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PROBLEMS ON EARTHQUAKE DISASTERS IN RURAL AREA- CONSIDERATION FROM THE RECENT DAMAGING EARTHQUAKES IN HOKKAIDO, NORTHERN JAPAN

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SUMMARY

Problems on earthquake disasters in rural area are discussed through the experiences due to recent damaging earthquakes attacked Hokkaido, northern Japan. In the field of earthquake disaster engineering, main concern has been focused on the problems in the densely populated area in large cities. It is obvious that in a large city seismic risk is very high because of concentration of vulnerable structures and complex functions. On the contrary in rural area seismic risk is rather small compared with urbanised area in general but there might be different problems due to the situation of isolation and less population in wide area. From the ratio of area, the chance to be attacked by earthquakes is much higher in rural area than in urbanised area. Therefore the problems in the rural area is also important in the earthquake disaster mitigation programs. In Hokkaido, northern most Japan, we had three large damaging earthquakes in 1993 and 1994. These events attacked not only urbanised area but also more wide rural area and caused much damages in primary industrial area. In this paper, problems on earthquake disasters are discussed through the experiences of three earthquakes. Firstly, reconnaissance reports, various data in local government and organisations, newspapers and related statistics are gathered and rearranged. Secondary, damaging and recovery processes and their effects to local society are revealed for each sector and specified problems in rural area are pointed out. Finally, new approach to the disaster mitigation programs in rural area is indicated

INTRODUCTION

Hokkaido had been attacked by large damaging earthquakes within a year and half of 1993 to 1994. An outline of these three events and lessons were discussed (Kagami, 1995). These earthquake disasters caused much damages not only to buildings and facilities in urbanised area but also to primary industries of agriculture, forestry and fishery in wider area. Hokkaido is the northern most prefecture of Japan and has 212 municipalities. The area is 83.518 km^2 which corresponds to the 20% of total area of Japan. In spite of her big territory her population is 5.6 million (only 4.7% of Japan) and one third of it concentrates in the Sapporo Metropolitan area. The most of other parts of Hokkaido are less populated area and their main industries are primal ones of agriculture, forestry, fishery and mining.

METHOD FOR SURVEY

Various kinds of reports related to the three earthquakes are widely surveyed including reconnaissance reports edited by local governments and community. Local newspapers are also referred which contain many local information in affected area. Earthquake related articles from January 1993 to October 1998 are picked up and made database. In the affected area related informations were also gathered through local library and museum. In addition, interviews to persons in charge of disaster management of local governments were carried out.

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OUTLINE OF THE THREE EARTHQUAKES

Hokkaido island is situated on the North American Plate and is compressed by the two major plates of Eurasian and Pacific as shown in Figure 1. From 1993 to 1994 large scale of earthquakes occurred at the boundary of these plates. These are Kushiro-oki earthquake of 1993, Hokkaido Nansei-oki earthquake of 1993 and Hokkaido Toho-oki earthquake of 1994. In Table 1 parameters of three earthquakes and their disaster aspects are compared and listed. All the three earthquakes are large ones of Magnitude 8 class and maximum intensities were reported as 6 in JMA scale. Detailed intensity surveys were carried out through questionnaire methods distributing to each local municipalities (Kagami et al, 1996). Isoseismal contours were drawn from the estimated intensities at 212 points as shown in Figure 2. In the case of Kushiro-oki earthquake(Fig.2(a)) the region of seismic intensity 5 in JMA scale, equivalent to VII in MM scale, cover Kushiro area and elongates to west and coast directions. In the case of the Hokkaido Nansei-oki earthquake the area larger than intensity 5 is much smaller than the case of Kushiro-oki event. Figure 2(c) shows the case of the Hokkaido Toho-oki earthquake and the area of intensity 5 and more is much wider than the Kushiro-oki earthquake. Figure 3 shows which earthquake caused highest intensity to each area and curves indicates their boundary. All the epicenters were in the sea region but only the Hokkaido Nansei-oki earthquake caused serious tsunami damage. The Kushiro-oki earthquake occurred midwinter in the cold region and this characterised its disaster. At that time outside temperature was minus 7 degrees in centigrade and the surface ground was frozen down to several tens centimetres. We should understand the disaster due to this earthquake was took place under these conditions. All the three earthquakes happened to occur in not so late nighttime and most of peoples were in their own houses.

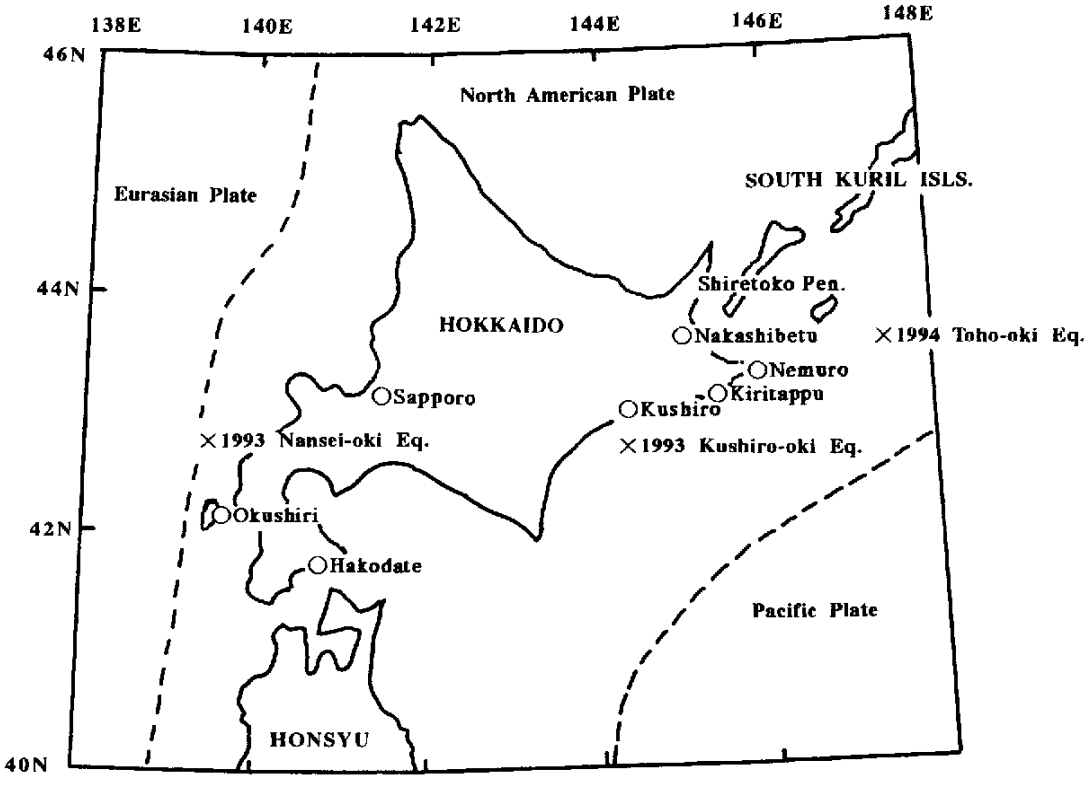

Figure 1 Location map of the three earthquakes affected Hokkaido in 1993 and 1994.

Table 1 Comparison of disaster aspects among three earthquakes

Earthquake name	Kushiro-oki	Hokkaido Nansei-oki	Hokkaido Toho-oki
Magnitude	7.8	7.8	8.1
Max Intensity	6(JMA)	6(JMA)	6(JMA)
Tsunami	None	Large	Slight
Season	Mid winter	Summer	Autumn
Temperature	Below zero	Rather high	Moderate
Heating device	In use	Not in use	Not in use
Day of week	Friday(holiday)	Monday	Thursday
Time	8 PM	10PM	10PM
Central city	Kushiro	Okushiri	Nemuro, Nakashibetu
(Population)	200,000	5,000	30,000 20,000
Dead	2	229	0
Injured	966	323	435
Housing damage			
heavy	53	601	39
Moderate	254	408	382
Fire	9	189(burned)	1
Total loss	55	132	57 billion yens

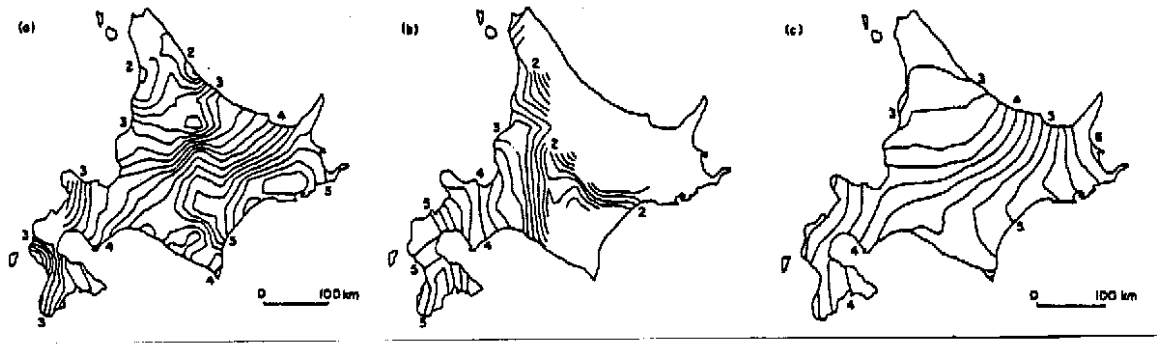

Figure 2. Isoseismals estimated by questionnaire survey (Kagami et al, 1996). (a)The 1993 Kushiro-oki, (b)The 1993 Hokkaido Nansei-oki and (c)The 1994 Hokkaido Toho-oki earthquake.

Figure 3. Map showing which earthquake caused highest intensity to each municipalities and their boundary.

STATISTICS OF MONETARY LOSS OF THE EARTHQUAKES

Earthquake damage data are collected and counted by local municipalities and summarised by the central prefectural government. Damages are classified into items of Human casualties, Dwelling houses, Other buildings, Agriculture, Public constructions, Fishery, Forestry, Sanitary facilities, Commerce and industry, Public educational facilities, Social educational facilities, Welfare facilities and Others. And each item is consist of several categories and total number of cases and monetary amount of loss are listed. From the final versions of the reports, only monetary loss of each items is picked up and listed in Table 2.

Table 2. Monetary loss of three earthquakes in million yens

Item	Kushiro-oki	Nansei-oki	Toho-oki
Dwelling houses	2555	12069	5671
Other buildings	147	888	4
Agriculture	4386	13212	2667
Public constructions	21396	52263	27272
Fishery	1609	13429	2129
Forestry	1731	21737	1044
Sanitary	918	838	935
Commercial	16577	13081	10081
Public education	1186	2535	482
Social education	997	448	639
Welfare	231	471	145
Others	3285	931	6178
Total	55024	132308	57339
Affected municipalities	99	60	63

Total amount of monetary losses are 50, 132 and 57 billion yens for Kushiro-oki, Nansei-oki and Toho-oki earthquakes respectively. Nansei-oki damage is twice of that of the others. As for the damage to dwelling houses shows about 5% in the case of Kushiro-oki which is about half of that of Nansei-oki and Toho-oki. Damage of public constructions such as road, bridge, port and river embankment, have biggest share of 40 to 50% for each earthquake. Fishery damage is remarkable in the case of Nansei-oki because of severe tsunami attacked Okushiri island and coastal villages on the main island. Forestry damage is also remarkable in the case of Nansei-oki. On the contrary as for the commercial damage in the case of Kushiro-oki its share reaches to 30% because that affected Kushiro city is the central city in eastern Hokkaido. Thus percentage among damaging items shows clear regional characteristics.

DAMAGE TO PRIMARY INDUSTRIES

Damaged area by the three earthquakes are indicated in Figure 4. Among the damaging items primary industries are discussed here and damages due to three earthquakes are characterised as follows.

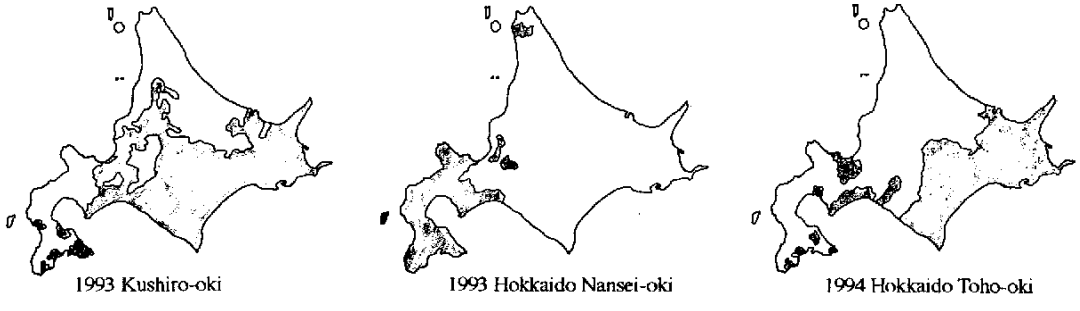

Figure 4. Damaged area by the three earthquakes.

Agriculture

Damage of agriculture appears from low seismic intensity of less than 4 in JMA scale and therefore affected area was very wide for each earthquake. Especially agricultural facilities such as irrigation channel, embankment of earth dam and so on are very vulnerable and caused much amount of monetary losses even in low intensity regions. Many aged silos and barns are still remaining due to sluggish of agriculture and some of them are damaged. In the case of Nansei-oki earthquake, rice field was damaged by the flooding and deformation of land due to liquefaction. Toho-oki earthquake affected to the dairy farmers too and cow breedings were disturbed by the shortage of water supply for a long time. After this earthquake two families were gave up farming and moved because of additional restoration cost to holding debt.

Fishery

All the three earthquakes attacked coastal fishery villages. During the Kushiro-oki earthquake 102 fishery and 4 regional harbour were damaged. The Kushiro harbour which is one of the biggest fishery base in Japan, was severely damaged due to collapse of piers and subsidence of back yards by liquefaction. In the process of restoration the Toho-oki earthquake occurred and damaged again where reinforcement for anti-liquefaction were not done yet. Nansei-oki earthquake accompanied very large tsunami and caused sever damage to the fishery. Okushiri island and western coastal lines of the mainland of Hokkaido were attacked by tsunami and harbour facilities were destroyed and also caused sever damage in fishing boats (676 were lost) and fishing implements. Fishing places near coast were also destroyed by tsunami waves and coastal fishings had been stopped for long time.

Forestry

Damages of forest trail are dominant due to land sides. In the case of Nansei-oki earthquake large avalanches caused sever damage in the forest of Okushiri island. It took much time and effort to identify damaged area and helicopter was used to the survey. Forestry factories were also damaged due to the Kushiro-oki earthquake.

Mining

In Hokkaido coal mining used to be one of the most important industry until 1960s and there were many coal mines but nowadays only one mining is operating at the offshore of Kushiro. During the Kushiro-oki earthquake there was no damage at gallery beneath the sea. No much damage are reported for other mining industries.

PROBLEMS IN RURAL AREA

Damages due to the three earthquakes include special problems related to the rural area and these are rearranged by the following keywords.

Immediate response by local government

In rural municipalities, population has been decreasing especially in young generations and financial base is also poor. Therefore, immediate response after the occurrence of earthquake is forced to start with less manpower and resources. And more, it must cover wide area compared less population and it accelerates the difficulty in emergency response which should be done based on damage information. From the stage of gathering damage information it take much time to cover the entire territory and it cause the delay of next response. For examples, during the Toho-oki earthquake it took much time to check whole road and to identify the damaged part of water supply system.

Medical treatment

In Hokkaido there are not few municipalities where only one medical doctor lives and local hospital and clinics have difficulty of keeping doctors and stuffs in daily medical treatment. High lever medical treatments are entirely depends to large hospitals in the central cities of Kushiro and Hakodate. At the occurrence of earthquake disasters medical treatment have many troubles in rural regions. Most of heavy injured peoples can not be treated nearest clinics or hospitals and are transported to the large hospitals in the central city. For examples, during the Nansei-oki earthquake, many injured peoples were transported as shown in Figure 5. In Okushiri island there were one hospital in Okushiri main town and one clinic in Aonae, which settlement was destroyed completely by tsunami and earthquake fire. At the time of earthquake occurrence doctor was absent in

Aonae and aid from Okushiri could not reach due to road interruption. Medical treatment was started at the next morning by Self Defence and Red Cross Medical Teams from Sapporo, the capital of Hokkaido. At the time of Toho-oki earthquake, a woman injured by car dropping to the road cracks was sent to the hospital in the next town but due to the damage of X-ray facility, she was sent again by helicopter to Kushiro. In the medical treatment in disaster more linkage among hospitals are needed.

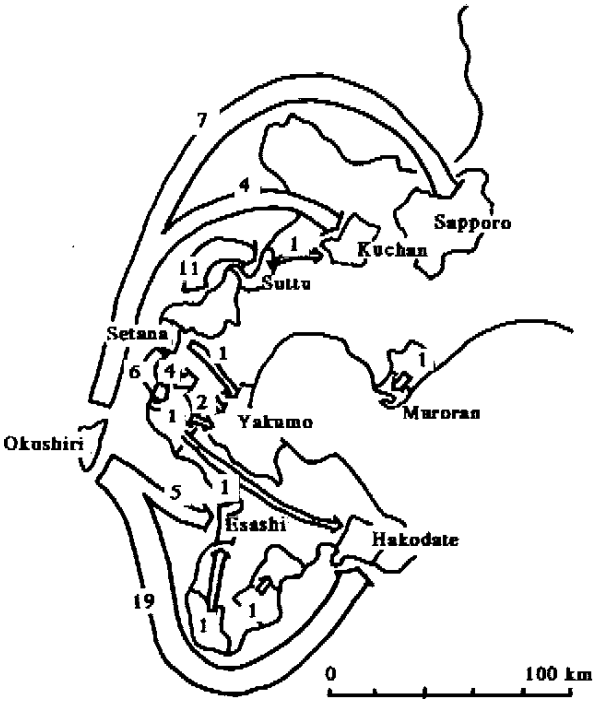

Figure 5 Number of inpatients transported from the disaster area of the 1993 Nansei-oki earthquake (after Murakami, 1995).

Transportation

Most transportation must depends on private cars in rural area because that local railroads had been demolished and public bus service is difficult to maintain under the conditions of decreasing population and mortorizations. Total length of road is very long comparing population and there are many vulnerable filled road crossing small rivers in the eastern Hokkaido. Along coastal lines small settlements are situated and connecting roads are constructed cutting steep cliff. Rock falls interrupt these road and in case of dead end road settlements are isolated for a long time. For examples, three settlements at Shiretoko peninsula, northeast end of Hokkaido, were isolated due to danger in rock fall after the Toho-oki earthquake and fishing boats were chartered temporary. In addition to the problem of dead end road, there are many places where villages are connecting with single road and no detour route. Isolate island has serious problems. For the typical examples Okushiri island has two ferry lines and one air commuter line to Hakodate and dairy life was supported with surrounding cities. At the Nansei-oki earthquake, ferry was interrupted for two days due to pier damage. It took two more days to reopen airlines because the restoration of runway pavements needed asphalt materials which was brought by recovered ferry route. At the isolate island, most of materials are depended to outside and transportation is very important.

Restoration of lifelines

In rural area, especially dairy farm area, houses are scattered in wide area and total length of lifelines become long comparing the number of users. Therefore, it took much time and effort from finding damaged site to restoration process. Lifelines are indispensable not only for citizens life but also primary industries. Cow breeding farming needs much water for cow's drinking and washing for milker but at the process of restoration, recovery of drinking water supply was prior to that of agricultural use.

Lack of disaster information

In general disaster information is easy to concentrate to big cities but in rural area it take much time to receive those information. From our interviews after the earthquakes local people complains lack of disaster information. For examples TV shows only damage in big cities.

COUNTERMEASURES AFTER THE EARTHQUAKES

After these earthquakes disaster mitigation programs are promoted by local governments. The Great Hanshi-Awaji Earthquake Disaster of 1995 gave us much impact for all over the country even to Hokkaido and this activities were accelerated.

Revise of disaster mitigation programme

Among the various countermeasures, revising disaster mitigation plan have been started at first. Described articles in the plan are checked and revised referring the experiences of the earthquakes occurred in Hokkaido. These are countermeasures for tsunami and liquefaction, immediate response, quick restoration and so on. From the experience of Hanshi-Awaji Disasters, new items are also added to the plans. The maximum seismic intensity was 7 in JMA scale, equivalent XI-XII in MM, and shows much higher collapse rate of dwelling houses than the three earthquakes in Hokkaido. It conclude that much higher intensity should be considered. The other items are utilising voluntary activities, mental care problems, and so on. Almost of all municipalities revising the plan was started. These information were transmitted to the local peoples distributing booklet or pamphlet with maps showing risk in the region. For examples, in Kushiro city inundation risk map is prepared using the result of the simulation of tsunami.

Cooperation of local governments

In rural area it is difficult to face up to disasters by a single local municipality and cooperation with surroundings are indispensable. Agreements of cooperation during disasters have been contracted among central city and surrounding towns and villages on support each others. A linkage among local cities are also contracted. On medical service high level treatment is limited to the central hospital in large city and network of hospitals and clinics operate in dairy activities. In case of disaster more strong network is needed and contracts among medical facilities have been agreed.

Countermeasures for Tsunai disaster

Both Nansei-oki and Toho-oki earthquakes caused tsunami disasters to the coastal area of southwestern and eastern part of Hokkaido. These areas are faced to the plate boundaries which cause large scale earthquake accompanying tsunami and the eastern coast have a high possibility for another type tsunami by far earthquakes occurred around the whole Pacific ocean. For these area countermeasures for tsunami disaster are the first priority problem among various countermeasures. At first risk maps for inundation were prepared and distributed to people for enlightenment of site risk and evacuation method. A tide embankments have been constructed in these area. For examples in Okushiri, high embankment was made after the Nihonkai-chubu earthquake of 1983 considering maximum tsunami height of the site. However 1993 earthquake tsunami was higher than that of 1983 and could not resisted. After the earthquakes embankments were rebuild and levee raised. Maintenance of water gate of the embankment is also important. In the case of Toho-oki earthquake, at Hanasaki harbour, Numuro, water gate was not closed because of its deformation and caused inundations. In Aonae, Okushiri island, new housing lots were developed filling a soil for 6 meters high to protect from tsunami. Evacuation facilities with rigid structure are useful in high risk area, and many facilities were constructed after the both earthquakes. For examples, at Kiritappu situated on land-tied island in eastern coast, new recreation center with hot spa was open. This facility has a function of refuge place in case of tsunami disasters. Evacuation routes were also prepared with stairs climbing up to hills behind residential area and their signs in many palaces. Maintenance of these facilities especially in winter time is dispensable because these area is snowy cold regions. However most of these facilities are covered by snow in winter time.

Wireless disaster information system

Wireless information system connecting local government with each household have been constructed. This system is very powerful for transmission of tsunami warning and information. After the earthquakes this

system have been installed from coastal area. However these installation has not reach to the whole inland area and there is a regional differential in service.

CONCLUSION

Through the case studies on earthquake disaster and their influence to regions for the recent three damaging earthquakes occurred in Hokkaido, northern Japan, problems in rural area were discussed and revealed. Specified problems in rural area were extracted from the feature of damages to primary industries and their countermeasures were also discussed. For rural regions the following problems are pointed out.

1) Difficulty of emergency response

2) Importance of emergency medical treatment

3) Vulnerable transportation

4) Maintaining and restoration of lifelines

5) Lack and unbalanced information

All the problems listed above are come from less population in wide area and show strong contrast to that of in urbanised area with high population density. We should pay more attention to the problems in rural area. For these problems various measures have been adopted especially after the recent earthquakes. The following measures are proposed for the future regional disaster mitigation programs in rural area.

1) Strengthening of structures against earthquake

2) Robust transportation system

3) Strengthening of lifeline system

4) Construction of information network

5) Utilisation of manpower and resources

6) Disaster education and enlightenment

Measurers 1) to 4) are fundamental ones but it take much effort especially to clear in financially. It is very difficult and not practical to promote these measures with an only purpose of disaster prevention. To grade up the potential for disaster resistibility has the same direction with the improvement of daily convenience. These measures should be promoted with pursuit of daily amenity.

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