

ANALYSIS OF THE PROCESS OF BUILDING DAMAGE INSPECTION DUE TO LIQUEFACTION DURING THE GREAT EAST JAPAN EARTHQUAKE



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SUMMARY

Severe liquefaction damage occurred in Urayasu City, Chiba Prefecture, as a result of the Great East Japan Earthquake on March 11, 2011. Urayasu City is built on reclaimed land where three fourths of the city area was filled after 1962 and 164,040 people live in the overcrowded 17.3km² city area. Liquefaction damage occurred to the whole reclaimed land in Urayasu City and most detached houses were affected by the damage. In this study, the process of building damage inspection in Urayasu City due to liquefaction damage without parallel in the world is clarified, and new issues are extracted which were not observed in past cases.

Keywords: Building Damage Inspection, Liquefaction, Great East Japan Earthquake, Urayasu City

1. INTRODUCTION

The Great East Japan Earthquake, which devastated the Tohoku region on March 11, 2011, caused liquefaction in many parts of the Kanto region. Three-quarters of the entire area of the city of Urayasu, Chiba Prefecture, among others, sustained liquefaction damage. The area sustaining such liquefaction consisted of new land reclaimed in or after 1962. As a city adjacent to Tokyo, Urayasu is overpopulated with 164,040 residents for every 17.3 km², and as much as 76% of the population resides in multiple-dwelling houses, but detached wooden houses suffered serious damage by liquefaction.

Soon after the outbreak of the earthquake, Urayasu was supplied with water by means of water tank trucks because of breaks in water supply services in many parts of the city. Under such a circumstance, the city had so little time such that it could not construct a framework for building damage inspections and did not have any procedure for inspecting building damage attributable to liquefaction. However, despite these problems confronting the city, it started issuing building damage certificates to its citizens on May 1, 2011.

The study presented herein elucidates the process of building damage inspections in the city of Urayasu—an area damaged by the largest-scale liquefaction the world has ever experienced—and thereby identifies new issues that did not arise in past cases.



Photograph 1. Mark of liquefaction



Photograph 2. Building damage because of liquefaction

2. METHOD OF STUDY

The study was conducted as described below through building damage inspection activities that the authors participated in after the earthquake, in the city of Urayasu.

(1) Ethnography survey, in which the authors observed the disaster response process from March 20 through May 1, 2011, at the Fixed Property Tax Division of the Urayasu City Government Office responsible for building damage inspections and the issuance of building damage certificates

(2) Survey on the staff members of the Urayasu City Government Office who participated in the abovementioned duties that took place in May and August 2011

3. OVERVIEW OF URAYASU AND SUMMARY OF DAMAGE

The city of Urayasu is divided into three major areas: the Motomachi area (tracing back to the old Urayasu-machi area), the Naka-machi area (which consists of phase-1 reclaimed land [1962 through 1975]), and the Shin-machi area (which consists of phase-2 reclaimed land [1975 through 1981]). The Naka-machi and Shin-machi areas are ranked high among “towns people desire to live in” and are known as popular residential areas. However, these two reclaimed land areas sustained devastating liquefaction damage by the earthquake, whereas few houses incurred damage in the Motomachi area.

The population of Urayasu is 164,040—or 72,714 households (as of the end of March 2010). Of the 164,040 citizens, 24% live in detached houses and as many as 76% reside in multiple-dwelling houses. During the Great East Japan Earthquake, detached houses were seriously damaged by liquefaction; 88.9% of the detached houses in the Naka-machi and Shin-machi areas suffered partial destruction or more serious damage.

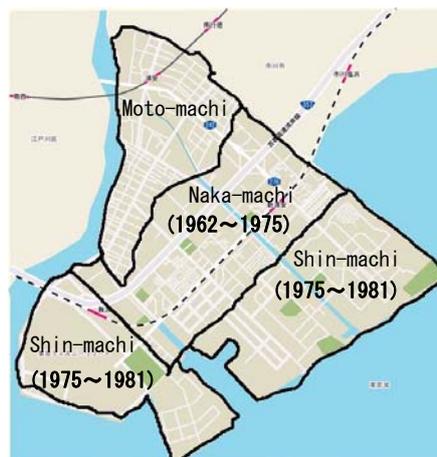


Figure 1. Reclamation time of Urayasu-city

Liquefaction also caused serious damage to lifeline infrastructure, including public water supply, sewerage, gas, and electricity. Water supply to up to 33,000 households was cut off, and 10 days after the earthquake, as many as 4,000 households were unable to receive public water supply. As of April 2012, more than one year after the earthquake, public water is still supplied through temporary water pipes in some areas.

4. ANALYSIS OF BUILDING DAMAGE INSPECTION PROCESS

It became clear that the process of operations from the occurrence of the March 11 earthquake to the issuance of building damage certificates on May 1, 2011 was divided into four phases. This section describes the process of each phase.

4.1. Phase 1 (March 11 to March 20, 2011)

- Period when staff members of the Urayasu City Government Office were engaged in water supply activities and when no inspection framework was in place -

Since water supply to 33,000 households, which accounted for 45% of all households of the city of Urayasu, was interrupted, the city devoted all its energies to emergency water supply activities. The city also had to allocate substantial manpower to the distribution of sandbags to the houses that subsided as a consequence of liquefaction. The city's Fixed Property Tax Division, which was responsible for building damage inspections, was aware of the importance of the inspections but could not make preparations at all because relief to the citizens experiencing the harshest conditions was given the highest priority.



Photograph 3. Temporary water supply pipe(April,6,2012)

Meanwhile, the Construction Guidance Division of Urayasu performed an emergency safety inspection on detached houses in the Naka-machi and Shin-machi areas, which suffered damage by liquefaction, in order to determine whether emergency safety assessment had to be conducted. Conducted by three teams of pairs a day, the inspection, which was a visual appearance inspection, covered 8,880 buildings and was terminated on March 20, 2011. The results of the inspection were classified into three ranks—rank A (minor damage), rank B, and rank C (major damage)—according to the degree of damage to the ground, the foundation, and the outside wall. In the inspection carried out in the Naka-machi and Shin-machi areas, the percentages of the buildings assessed as rank A, rank B, and rank C were 5.0%, 5.3%, and 0.1%, respectively, and the majority, or 89.6%, of the buildings were found undamaged.

On the other hand, the citizens began to inquire to the Urayasu City Government Office regarding the building damage inspection about a week after the earthquake, and the government office received more than 1,000 applications for the inspection as of March 20, 2011. The abovementioned areas requiring emergency water supply activities were where liquefaction damage occurred and a tentative building damage inspection began based on the results of the emergency safety inspection performed by the Construction Guidance Division. At that time, the staff members of the Housing Team of the Fixed Property Tax Division formed two teams of pairs to conduct the tentative building damage inspection according to the Cabinet Office's guidelines "Wooden/Prefabricated Questionnaire A." Since this questionnaire was not intended for liquefaction damage and as the subsidence of entrances, garages, etc., was not considered to be actual damage, the inspection personnel conducted the inspection, predicting that complaints would pour in from the citizens later.

4.2. Phase 2 (March 21 to March 25, 2011)

- Period when an inspection framework was constructed -

4.2.1. Acquisition of personnel

What the manager of the Fixed Property Tax Division most concentrated energies on was the acquisition of personnel to conduct inspections and manage inspection data. The number of the staff members of the Fixed Property Tax Division was only 15 then, and the manager of the division requested the managers of the other divisions of the government office to call up former staff members with experience working in the Fixed Property Tax Division for help. The Fixed Property Tax Division also tried to find inspectors through Network Ojiya and, at the same time, asked for the help of expert staff members in construction as secondary inspectors through the Japan Association of City Mayors.

4.2.2. Determination of inspection policies

As a result of the request for help through Network-Ojiya, Urayasu received advice from staff members of the cities of Ojiya, Kashiwazaki, and Wajima, as well as from Mr. Tanaka at Fuji Tokoha University from March 23, 2011, and began to study inspection policies. Below is some of the information on the inspection policies finalized during that process.

- 1) Conduct building damage inspection in the Naka-machi and Shin-machi areas, which sustained damage from liquefaction. Start the inspection from the parts most seriously damaged as a complete enumeration of detached houses.
- 2) In the less-damaged Motomachi area, perform an inspection on only the buildings that applied for inspection.
- 3) Use the guidelines stipulated in “Wooden/Prefabricated Questionnaire A,” issued by the Cabinet Office.
- 4) Assuming that a team inspects 50 buildings a day, 10 teams (a team consists of two personnel), or 20 personnel, shall complete inspecting 10,000 buildings in 20 days.
- 5) Pass an “Inspection Completed Slip” to each inspected building.
- 6) Ask the Tax Office of Chiba Prefecture to inspect non-wooden multiple-dwelling houses and business establishments operating in the coastal zones.
- 7) Issue building damage certificates from May 1 or about a month after the start of the inspection.
- 8) The Tax Collection Division is responsible for studying and determining a building damage certificate issuance system and information management.
- 9) Repeatedly announce the start of the building damage inspection in advance through briefings by the mayor of Urayasu and neighborhood rounds by loudspeaker vans, and inform the police of the inspection to obtain their understanding and cooperation.

4.3. Phase 3(March 25 to April 30, 2011)

- Period when the building damage inspection was performed -

On March 25, 2011, a workshop concerning the building damage inspection has held for 16 supporting personnel found through Network Ojiya and the staff members of the city of Urayasu. In advance of the workshop, a visual appearance inspection and floor inclination measurement were performed on March 23, 2011 at the house of a staff member of the Urayasu City Government Office damaged by liquefaction, in order to determine whether the inspection method was appropriate. On March 26, the full-scale inspection began using up to 12 teams of three a day, or seven to eight teams a day on average, and about 10,000 buildings were inspected over 40 days. It took about five to 10 minutes to inspect one building, and each team investigated some 50 buildings a day.

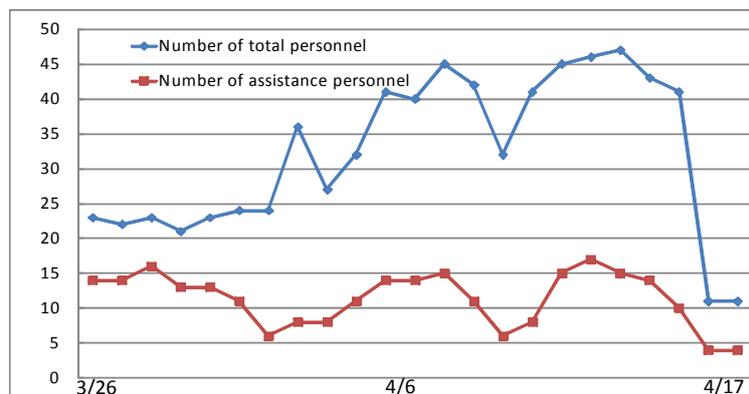


Figure2. Changes in the number of inspection personnel

The Fixed Property Tax Division worked from early morning to 12:00 a.m. for more than a month to sort out the questionnaires, input data, download photos into personal computers, and prepare copies of house maps and cars for the inspection to be conducted on the following day at the same time. Fundamentally, these operations should have been performed by staff members who did not visit and

inspect buildings but who could concentrate on coordination. However, those who investigated buildings in the daytime carried these tasks out after they came back to the government office because priority was given to the acquisition of field inspectors in concurrence with the issuance of building damage certificates. Table 1 shows the result of the building damage investigation.

Table 1. Result of building damage investigation

	Motomachi area	Nakamachi, Shinmati area	Total	Damage rate
Major damage	0	17	17	0. 2%
Major-Moderate damage	0	1, 538	1, 538	15. 6%
Moderate damage	1	2, 116	2, 117	21. 4%
Minor damage	136	4, 964	5, 100	51. 6%
No damage	12	1, 095	1, 107	11. 2%

In addition, during the initial stage of the inspection, lavatories in the inspected areas were not available at all, and the inspection personnel had no choice but to use temporary lavatories prepared in specific locations. Convenience stores still did not re-open, which also made it quite difficult for the inspection personnel to secure food, and this placed heavy burdens on them regarding logistics.

4.4. Phase 4(From May 1, 2011)

- Issuance of building damage certificates, the handling of complaints, and the performance of secondary inspections -

4.4.1.Issuance of building damage certificates

Prior to the start of the issuance of building damage certificates on May 1, 2011, the Urayasu City Government Office sent by mail the results of assessments to each of about 30,000 households subjected to the primary inspection in late April and requested them to bring the result of assessment with them when they come to the government office to have a building damage certificate issued. Substantial confusion, such as an influx of recipients from the first day, did not occur because the days of the issuance of building damage certificates were specified for each area.

In the same period, the Cabinet Office considered relaxing the damage certification conditions in response to strong demand from the municipalities seriously damaged by liquefaction so that there was a possibility that the contents of issued building damage certificates would be modified. On May 2, 2011, the Cabinet released new damage certification conditions, which were much more relaxed than the previous ones. Consequently, the city of Urayasu had to check all questionnaires, including ones already issued, and review the results of judgment according to the new certification conditions. On the other hand, the possibility that a higher rank of judgment would be awarded (damage would be certified to be more serious) as a result of the review of the damage certification conditions was effective in that it reduced the dissatisfaction of the citizens visiting the Urayasu City Government Office to receive a building damage certificate upon the result of assessment.

4.4.2.Secondary inspection and the handling of complaints

A secondary inspection (building internal inspection) was performed for the victims who were not satisfied with the result of the primary inspection and who requested another inspection. The number of requests for the secondary inspection exceeded about 200. However, compared with the visual appearance check of the primary inspection, this inspection took at least an hour to complete, and thus only about four buildings were inspected a day. To carry out this inspection, three-person inspection teams were organized, each of which was made up of a supporting person dispatched through the Japan Association of City Mayors (and who was an expert in construction) along with two staff members of the Fixed Property Tax Division of the Urayasu City Government Office. Up to five teams a day conducted the inspection.

The government office also received about 1,500 requests from citizens for the re-measurement of the inclination of their houses because of the modifications to the damage certification conditions set by the Cabinet Office, as well as due to aftershocks. To meet these requests, a visual appearance check,

not a building internal inspection, was performed as in the primary inspection.

The cases of land subsidence resulting from liquefaction and without any inclination of the house and damage to the inside of the house by earthquake motion accounted for the majority of the complaints from the victims. It was impossible to count damage points in these cases, with the original damage certification conditions defined by the Cabinet Office. Under the modified damage certification conditions issued on May 2, 2011, on the other hand, any and all buildings subsiding to a depth of 25 cm or over into the ground from the top end of the foundation became certified to be half-collapsed. However, land subsidence of less than 25 cm and the subsidence of exterior structures into the ground were excluded from damage, and it was, therefore, quite difficult to obtain the understanding of those affected despite repeated explanations.

5. CONCLUSION

This section focuses on the issues confronting building damage inspections in connection with large-scale liquefaction, which were identified in the elucidation of the process of the building damage inspection conducted in the city of Urayasu.

- 1) Due to the large-scale liquefaction damage and the interruption of public water supply over wide areas, it took a lot of time and manpower to supply water and stack sandbags. As many as 10 days were required to make preparations for the building damage inspection and to acquire necessary personnel.
- 2) The Cabinet Office's guidelines on the application of damage certification conditions for houses did not clearly define an inspection method for liquefaction. For this reason, the city of Urayasu performed the building damage inspection based on a general earthquake inspection procedure. However, that inspection procedure was unable to accurately keep track of the actual situation of damage, and the city had to perform the inspection by trial and error.
- 3) In response to strong demand from the heads of the disaster-stricken areas, the application of the damage certification conditions to ground liquefaction damage was reviewed and the inspection method was modified on May 2, 2011, when the inspection was still in process. The Urayasu City Government Office had to re-check all questionnaires already examined and re-certify damage from the beginning.
- 4) The liquefaction damage that the city of Urayasu sustained was characterized by little damage to the inside of houses by earthquake motion despite serious damage to the ground. The inclination of each building was, therefore, the only measure of the degree of damage. Although there was a difference in the inclination of buildings among complete collapse, large-scale half-collapse, and half-collapse, there was little difference in costs incurred by jacking up and repairing buildings. It was difficult to obtain the understanding of those affected regarding this point.
- 5) As time passed, some buildings further inclined and some became less inclined, thus needing to be re-inspected.
- 6) The Urayasu City Government Office conducted the inspection with uncertainty about whether the use of a 1.2-meter plumb bob for the measurement of the inclination of high-rise non-wooden multiple-dwelling houses was appropriate and at what point of a building standing several dozen meters high the inclination should be measured.

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