative, it would be useful in the damage survey, especially for the catastrophic events in the metropolitan area.

REFERENCES

Cabinet Office, Government of Japan (2001). Guideline for the Damage Inspection

Cabinet Office, Government of Japan (2006). Supplemental Manual for the Damage Inspection Guidelines –Examples of the Loss Evaluation Practices with Damage Photos-

Horie, K., Maki, N., Shigekawa, K., Tanaka, S., and Hayashi, H. (2000). Development of Damage Assessment for Wooden Structures –Correlation between Damage Assessment Purpose and Category-, *Journal of Social Safety Science* **2**, 139-144.

Horie, K., Maki, N., Shigekawa, K., Tanaka, S., and Hayashi, H. (2002). Building Damage Assessment Method for Disaster Responder –Development of Damage Assessment Training System-, *Journal of Social Safety Science* **4**, 167-174.

Horie, K., Shigekawa, K., Maki, N., Tanaka, S., and Hayashi, H. (2005). Application of Damage Assessment Training System (DATS) to Ojiya City following 2004 Niigata-ken Chuetsu Earthquake –Through a Disaster Response Support Activity for Issuing Victim Certificate-, *Journal of Social Safety Science* **7**, 123-132.

Shigekawa, K., Tanaka, S., Horie, K., and Hayashi H. (2005). Some Regulational Issues on Building Damage Assessment –A Case Study of Niigata-ken Chuetsu Earthquake-, *Journal of Social Safety Science* **7**, 133-140.

Tanaka, S., Shigekawa, K., and Takashima, M. (2006). Operational Issues for the Housing Damage Evaluation Process in the 2004 Mid-Niigata Earthquake Disaster, *Journal of Social Safety Science* **8**, 51-62.

Tanaka, S. (2008). A Study on the Building Damage Assessment Processes for the 2007 Niigata Chuetsu Oki Earthquake Disaster: Kashiwazaki Case Study, *Proceedings of the Annual Conference of the Institute of Social Safety Science* **22**, 45-48.