

Survey study on the business recovery process of the daily stores located on different soil conditions at Tohoku region by the 2011 off the Pacific coast of Tohoku Earthquake on March 11.



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SUMMARY

This paper explores the business recovery process of damaged daily stores around the Tohoku areas by the 2011 off the Pacific Coast of Tohoku Earthquake on March 11. In order to survey the damage states of these facilities and emergency responses of human actions, on-site observation and oral interviews to these stores were conducted for 3 cities, which are Ichinoseki, Ohsaki and Kurihara cities with different soil conditions. The survey was conducted during the period between April 11 and 30. These facilities are selected considering the distribution of strong shaking and Tsunami disaster in addition to the geographical and local soil conditions. In this paper, about 100 facilities were surveyed and the relations between business interruption time and major factors are studied focusing on local soil conditions, ground shaking levels and lifeline systems mainly on the recovery of sewage lines and water supply associated with emergency response management.

Keywords: Business Continuity Plan (BCP), Business Interruption Time, Power Loss Time, AVs30

1. INTRODUCTION

The concept of business continuity plan (BCP) was proposed in Europe and the United States as a concept of a crisis management approach for businesses and other organizations. The purpose of business continuity planning is to maintain important functions of the organization in the event of an emergency without specifying a type of threat. In Japan, in August, 2005, the Cabinet Office of the Government of Japan released the Business Continuity Guidelines (Cabinet Office, 2005), which recommends business continuity planning in preparation for "a strong earthquake that poses a serious disaster risk and about which the rest of the world is concerned" as the type of natural hazard to be assumed first. Since then, public organizations and various trade organizations have released their guidelines, and a growing number of organizations, particularly in the private sector, have been working on business continuity planning.

In areas affected by a disaster such as an earthquake, there are many affected people who are in need of drinking water, food and other daily necessities, such as local residents who did not have to go to designated local shelters or who returned to their houses after temporary evacuation. It is therefore necessary for retail businesses and stores dealing mainly in drinking water, food and other daily necessities (hereinafter referred to as "daily goods stores") to take prompt response actions. In the event of a disaster, daily goods stores cannot lower the rate of operation as in manufacturing facilities. Instead, daily goods stores need to resume business as soon as possible after checking on safety in the stores.

When drawing up a BCP for a private business, it is important to do the following:

- (1) Selecting important areas of activity and tasks and identifying related business activities
- (2) Conducting a business impact analysis (BIA) to evaluate the impact of interruption on the business

organization and calculate business interruption time and target recovery time

(3) Selecting actions to be taken in order to achieve the target recovery time indicated in the BIA from the occurrence of the assumed disaster or damage

(4) Verifying the effectiveness of the BCP that has been drawn up

Keeping these BCP considerations in mind, in this study a preliminary survey was conducted concerning actions taken by businesses operating daily goods stores in the areas affected by the 2011 Off the Pacific Coast of Tohoku Earthquake. Then, a field survey was conducted mainly on the recovery of daily goods stores located in the areas, mainly in northern Miyagi Prefecture and southern Iwate Prefecture, that suffered serious damage from the 2011 Off the Pacific Coast of Tohoku Earthquake. On the basis of the survey results, post-quake bottlenecks for the affected daily goods stores and business recovery processes were identified, and the effects of topographical and geological conditions on business interruption time were evaluated.

2. SURVEYS

2.1 Preliminary survey

An interview survey was conducted of a nationwide chain (hereinafter referred to as "A Company") of convenience stores concerning actions taken by daily goods stores in response to the 2011 Off the Pacific Coast of Tohoku Earthquake.

2.2 Field survey

A field survey was conducted of a number of stores affected by the 2011 Off the Pacific Coast of Tohoku Earthquake (hereinafter referred to as "Off the Pacific Coast of Tohoku Earthquake") concerning post-quake business continuity. In the survey, interviews were conducted concerning the items listed in Table 1. The surveyed stores are retail stores dealing in daily necessities such as drinking water and food including supermarkets and convenience stores (hereinafter referred to as "daily goods stores"). The survey covered areas that were high-seismic-intensity areas located in Miyagi and Iwate prefectures outside the areas flooded by the tsunami caused by the Off the Pacific Coast of Tohoku Earthquake and that were relatively unaffected by the accident involving the Fukushima Daiichi Nuclear Power Station and Fukushima Daini Nuclear Power Station of Tokyo Electric Power Company. After the earthquake, academic societies in relevant fields such as the Architectural Institute of Japan reported various cases of ground damage such as liquefaction that had occurred mainly in reclaimed land areas located in back marshes formed by cohesive soil or humic soil.

The survey areas, therefore, were selected from areas with different topographical and geological conditions located mainly in the northern part of Miyagi Prefecture. Of the areas covered by the field survey, the cities of Osaki and Kurihara in Miyagi Prefecture have similar distributions of mountains, volcanic areas and lowlands. Ichinoseki City in Iwate Prefecture is located mainly in mountains. Many of the lowlands in Osaki City are back marshes (see Fig. 1 and Fig. 2). The field survey was conducted from April 16 to 19 and from April 25 to 27, 2011. The survey covered a total of 65 stores. When the interviews were conducted, the state of damage to buildings and equipment at each store was evaluated visually.

Table.1 Major items in oral interview

①	Reopening Operation of Business	<ul style="list-style-type: none"> •Time of Business Recovery •Reopening Operation Process
②	Key Factors affected on Business Continuity	•Building Damage
		•Lifeline Damage
		•Attendance of Employee
		•Requisite Goods Supply
		•Necessary Information
③	Most Serious Problem just after Earthquake	

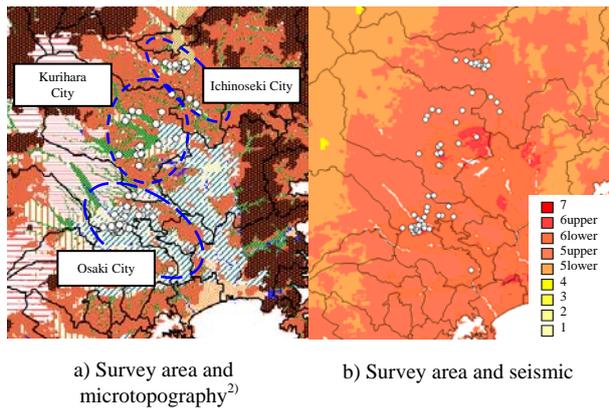


Fig.1 Target cities and facilities in field survey

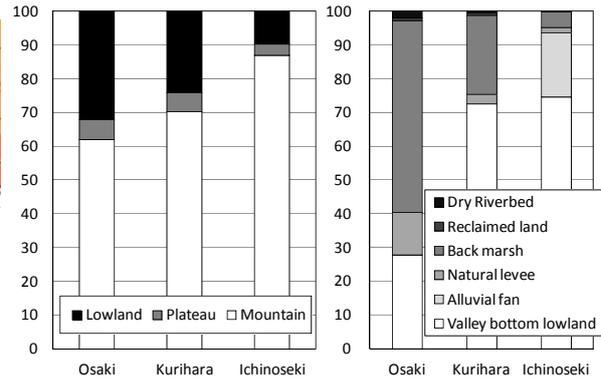


Fig.2 Geography in survey area Wakamatsu et al.(2008)

3. SURVEY RESULTS

3.1 Post-quake organizational structure

In the preliminary survey, interviews were conducted concerning the organizational structure of A Company in the event of a disaster. Figure 3 illustrates the organizational structure of the convenience store chain of A Company. In the event of a disaster, A Company sets up disaster response headquarters at its head office. The company also sets up emergency response centers at its branch offices and branch stores and collects information on its stores and other relevant information. If a store loses power, information on the power loss is sent from the register system installed at the store to the head office, and the information is relayed through a branch office or branch store to the manager in charge of the store. The manager in charge of the store then contacts the store to collect detailed information such as the state of the store. Then, the collected information is put together at the branch store, branch office and then head office levels so that the information thus obtained can be used to make decisions as to actions to be taken at the head office.

According to A Company's manual, if the soundness of a store in the area affected by a hazard such as an earthquake needs to be checked, the company dispatches an in-house construction team to the affected area on the day of the disaster so as to evaluate the earthquake resistance of the store and determine whether or not rebuilding work is necessary. Even if rebuilding work is necessary, priority is given to the resumption of operation if damage is minor. If building damage is not minor and interior and exterior restoration work is necessary, store operation is not resumed until the restoration work is completed.

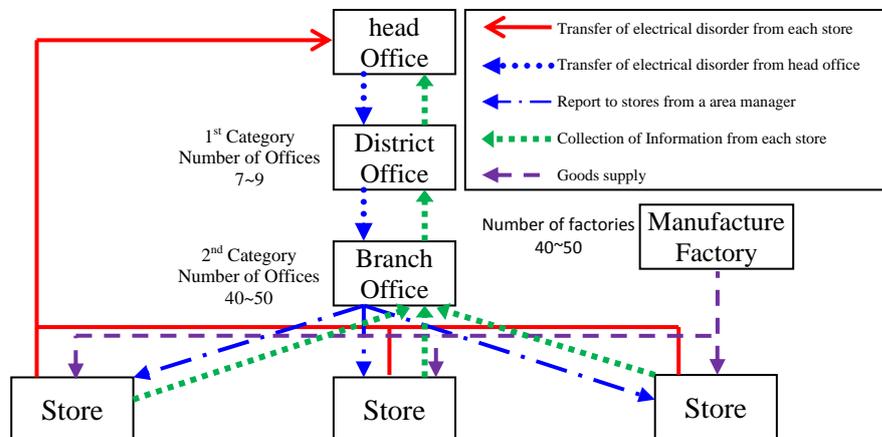


Fig.3 Information transfer at disaster in a typical daily store

3.2 Interview survey results on business resumption

Table 2 shows how business was resumed at daily goods stores. Business interruption time was defined as the number of non-operating days on the assumption that a day on which a store resumed limited-time or partial operation is regarded as a day on which operation was resumed. As shown in the table, the operation of about 70 percent of the stores surveyed was interrupted by the Off the Pacific Coast of Tohoku Earthquake. Comparison of Osaki City, Kurihara City and Ichinoseki City in business interruption time reveals that the business interruption time of the daily goods stores located in Ichinoseki City, which is mostly mountainous, tends to be shorter than that of the stores in the other cities.

Table.2 Business interruption time at 3 cities

		Osaki City	Kurihara City	Ichinoseki City	Total Numbers	Ratio(%)
Interruption Time	Uninterrupted	8	3	6	17	26
	no later than 3 Days	12	2	4	18	28
	less than 1 Week	4	5	4	13	20
	more than 1 Week	7	8	2	17	26
Total		31	18	16	65	100

3.3 Interview survey results on main factors hampering business continuity or resumption

This section shows the survey results concerning the interview survey items shown in Section 2.2 obtained from the field survey of daily goods stores located in the northern part of Miyagi Prefecture or the southern part of Iwate Prefecture. Information obtained after the preliminary survey is also shown in this section.

a) Building damage

None of the daily goods stores surveyed was completely destroyed by the Off the Pacific Coast of Tohoku Earthquake. Building damage such as falling of ceiling materials occurred at four stores, but at the time of the survey, safety measures had already been taken to prevent the members around the fallen ceiling members from falling down, and the stores were already in operation. Near the stores in which the floor surface had become uneven, phenomena indicating the occurrence of liquefaction, such as uplifting of sewers were observed.

In the case of A Company, there was little or no damage to the structural frames or secondary members of the store buildings. Therefore, except at stores located in areas where residents were evacuated (e.g., the areas flooded by the tsunami, the evacuation areas associated with the accident involving Fukushima Daiichi Nuclear Power Station and Fukushima Daini Nuclear Power Stations of Tokyo Electric Power Company), A Company continues store operation, in some cases by limiting operating hours or making partial use of the stores.

b) Lifeline damage

Table 4 shows how the electricity and water supply to the daily goods stores surveyed were affected. As shown, about 70 percent of the daily goods stores surveyed encountered some kind of electricity or water supply problems. It can be seen that both electricity and water supply were restored within one week at about 60 percent of the stores.

c) Reporting to work of employees

Table 5 shows how employees reported to work. There were many stores that completed checking on the safety of their employees on the day of the earthquake even though available means of

communication were limited at many stores. This is because many of the employees of these stores lived near the stores and reported to work voluntarily. The employees who were using their cars for commuting could not report to work because of gasoline shortage.

d) Procurement of necessities

Table 6 shows the questionnaire results regarding the procedure of necessities. The items thought to be most necessary included food, drinking water and dry cell batteries, and in some cases portable gas stoves were needed as heat sources. Items that became in short supply or that were sold out after the earthquake were similar; food, drinking water and dry cell batteries were sold out at many stores.

A Company has a manufacturing factory in each of the prefectures in the Tohoku region. Even though the factory in Miyagi Prefecture went out of operation, therefore, the company was able to transport and supply merchandise to the stores in Miyagi Prefecture from the factories in other prefectures. The film used for packaging of some types of merchandise and receipt rolls for registers, both of which were being manufactured at other companies' factories, became in short supply in some cases. An important matter related to the supply of merchandise was to find ways to transport merchandise efficiently.

e) Acquisition of necessary information

Table 7 shows how necessary information was obtained. After the earthquake, about 90 percent of the stores surveyed were able to obtain necessary information. Television was not used at many stores as a means of obtaining information because of power loss, etc. Instead, radio was used at many stores. From immediately after the earthquake, television and radio reported mainly on the areas severely affected by the tsunami, etc., and information on local communities was difficult to obtain. In some of the areas where information was difficult to obtain, information was obtained and exchanged by passing around community newsletters, through local broadcasting systems and by word of mouth at the stores where people concentrated.

3.4 Interview survey results on the most serious post-quake problems

Table 8 shows the interview survey results concerning the most serious problems encountered following the earthquake. The most serious problems mentioned by the largest numbers of respondents were gasoline shortage, power loss and drinking water shortage. This indicates that in order to ensure business continuity of daily goods stores, it is important to take some kind of measures to solve these problems.

Table.3 Building damage

Building Damage		Total Numbers	Ratio(%)
Fully-Destroyed		0	0
Partially Destroyed	Celling Damage	4	6
	Duct Damage	1	2
	Crack in the Car Parking Space	1	2
	Floor Damage	1	2
No Damage		58	89
Total Numbers		65	100

Table.4 Interference of lifeline

Building Damage		Total Numbers	Ratio(%)
Fully-Destroyed		0	0
Partially Destroyed	Celling Damage	4	6
	Duct Damage	1	2
	Crack in the Car Parking Space	1	2
	Floor Damage	1	2
No Damage		58	89
Total Numbers		65	100

Table.5 Attendance of employee

Attendance of Employee		Total Numbers	Ratio(%)
Confirmation of the Safety	Current Day	18	82
	At Work	1	5
	Several Days	3	14
	Total Numbers	22	100
Condition of Attendance	All Employee	2	33
	Few Employee (Neighbor)	3	50
	No Employee	1	17
	Total Numbers	6	100

Table.6 Procurement of necessities

a) Most necessities			b) Short supply after earthquake		
Requisite Goods Supply	Total Numbers	Ratio(%)	Supply Shortage after Earthquake	Total Numbers	Ratio(%)
Foods	6	21	Foods	12	27
Drinking Water	9	31	Drinking water	11	24
Dry Cell Battery	7	24	Dry Cell Battery	9	20
Electrical Lamp	1	3	Electrical Lamp	1	2
Stove Bumer	5	17	Battery Charger	4	9
Hand Warmer	0	0	Stove Bumer	2	4
Candle	0	0	Hand Warmer	2	4
Gas	1	3	Candle	3	7
Total Numbers	29	100	Matches	1	2
			Total Numbers	45	100

Table.7 Acquisition of necessary information

Acquisition of necessary information		Total Numbers	Ratio(%)
Disaster Damage in Local Communities	Obtain	16	89
	Difficult Obtain	2	11
	Total Numbers	18	100
Acquisition of Information	TV	1	4
	Radio	8	32
	Grapevine	3	12
	One Seg	3	12
	Car Navigation System (TV)	4	16
	Areal newspaper / Areal broadcast	5	20
	Newspaper	1	4
	Total Numbers	25	100

Table.8 Most serious problems just after earthquake

Item	Total Numbers	Ratio(%)
Foods Shortage	1	4
Drinking Water Shortage	5	19
Dry Cell Battery Shortage	1	4
Defect of Electrical Torch	1	4
Heat Source Shortage	1	4
Gasoline Shortage	8	31
Supply Necessaries	1	4
Power Loss	6	23
Failure of Information in Local Area	1	4
No Employees	1	4
Total Numbers	26	100

4. FACTORS AFFECTING BUSINESS RESUMPTION OF DAILY GOODS STORES

Table 9 shows the bottlenecks for partial (e.g., limited-time operation, limited-floor-space operation, storefront operation) or normal operation of daily goods stores identified on the basis of the preliminary survey and field survey results. The factors listed in the table are thought to be almost equally important during normal operation. In cases where partial operation is inevitable because of an emergency such as a natural disaster, it is most important to ensure safety of the store and its surrounding area. As for other factors, it has been found, from the results of the preliminary and field surveys of A Company mentioned earlier, that problems can be alleviated by taking appropriate measures such as restricting customer traffic or limiting operating hours depending on the circumstances.

Table.9 Bottleneck of business continuity of daily goods store

Key Factor	Partial/Time-limited	Usual
Safety of Surrounding Area	○	○
Safety of Building	○	○
Attendance of Employee	△	○
Supply of Lifeline	△	○
Necessary Goods Supply	△	○
Recovery of Production Factory	△	○
Gasoline Supply	△	○
Information in Surrounding Area	×	○

Priority: ○···high, △···middle, ×···low

Figure 4 shows a flowchart for the post-disaster business resumption process developed on the basis of information obtained concerning the business resumption of daily goods stores. The priorities shown in Fig. 4 were determined according to the degree of importance of actions, namely, ensuring safety, making personnel available and making supplies available (in descending order), by referring to the bottlenecks for business resumption of daily goods stores shown in Table 9. It is thought that long-term or permanent closure of a store can be prevented by ensuring the safety of the surrounding area and the store and ensuring the availability of personnel. With respect to the action of ensuring the availability of personnel, even if personnel cannot be made available in the number required for normal operation, problems can be alleviated by restricting customer traffic. As for the movement of goods and supplies from lifeline utilities, problems can be alleviated by such means as limited operation even if their supplies have been adversely affected.

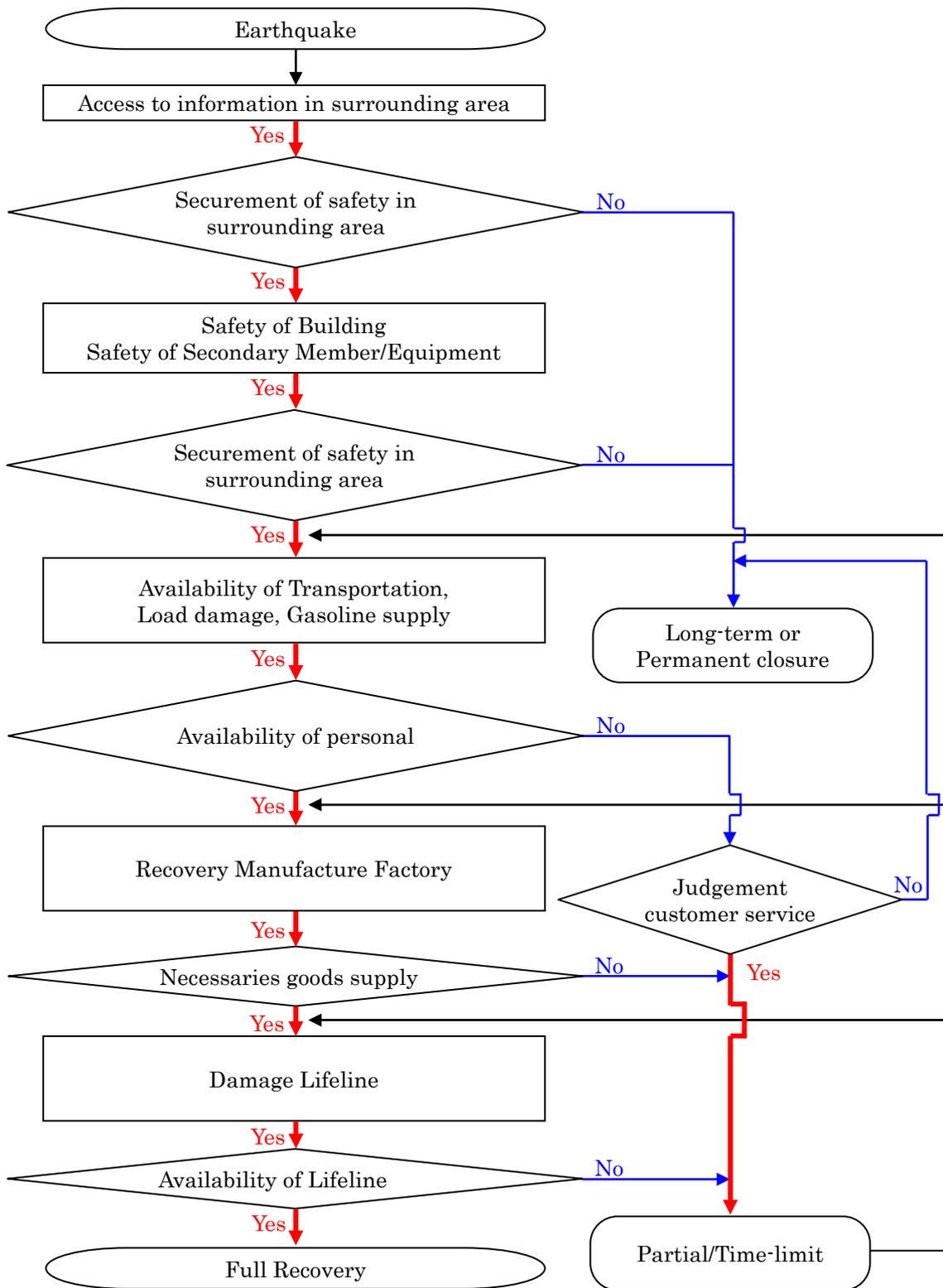


Fig.4 Flowchart for the post-disaster business resumption process

5. DISCUSSION

In this section, the store-by-store business interruption time data obtained as part of the field survey results are classified by city (Ichinoseki, Kurihara and Osaki) and examined.

Figure 5 shows the relationship between the business interruption time of daily goods stores and the seismic intensity at the different store locations. The seismic intensity at each store location was estimated by two-dimensionally interpolating the seismic intensities announced by Japan Meteorological Agency, taking into account the ground conditions (Wakamatsu and Matsuoka, 2008; Fujimoto and Midorikawa, 2003, 2006; Matsuoka and Wakamatsu, 2008; Matsuoka, 1994). The business interruption time of the stores located in Ichinoseki City tends to be shorter than those of the stores in the other areas, but the data do not show any obvious tendency depending on local seismic intensity or any significant difference among the different areas. One likely reason for this is that in the survey results, the influence of seismic intensity difference on store damage is small (Fig. 6).

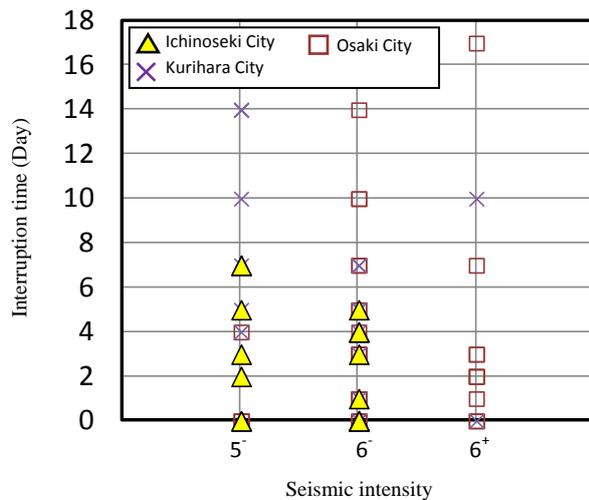


Fig.5 Relationship of between seismic intensity and interruption time

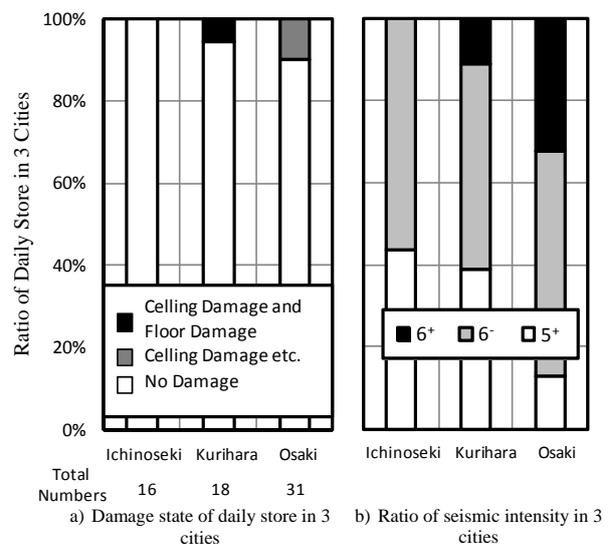


Fig.6 Ratio of damage state and seismic intensity of daily goods store in 3 cities

The results of the field survey of the daily goods stores located in the Tohoku region have shown that business recovery of a store tends to be limited (mainly, limited-time operation) until power supply to the store is restored (Tables 7 and 8). Attention was paid, therefore, to power interruption time, and the relationships with seismic intensity and the ground conditions were examined. Figure 7 shows the relationship between the power interruption time and local seismic intensity at different store locations. As shown, the relationship between the power interruption time and local seismic intensity at different store locations does not show any significant tendency. Figure 8 shows the relationship between the average shear wave velocity, AV_{s30} , in the subsurface layers in the 250 m mesh in which each store is located and the power interruption time at the store. At the stores located in Ichinoseki City, where the ground is relatively hard, power interruption time was not longer than one week, and power was restored relatively early. In contrast, at the stores located in Osaki City, where the ground is relatively soft, power interruption continued for 3 to 10 days. Figure 9 shows the business interruption time and power interruption time at different stores. As mentioned earlier, the affected stores had to continue limited operation such as limited-time operation until power supply was restored. It is thought that under such circumstances, interruption time is greatly affected by the ability of each business or store to cope with an emergency. In view of this, attention was then given to the stores that were in a condition relatively close to the pre-quake condition and were located in the areas where lifelines had been restored, instead of the stores in a limited-recovery condition such as limited-time operation.

Figure 10 shows the relationship between the average shear wave velocity, AV_{s30} , in the subsurface layers and business interruption time. Among the stores where business interruption time was longer than power interruption time, the stores located in Ichinoseki City, where the ground is relatively hard,

were restored earlier, while the restoration of the stores located in Osaki City, where the ground is relatively soft, tended to take longer.

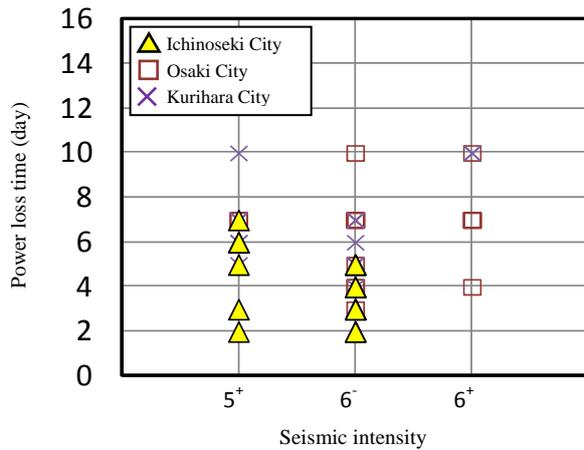


Fig.7 Relationship of between seismic intensity and business interruption time

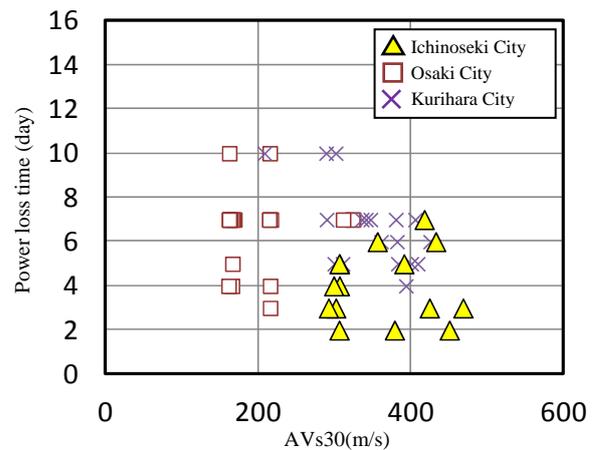


Fig.8 Relationship of between AVs 30 and power loss time

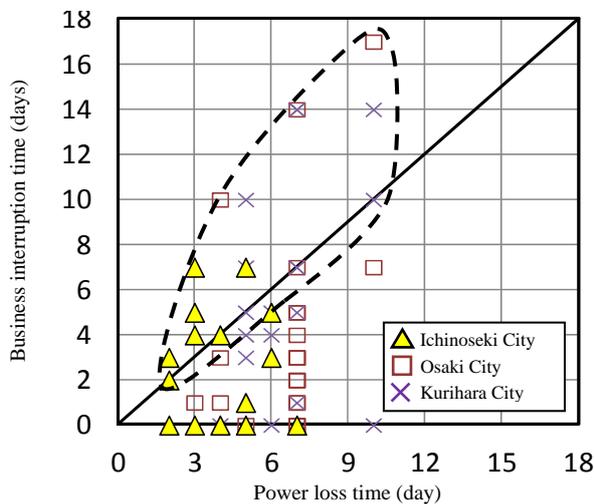


Fig.9 Relationship of between power loss time and business time in the daily store

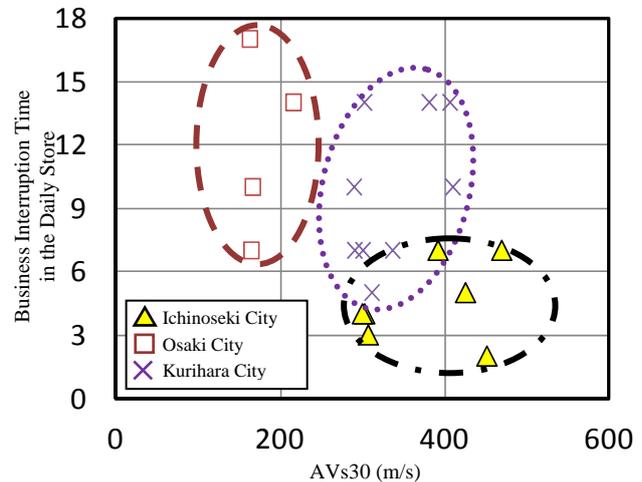


Fig.10 Relationship of between AVs30 and business interruption time in the daily store

6. CONCLUSION

In order to study the business continuity situation of daily goods stores following the 2011 Off the Pacific Coast of Tohoku Earthquake, a preliminary survey of A Company operating a nationwide chain of convenience stores was conducted concerning the response to a disaster such as an earthquake, followed by a field survey of some of the daily goods stores located in the northern part of Miyagi Prefecture and the southern part of Iwate Prefecture. On the basis of the survey results, bottlenecks for business continuation of daily goods stores were identified, and a flowchart for post-disaster business resumption was developed. The business interruption time of the stores surveyed was examined from the viewpoint of the relationship between the ground conditions of the areas where the stores are located and power interruption time. Main results obtained are as follows:

- 1) Concerning the influence of local seismic intensity on the business interruption time of daily goods stores, there was neither obvious tendency nor significant difference depending locality. One likely reason is that about 90 percent of the stores surveyed had suffered structural damage, and the influence of seismic intensity difference on store damage was small.
- 2) With respect to power supply, which is a factor greatly affecting the restoration of daily goods

stores, local seismic intensity did not show, in the survey results, any obvious tendency to affect power interruption time. In the relationship between power interruption time and the average shear wave velocity AVs30 in the subsurface layers, however, power interruption time tended to become shorter as AVs30 increased although the values were highly variable.

3) Among the stores whose business interruption time was longer than the power interruption time, the stores located in Ichinoseki City, where the ground is relatively hard, were restored earlier, while the restoration of the stores located in Osaki City, where the ground is relatively soft, tended to take longer.

The survey results obtained in this study concern daily goods stores located in inland areas where the influence of the tsunami was relatively small. As a next step, the authors intend to conduct surveys of stores located in and around the areas flooded by the tsunami and further study factors affecting the business continuity of the daily goods stores in those areas in the event of a disaster.

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