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Emergency Management for Urban Disasters due to Severe Storm - Lessons Learned from Typhoon 9119 Disaster -

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INTRODUCTION

Typhoon 9119 hit Hiroshima city in the evening of September 27, 1991, as shown in Fig. 1. This typhoon brought little rains of 8 mm, and record-braking strong winds to Hiroshima, with its maximum instantaneous winds speed of 58.9 m/s and its maximum wind speed of 36.0 m/s. As a result, the electric power distributing system in Hiroshima city had been damaged so severely that it took at most five days for recovery operations to complete. During the recovery operations, more than 600,000 people had experienced the worst lifeline functional failure in terms of both its scale and duration that ever experienced in Japan since W.W.II until Hanshin-Awaji earthquake disaster in 1995. I would like to discuss in this paper what should be learned from this urban storm disaster from emergency management point of view.

TWO CAUSES OF ELECTRIC POWER SHUT-OFF IN HIROSHIMA CITY

Hiroshima city has a large city area of 740 37 km^2 and a population of 1,085,677 (based on the 1989 census). The central part of Hiroshima city is located on the sand banks developed at the river mouth of Ohta-Gawa. This part of the city, which is called "Kyu-shigai (Old City)", is densely inhabited districts with a population of more than 600,000 people. The electric power system in this area was severely damages by the typhoon 9119. Fig. 2 shows the temporal changes of electric power shut-off rate in the central part of Hiroshima city due to the typhoon 9119. It is clear from the figure that the electric power shut-off in the central part of Hiroshima city had two different phases due to different causes.

Strong winds by the typhoon in the evening of September 27 damaged open-aired transmission and distribution cables so severely that caused the first phase of electric power shut-off in the central part of Hiroshima city. As shown in the Fig. 2, shut-off rate amounted to a 99 percent of all the contracts served by Hiroshima Branch of Chugoku Electric Company (390.000 of 394,000 contracts). It took two days

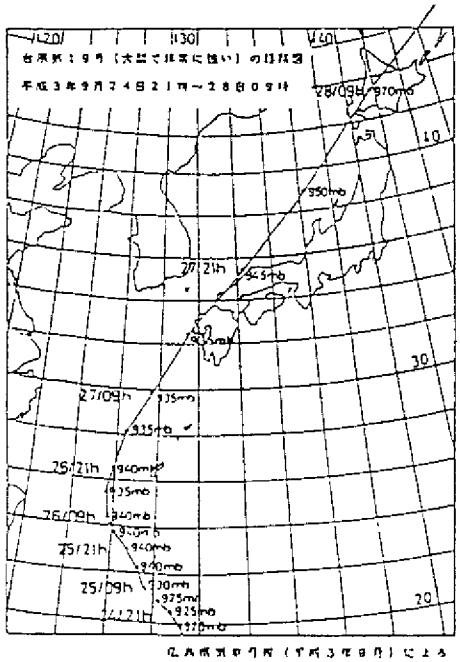


Fig. 1 The Path of Typhoon 9119

for the recovery operations to almost complete. It seemed that electric power shut-off was almost over in the night of September 29th until a small rain started to fall.

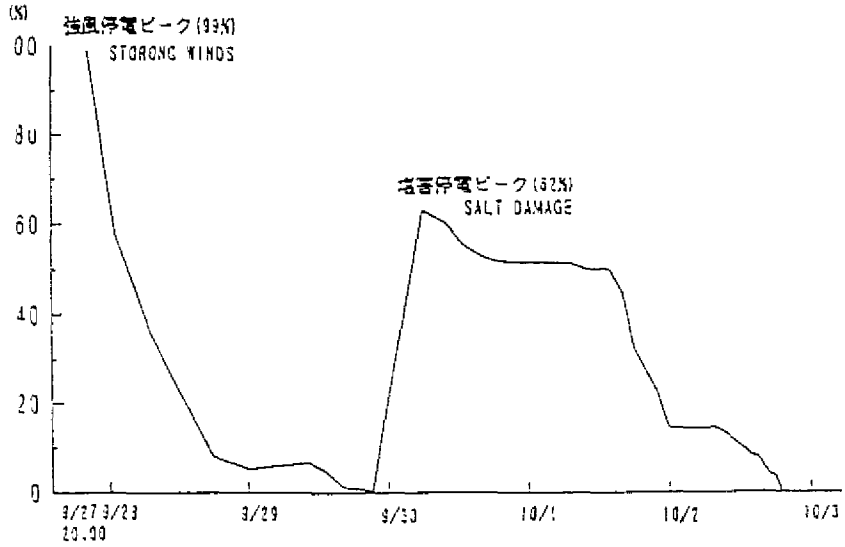


Fig 2 The Temporal Changes of Electric Power Shut-off in the Central Part of Hiroshima City

It was this rain that triggered the second phase of electric power shut-off in the central part of Hiroshima city. The shut-off rate was increased again up to a 62% by the early morning of September 30th. A severe salt damage was found to those open-aired power distributing facilities located within the regions less than 5 km from the coastline of Hiroshima Bay. In these regions, strong winds by typhoon9119 made lots of sea water adhered to such open-aired power distributing facilities as insulators and transformers installed to the electric poles. After the typhoon, water dried up and salt remained. Short circuit of power distributing system was occurred, because of the melting salt by the rain in the night of 29th. The initial strategy taken by Chugoku Electric Power Company was to ask the help from Hiroshima City Fire Department to washing out salt by fire engines. This attempt turned out to be unsuccessful so that the electric company had to change their recovery plans to replace all salt-damaged parts It took other three days for recovery operations to complete.

A SUMMARY OF URBAN LIFELINE DISASTERS OBSERVED IN HIROSHIMA CITY DUE TO TYPHOON 9119

To understand the causal structure of the urban lifeline disasters observed after the typhoon 9119, newspapers articles published in the three newspapers for the first 40 days starting September 28th were analyzed using Interpretative Structuring Modeling method (i.e. ISM). A total of 312 articles were collected based on the Chugoku Shinbun (the most popular local newspaper), and the Asahi Shinbun and the Yomiuri Shinbun (as the representatives of national newspapers), and 136 phenomena were identified for analysis by the consensus among four experts on this issue.

It was found that the "strong winds" due to the typhoon in the evening of September 27th was the prime cause of all the disasters consisted of 131 phenomena As shown in Fig. 3, the following four distinctive disaster clusters were found , all of them shared the strong winds due to the typhoon as their cause; Disasters due to electric shut-off (consisting of 57 phenomena), Disasters due to strong winds per se (14 phenomena), disasters due to high tides (34 phenomena), and disasters due to transportation paralysis (21 phenomena). It what follow, the diversity and complexity of the disasters caused by the electric shut-off will be briefly summarized in terms of 1) the vulnerability of a technologically advanced

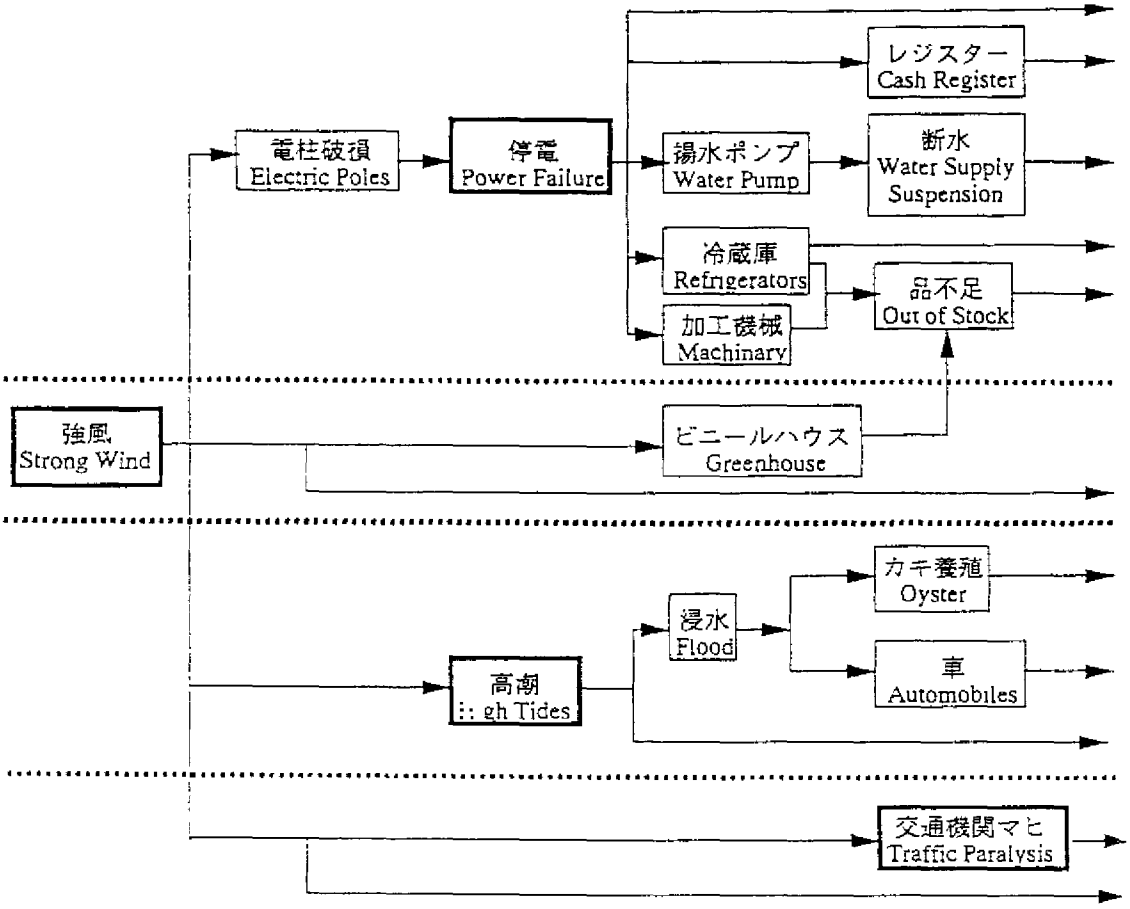


Fig. 3 Causal Relationships among Disaster Phenomena caused by Typhoon 9119

society, 2) the suspension of water supply following the electric shut-off, and 3) the logistics of the perishables.

(1) The vulnerability of a high-tech society

Various kinds of the alternate methods were sought for with the outbreak of electric shut-off. Candles and flashlight were indispensable items so that they became hard to buy during the electric shut-off period. Emergency power generators were installed in many important building structures such as the hospitals and broadcasting stations as a back-up electric system for the electric shut-off. They worked well for the first few hours until their fuels were gone. Beyond that moment, it was very rare for those institutions to have the plan for securing fuel supply for their emergency power generators in case of emergency.

Human power became to substitute those jobs operated by the electric-powered system. Traffic signals were gone, and the policemen began to control the traffic flow at intersections. Automatic transaction machines for banks and post offices were gone, and the bankers and postmen began to process money transaction by hand under candle lights. Such highly-advanced medical equipment used in the intensive care unit were gone, and artificial respiration systems were operated manually, or the patients were forced to transfer to other hospitals located in the non-electric shut-off area. Disposable syringes were used because sterilization was impossible to complete. Gas stations were closed because of pumping failure.

It was quite ironical that many security and safety devices failed to operate at the time of disaster; an advanced electronic security devices failed to operate, an automatic door lock system locked out the residents, and emergency call system at hospitals or homes for senior citizens could not reach out.

Production lines also had to be stopped so that a local car production company had to delay their shipment. Retail businesses were also damaged due to the shut-down of POS system. In many stores customers had to wait for a long time at cashier. There were stores to shorten their business hours or to stop their businesses at all.

Remote sensing systems used by the Meteorological Agency and by local businesses failed to send their records after their batteries were gone. Local public libraries were closed with the expectation of little visitors.

(2) Suspension of water supply following the electric shut-off

Suspension of water supply occurred in several hours after the electric shut-off because there were no power to pump up water to the roof of those buildings more than three stories or single unit houses built at hill sites. It created serious problems At individual household level, there was no water available for toilet, taking bath, cleaning and so forth. Schools had to be canceled because of the unavailability of water for toilet and catering for school lunch.

Various coping strategies have been taken to overcome their inconveniences. Many people stayed at hotels or pensions located at the areas where no water supply was suspended. There were sharp increase in the sales of box lunch and bottled mineral water, which became hard items to buy locally. Hiroshima City Government helped the victims by opening up fire hydrants on streets, and dispatched water wagons for emergency water supply operations. Many people had to go back and forth many times a day between their homes and water distribution points to get water.

(3) Logistics of the perishables during the prolonged shut-off

Problems occurred to marketing system of the perishable foods due to the prolonged electric shut-off. It became impossible to store the perishables in home refrigerators as well as large refrigerators for business use People became anxious about the outbreak of food poisoning problems. As a precaution measure, Hiroshima Prefectural Government had issued a food poisoning warning. Many shops and stores disposed the stocked perishables. Some burger shops chose to close their business temporarily. At some laboratory, a culture experiment was forced to terminate because of the uncontrollability of temperature conditions.

Traffic congestion during the prolonged electric shut-off made the situation worse to cause the shortage of the perishables during the shut-off period in some places and accordingly made the prices for the perishables higher in many places. In a newspaper article, it was reported favorably that a super market in the area where the electric power was shut off has a special price sale to beat the high prices for the perishables.

(4) Urban lifeline disasters and emergency management

By examining the influences of the electric shut-off for at most five days in Hiroshima city due to the typhoon9119 in detail, we can now understand how diverse and complex the disasters caused by the prolonged electric shut-off for wide area. It is a lesson we should learn from this disaster that the minimization of such indirect and functional losses due to lifeline failure is an important and new issue for urban disaster management we need a new perspective for disaster management. Present disaster management system in Japan has paid little attention to those indirect and functional losses discussed above, because of the limitation of "Saigai Taisaku Kihonho" (i.e , Disaster Management Act in Japan) which prescribes the goal of disaster management as only the protection of 1) land, 2) human lives, and their personal property.

DISASTER MANAGEMENT AS EMERGENCY MANAGEMENT

What we observed in Hiroshima city after typhoon 9119 made us to critically review present disaster management system in Japan. Japanese disaster management system has been relied heavily upon structural prevention and mitigation measures, which entertained first rate performance level in the world. It is the fact that we have not experience the storm disaster with more than 1,000 mortality since the Ise-wan typhoon in 1959. Urban functional disasters in Hiroshima city revealed that we are now reaching a stage where we should reset our goal of disaster management from the protection of human lives and their property to the protection of their quality of daily life. From this new standard, urban infrastructures performed poorly and resulted in great amount of indirect damages. In other words, urban vulnerability was still high even though the long and continuous efforts for the promotion of structural mitigation.

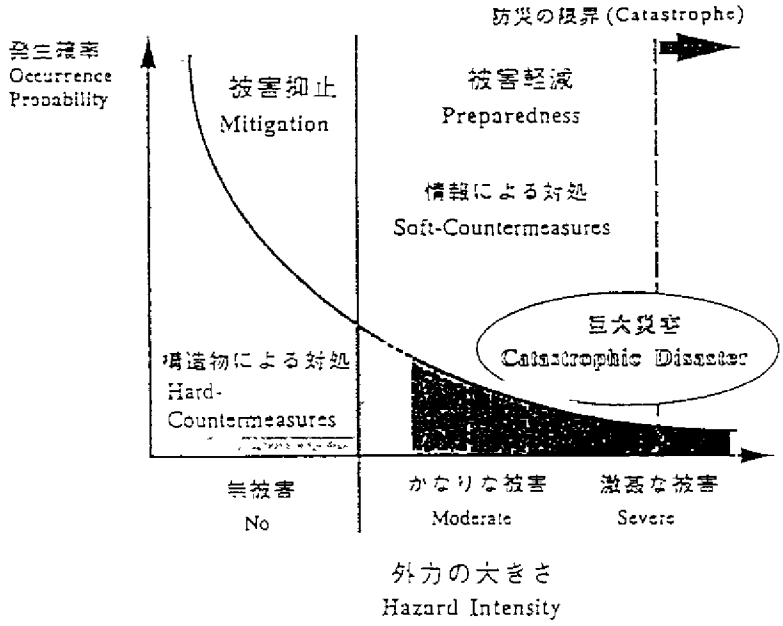


Fig. 4 The Relationship between Disaster Mitigation and Disaster Preparedness

As shown Fig. 4, there exists the limit for any mitigation measures beyond which damages may occur. We need preparedness measures to minimize the resulting damages and to facilitate recovery efforts for those disasters which exceed the limit of mitigation standard. We believe that a more well-balanced disaster management system should be established in which preparedness measures should be incorporated as the fail-safe system for structural and mitigation. The best mixture of both preparedness and mitigation should be our new goal to achieve. In what follows, we will examine how mitigation and preparedness measures worked in case of typhoon 9119 disaster.

"ISLAND OF CIVILIZATION" - A SUCCESS OF DISASTER MITIGATION

Fig. 5 and Fig. 6 shows the spatial distribution of the length of electric power shut-off for the areas served by Hiroshima branch of Chugoku Electric Company during the first and second phases. Power shut-off due to strong winds was occurred in the almost entire areas of Hiroshima city for the first phase. However, in the second phase of electric shut off, it was found like an "island" in the middle of the central part of Hiroshima city that there was an area free from electric power shut-off.

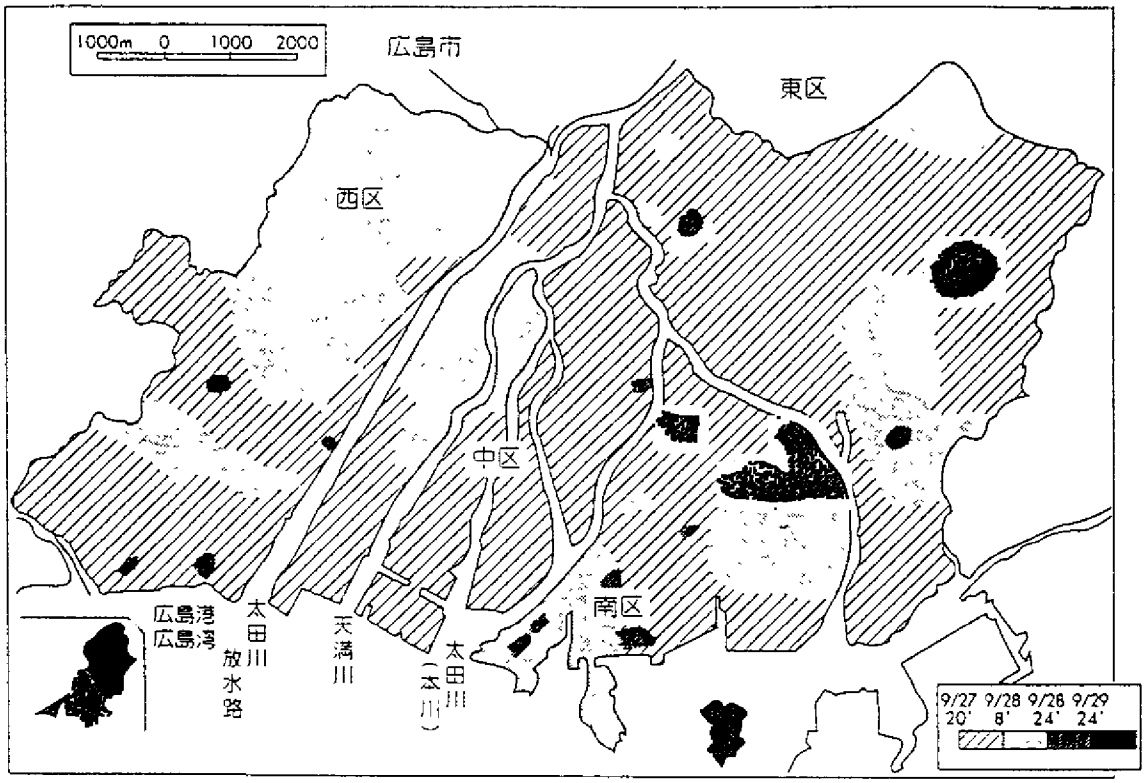


Fig. 5 The Spatial Distribution of Power Shut-off Due to Strong Winds of Typhoon 9119

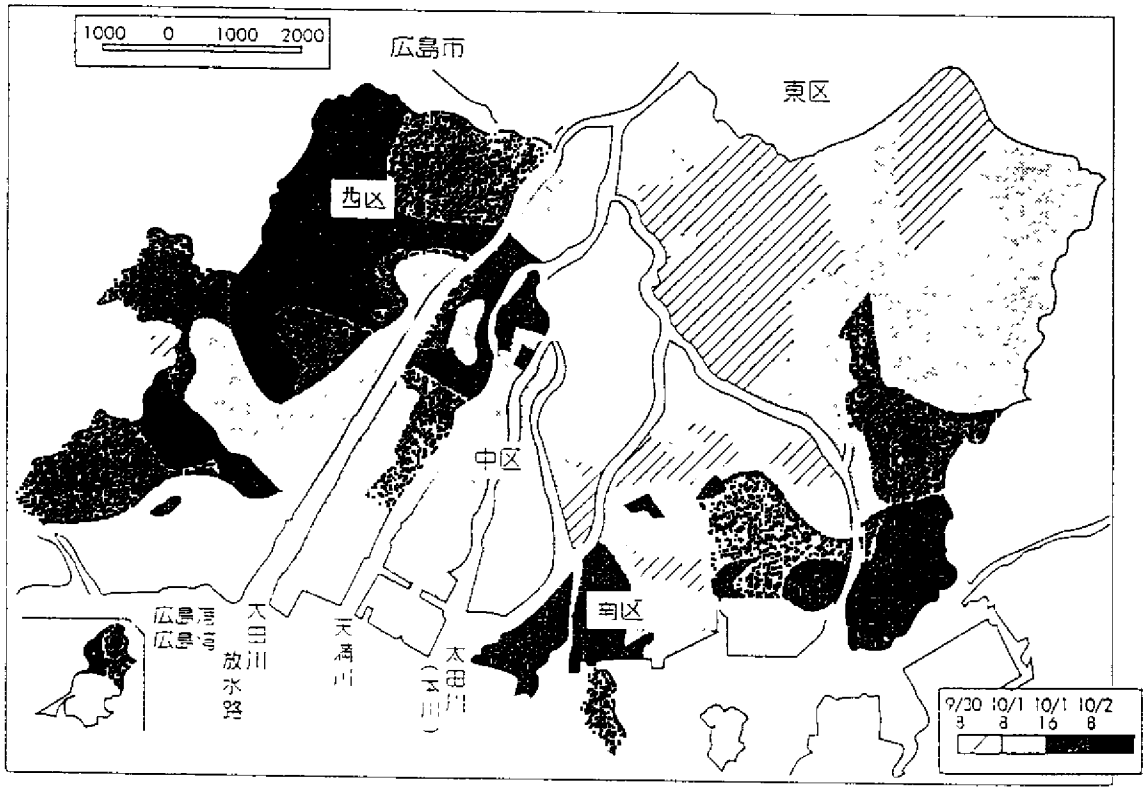
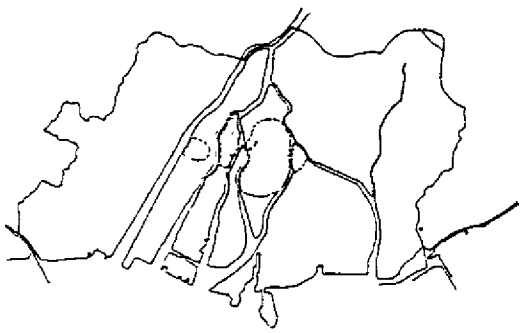
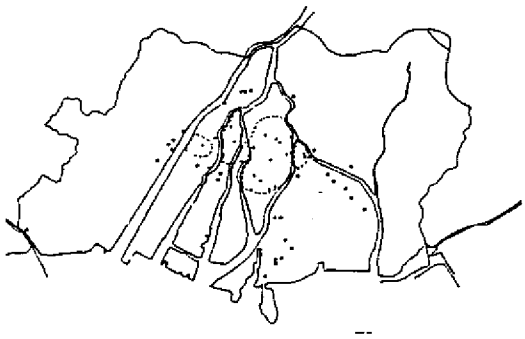


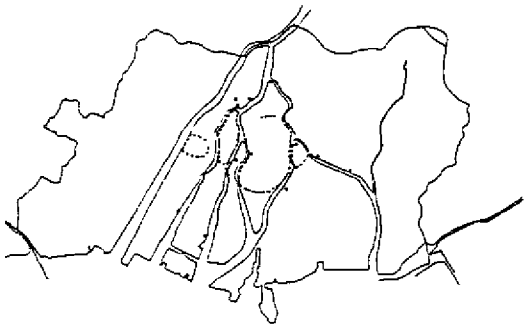
Fig. 6 The Spatial distribution of Power Shut-off Due to Salt Damage



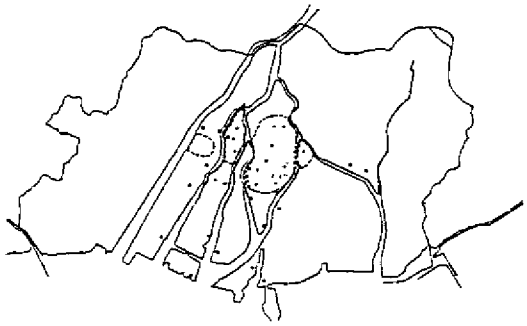
(a) The 220,000 Kw Contracts



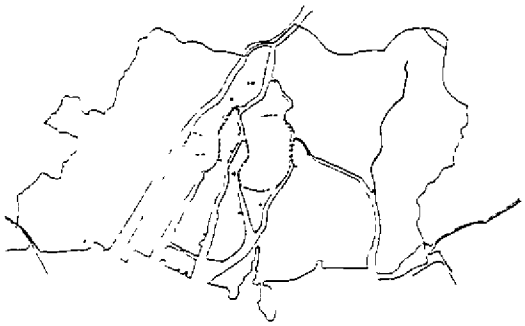
(b)Emergency Hospitals



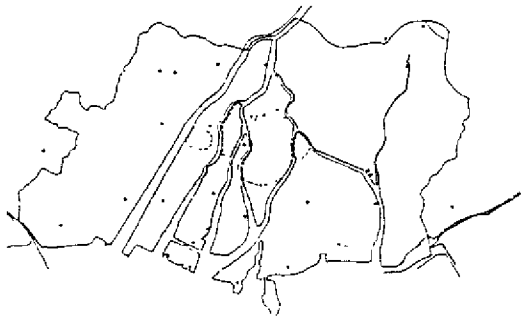
(c) Local Business Headquarters - Trading



(d) Local Business Headquarters - Construction



(e) Local Business Headquarters - Manufacturing



(f) Evacuation Sites at the Time of Disasters

Fig 7 The Spatial Allocation of Important Facilities in the Central Part of Hiroshima City

(1) Emergence of "Island of Civilization" during salt damage

It is wondering why only this particular area remained to be free from shut-off. The answer is the implementation of "Cable Box System (or CAB system)" in this area since 1986. The CAB system is the underground electric power distributing system that removes electric poles hanging high voltage distributing lines (6600V) and transformers for the safety and beautification of street. When the typhoon 9119 hit this area, the CAB system has been implemented for about 40 km long in the "island" area which remained to be free from shut-off. In conclusion, it is an evidence that the CAB system can be an effective measure to mitigate power shut-off due to typhoon.

Now, let us see how this area looks like. This area turned out to be the core of the city, where many important activities in Hiroshima city have been taken care of. In this area, there are governmental offices at various levels (regional branch of the national government, the headquarters of prefecture and city governments), business and financial centers (the regional branches of nationwide companies and the headquarters of local businesses), shopping malls and arcades, and various kinds of entertainment facilities. Even during the electric shut-off due to salt damage which lasted for at most three days, this area kept providing all kinds of social services available in this area. It seemed that this area appeared like an island of bright lights and power surrounded by the darkness. So, we named this area as the "Island of civilization".

The "Island of civilization" occupies only 6% of the total area of the central part of Hiroshima city. However, On this tiny island there exists 65 % of the big order contracts of 220,000 Kw that made by such facilities as governmental offices and department stores, and 33% of the emergency hospitals. As to the locations of the headquarters of top 50 local businesses, a high concentration on the "Island of civilization" was found both in the fields of trading (35%) and construction (45%), but not in manufacturing (8%). There are only two evacuation sites at the time of disasters on the island of civilization out of the total 28 sites located in the central part of Hiroshima city, which amounts to 7 %. In sum, however, there is a high concentration of important facilities in Hiroshima city on this tiny "Island of Civilization" as shown in Fig. 7.

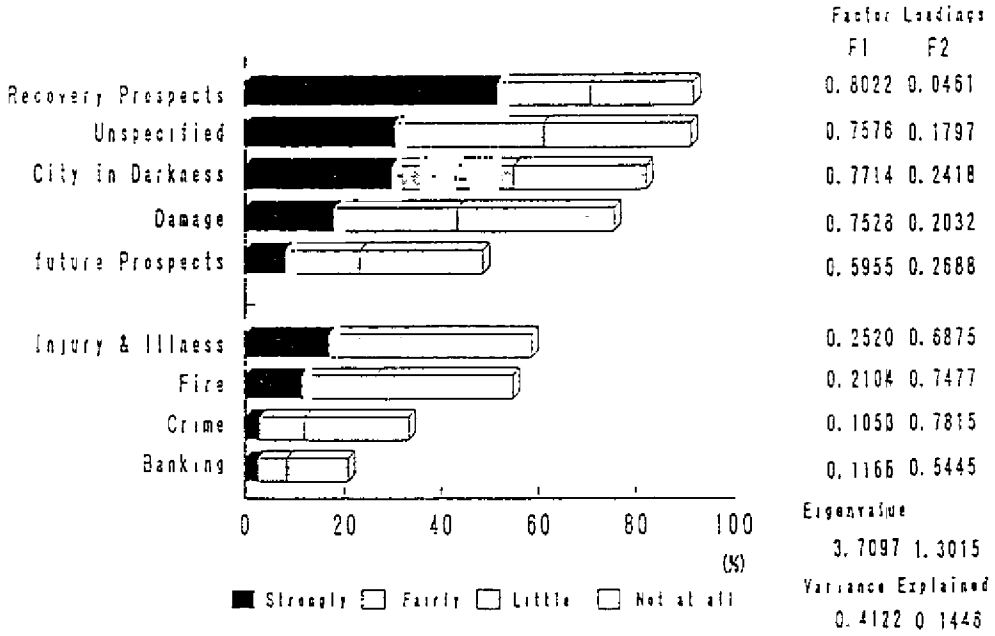


Fig. 8 The Limits of Patience with the Inconveniences due to Power Shut-off

(2) Evaluating "Island of Civilization" in terms of anxieties experience by local residents

Fig. 8 shows the kinds and their degree of anxieties experienced by the people in Hiroshima during the prolonged lifeline functional failure. The results of a factor analysis using varimax rotation identified two different kinds of anxieties; (1) People became anxious about in what way and to what extent the prolonged electric shut-off may affect their personal life, and (2) People became anxious about the stability of getting social services they need. Our survey, based on 2,145 samples, found that the local residents tended to experience the anxiety for their personal relevance with shut-off more severely than the anxiety for the stability of social services. Even during the prolonged lifeline functional failure, the people in Hiroshima worried about what was happening around their personal lives, but they still kept faith in the stability of social services such as banking, postal services, 911 services, medical cares, and retail business. In response to our interview, many people pointed out the existence of the "island of civilization" helped them to get things they needed and to get things done they had to do.

In conclusion, the existence of the "island of civilization" helped the people who suffered from five days long city-wide power shut-off due to typhoon 9119. This island was emerged as a result of the implementation of the CAB system. It is suggested as a lesson learned from this disaster that it is important for the minimization of social disorder during the lifeline functional failure to have at least one core part of the city to be able to maintain its normal functions.

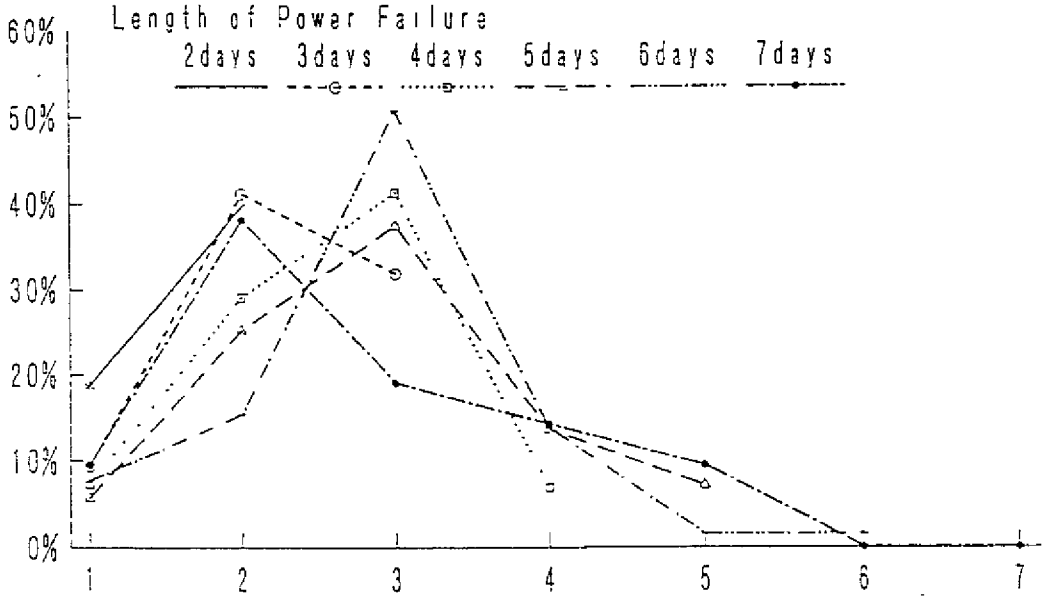


Fig. 9 The Anxieties Experienced by People in Hiroshima during Typhoon 9119 Disasters

INSUFFICIENT INFORMATION MANAGEMENT DURING THE PROLONGED SHUT-OFF - A FAILURE OF PREPAREDNESS

Based on our survey, all people in Hiroshima experienced electric power shut-off for about three days on the average. During electric power shut-off, it was accompanied by the suspension of water supply for about 50% of our sample. Since electric powered water pumps could not operate, the residents living in upper floors of multi-story building complexes and those in the houses located on the hill had to suffer water shortage in addition to power failure for about three days on the average. These results suggest that the lifeline functional failure tended to be getting more complicated and resultantly getting more severe in urban settings where people have to live more densely on the vertical direction.

(1) Limit of patience for local residents

It can be concluded from our survey that almost everybody living in Hiroshima city had to be forced to face with a new reality created by the violent chances in their natural and social environments due to typhoon. It seems clear from Fig. 9 that there was an absolute upper limit of at most three days for the people in Hiroshima on the average to put up with inconveniences regardless of the total days of the electric shut-off they experienced. This result suggests that people may have to change their coping modes for the prolonged disaster in three days. For the first three days, putting off their daily routines temporarily may be their basic strategy for coping even though all routines should be resumed once the disaster is over. People facing new reality due to disaster may start reconstructing their daily routines to adapt themselves to this new reality, which may be more stressful for the disaster victims. In such situation, people would appreciate any information which help them to increase their foreseenability and controllability for the things what is going on.

(2) Information management during the prolonged shut-off

Let us look at information seeking behavior taken by local residents during the shut-off period.

a) Information sources

Fig. 10 showed the preferences as the information sources by the local residents as to damage information and recovery information. In the figure, it was listed a total of 11 information sources; five mass media and five personal media. As to the mass media, newspapers, NHK radio, local radio, NHK TV, local TVs, and vehicle with public announcement system were selected. As to the personal media, face-to-face contact with neighbors, face-to-face contact with colleagues, face-to-face contact with friends, phone calls, and cable radio network were selected. Since the exposure to damage information was measures using multiple answer format, and exposure to recovery information was measured using single answer format, overall exposure rates were much higher in damage information as compared with recovery information. Here we will pay more attention to the residuals obtained from the regression analysis.

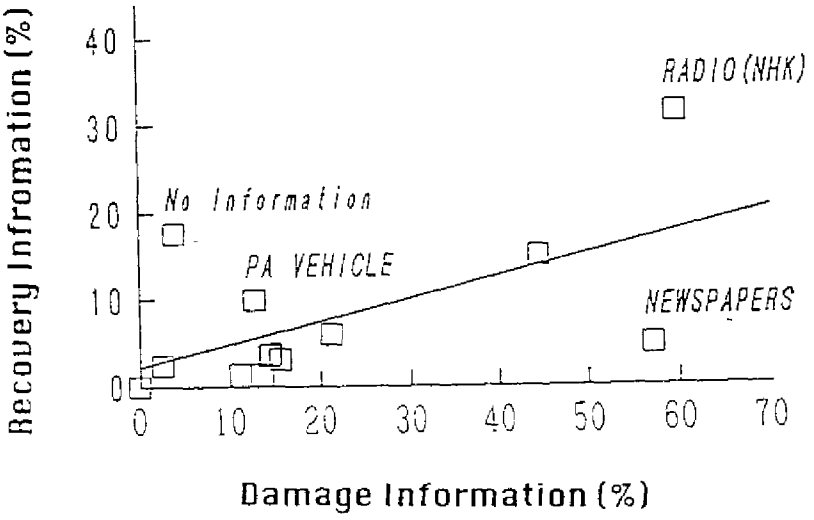


Fig. 10 Information Sources for Damage and Recovery Information

The results revealed the following facts: 1) People in Hiroshima city relied more on mass media in general that personal media as the information sources for both damage and recovery information. 2)

NHK radio had highest exposure rate among the mass media, which indicates that people regard radio as the most reliable emergency information source. 3) Newspapers covered damage information well, but they did not work as it should be as the information source for recovery information. 4) As to recovery information, vehicles with public announcement system became vital information source for very limited area. Recovery information was hard to disseminate as compared with damage information.

b) Inforamtion gap between what people want and what they got

In our survey, it was found that there existed the information gap between the kinds of information people wanted to have and the that they could acquire as shown in Fig. 11. The information people wanted to have most strongly is the information about how soon their shut-off problem will be restored to be normal. It was the most difficult information for the electric company to give. Instead the electric company kept providing the information about the overall amount and their location of shut-off, which was least appreciated by the local residents. How should we resolve this information gap?

We must look for the reason why the victims long for the recovery prospect information. In our interview with victims revealed that the victims really wanted to be kept informed that they could decide how to deal with disasters. It is thus suggested that we should provide ample factual information concerning the mechanism of disasters, strategies for recovery, and daily progress of recovery to let the victim have the informational basis for their autonomy.

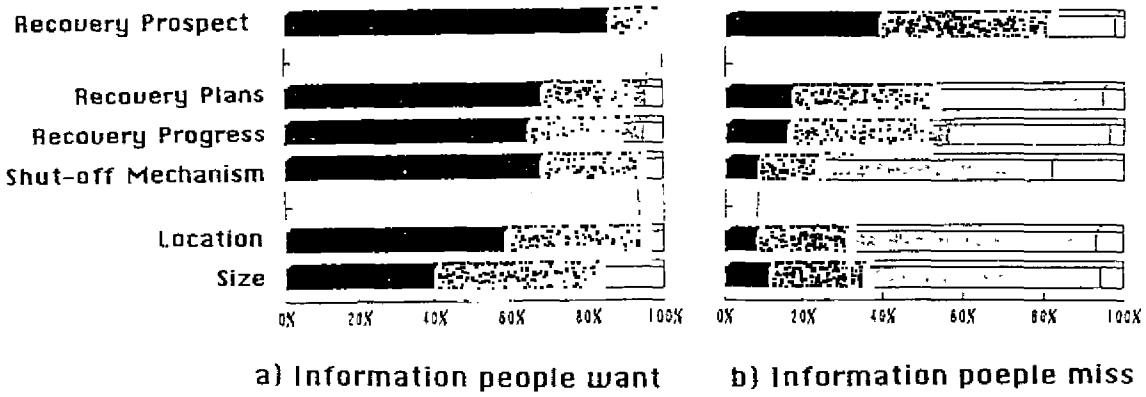


Fig. 11 Information Gaps between People Wanted to Get and They actually Got

(3) Local information flow system

Fig. 12 introduces a model for media selection for various kinds of information to provide ample factual information for the victims in the disaster impacted area. In this model, mass media and personal media should be used for different purposes. Mass media should provide the basic and common understanding what is going on and what would it be, while personal media let the victims know their personal relevance and emotional support for their ordeal. As to the mass media, not only broadcasting media but also printed media like newspapers should tale more active role as to the recovery information dissemination.

<table>
<tr><td rowspan="3">Media Type</td><td colspan="2">Mass Media</td><td colspan="2">Personal Media</td></tr>
<tr><td colspan="2">One-way communication</td><td colspan="2">Two-way communication</td></tr>
<tr><td>Broadcasting</td><td>Printed</td><td>Remote</td><td>Face-to-face</td></tr>
<tr><td></td><td>(TV & Radio)</td><td>(Newspapers etc.)</td><td>(Phone & Fax)</td><td>(Human)</td></tr>
<tr><td rowspan="4">Information Shared by Everybody</td><td colspan="2">Damage size and area</td><td colspan="2" rowspan="4"></td></tr>
<tr><td colspan="2">Damage Mechanism</td></tr>
<tr><td colspan="2">Overall Recovery Strategy</td></tr>
<tr><td colspan="2">Summary of Recovery progress</td></tr>
<tr><td rowspan="3">Information for the subgroup or individuals</td><td colspan="2" rowspan="3"></td><td colspan="2">Daily Recovery Progress Report</td><td rowspan="2">Individual Plan
Apology</td></tr>
<tr><td colspan="2">Concrete Local Recovery Plans</td></tr>
<tr><td colspan="2">Meta-information</td></tr>
<tr><td>Media Features</td><td>Quick/
Instantaneous/
Little capacity</td><td>Slow/
Long lasting/
Big capacity</td><td>Quick</td><td>Flexible</td></tr>
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Fig. 12 Local Information Flow System

CONCLUSION

Examining the urban lifeline disasters in Hiroshima city due to typhoon 9119 from emergency management point of view, it was a great success of disaster mitigation measures to have "Island of Civilization" as the result of adopting the CAB system, which is the underground electric power distributing system that removes electric poles hanging high voltage distributing lines and transformers for the safety and beautification of street. As this example indicates, disaster mitigation should be one function which should be taken into account in any city planning.

Urban lifeline disaster in Hiroshima city due to typhoon 9119 also indicates the efficient information processing at the time of disaster is the important preparedness measure we should utilize to minimize the stresses the victims and disaster workers may have. Since it needs to have long time and big money to improve mitigation standard, preparedness measures should be more emphasized to improve the overall level of disaster management. We also take advantage of mitigation by planning at any occasion for replacement of structures.

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