GOING TO DESIGNATED MAIN ACCOMMODATION SHELTER IN SCHOOL DISTRICT OR THE NEAREST SHELTER IN THE CITY

- A Case Study of Kanazawa City, Japan -

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1. INTRODUCTION

In Kanazawa city, there are 212 evacuation shelters (shiteihinanbasho in Japanese, hereafter accommodation shelters) that do not include parks and squares. 69 of them are main evacuation shelters ((kyotenhinanbasho in Japanese, hereafter main accommodation shelters or main shelters) that are primary schools, community centers, and other centers while the rest of evacuation shelters are secondary schools, high schools, community centers, and university's gym. According to the current policy on earthquake evacuation strategy in Kanazawa City, Japan, people are required to go to main shelters designated (hereafter designated shelter) in their primary school district (hereafter school district) for evacuation firstly, and in the case if the main shelters in a school district cannot meet the number of all the evacuees, other accommodation shelter in the same school district will be used to serve the evacuees. The reasons for this is that because these main shelters are primary schools and community centers, people all know about them well and people who live in the same school district may feel easy to stay in evacuation shelter together because of their acquaintance. However, in many cases, the designated shelter is not located in the center of the school district, so they are not the nearest shelters from people's houses located in the same school district. This made a conflict with the planning standard for choosing locations of evacuation shelters which is stated that each area with a radius of 2 km should be designated a main shelter in the center in order to support accommodation to evacuees during the disaster [1]. In other words, people should go to the nearest main shelter (nearest shelter) from their houses although that shelter is not located in their school district. Therefore, some question comes up to planners and policy makers that are 1) whether or not the current evacuation strategy followed the planning standard, 2) These two above scenarios: going to designated shelter in school district (hereafter scenario 1) and going to the nearest shelter in the city (hereafter scenario 2) which scenario is better and convenient for people. This research contributes a method for making a comparison between two scenarios of evacuation at the emergence stage of rescue and relief (3 day after the earthquake) based on the total evacuation distance that evacuees have travel to each main shelter and service areas of main shelters. The research may provide a visualized reference to planners and local government for reviewing the current shelter planning and current evacuation strategy in practice as well as advantage of going to the nearest shelters.

Besides of planning standard of shelter location choice in Japan mentioned above, in theory, many authors all over the world showed that minimum total distances from people's damaged houses to shelter is one of the criteria considered for selecting shelter location [2, 3, 4, 5]. Moreover, Soltani et al. [6] pointed out that the shortest distance from the evacuees' houses to shelters is one of two criteria proposed in most researches that he reviewed. Conversely, in practice in Kanazawa City, people were asked to evacuate at designated shelters in their school district although in many cases, the distance from those shelters to their houses is far away comparing with other shelters located in other school districts. Moreover, though it is said that it is convenient and comfortable to people living in the same school district for staying in evacuation shelter together, there are a lot of school districts in Kanazawa City where people live in a same Chos in Japanese, a local administrative unit in Japan) or Chomes (in Japanese, a smaller administrative unit of Cho) but belong to different school districts, such as, Izumi school district, etc.

The aim of this study is to make a comparison on evacuation strategy between two scenarios: going to designated shelters in school districts and going to nearest shelters by considering total evacuation distances from people's houses to main shelters and service areas of shelters.

2. METHODOLOGY

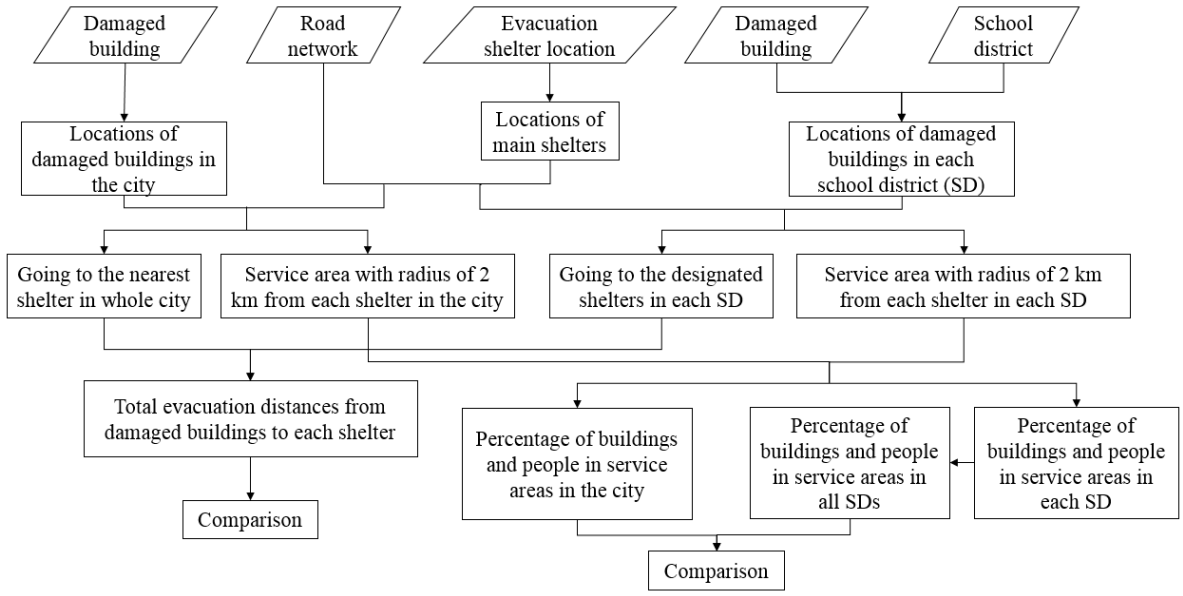

Fig.1- Flowchart representing a procedure for comparing service area and total evacuation distance between two scenarios

2.1. Data collection and preparation

Data on basic survey of urban planning in Kanazawa City that includes damaged building (locations of damaged buildings were calculated based on buildings data, fragility curves, and distribution of seismic intensity, and then exacted into damaged building data), road network, school district, evacuation shelter location (table 1) are collected from Kanazawa local government and prepared in ArcGIS software for calculation and simulation.

Table – 1 Data collection

No	Name of data	File type	Source	Usage
1	Damaged building	Shape file	Predicted based on building data	Shelter choice simulation.
2	Road network	Shape file	Kanazawa local government	
3	Evacuation shelter location	Shape file	Kanazawa local government	
4	Primary school district	Shape file	Kanazawa local government	

2.2. Shelter choice simulation

A simulation in which evacuees based on the road network to go to shelter for evacuation was conducted in two scenarios. In the scenario 1, evacuees were required to go to the 66 designated shelters in 62 school districts (some school districts have two main shelters, such as, Daitoku school district, Tagami school district,…) in Kanazawa City. In the scenario 2, people were asked to evacuate at the nearest shelter [7] of 66 main shelters from their houses in the city. The simulation was conducted by using network analysis function in ArcGIS software. And the simulated results show the number of evacuees and total evacuation distance at each shelter.

2.3. Comparison between two scenarios

The service area of each shelter according to two scenarios was created by using the network analysis function in ArcGIS software in order to examine how many percentages of evacuees could be served by the shelters. The size of the service area of each shelter was set as an area with a radius of 2km that was written on the planning standard for choosing shelter location in Japan. The scenario in which service areas of shelters could covers more evacuees is better than another one. Furthermore, from the simulation results, the total evacuation distance that evacuees have travel at each shelter in two scenarios was compared. The scenario with shorter total evacuation distances from evacuees' houses to shelters is better than another one. The procedure for comparing two scenarios was represented as figure 1.

3. ASSUMPTIONS

We made some assumptions for calculation and simulation as following. 1) The earthquake occurred at night (4 AM); 2) The earthquake was caused by Morimoto-Higashi fault. Its seismic intensity distributed in the whole city with the JMA of 5 to 7; 3) From 21 kinds of buildings with different functions of building data, there are five kinds that most people always stay at night that are house, house with shop, house with workplace, apartment, and apartment with workplace.

Therefore, we assume that all people live in these five kinds of buildings. 4) According to a report on earthquake disaster assessment in Kanazawa City, buildings with an area of less than 20m^2 is not considered for predicting building damage due to earthquake [8]. Therefore, based on the result on the building area of each building, we ignored buildings that have an area of less than 20m^2; 5) Because prediction of burned buildings was complicated and it will be another work as our further research. Therefore, in this study, we only focused on buildings with heavy and moderate damage (hereafter damaged building); 6) People whose houses are damaged heavily and moderately are required to go to main shelters for evacuation; 7) Road blockade caused by damaged buildings' debris was not considered in this study because it is our further research. 8) Predicted number of damaged building and evacuees were derived from the reference number 9 (table 2). The number of evacuees were total population of damaged buildings and it was calculated based on a method proposed by Thanh et al. (2015) [7]. These data were used as input data for the simulation on shelter choice; 9) Because 3 of 69 main shelters were located outside of the road network, only 66 main shelters were used as the input data for the simulation.

Table 2 – Number of damaged buildings and evacuees [9]

Kinds of buildings	Number of buildings	Number of damaged buildings	Number of evacuees
House	125904	26035	66340
Apartment	10289	992	7504
House with shop	8467	1978	3490
Apartment with shop	1388	142	1002
House with workplace	2114	540	999
Total	148162	29687	79335

4. RESULT ANALISYS AND DISCUSSION

This research created service areas with a radius of 2km of each main shelters according to two scenarios based locations of main shelters and road network using the network analysis in ArcGIS software (figure 3 and figure 4). The service area also presented number of damaged buildings and evacuees served by each main shelter. Figure 2 showed an example on service areas of Oshino primary school (shelter 57) according to two scenarios. The service area in scenario 1 covered 1357 evacuees while the number of evacuees covered by the service area in scenario 2 was 1480. In addition, the total evacuation distances from all evacuees' houses to Oshino primary school in scenario 1was about 338,788km while that of scenario 2 was 358,512km.

Moreover, the results on service areas of shelters showed that the service areas of shelters in the scenario 2 covered more buildings and evacuees than those in scenario 1 (figure 5 and figure 6). In more detail, most of buildings and evacuees were served by main shelters in scenario 2 and the percentages of them were 99.43% and 99.62% respectively. While in the scenario 1, the service areas of shelters covered 97.92% of total damaged buildings and 98.01% of total evacuees. Furthermore, from the figure 6, in the scenario 1, about 1600 evacuees (1.99%) live outside the service area with a radius of 2km while that in scenario 2 was about 300 evacuees. This means that about 1300 evacuees could not be served by the main shelters in scenario 1 but could be served in the scenario 2. In other words, there were some main shelters located in other school districts nearer than designated shelters in the same school district from these evacuees' houses. Therefore, it was proofed that in many cases, the designated shelters in school districts were not the nearest shelters from the evacuees' houses located in the same school districts although from the planning standard for choosing shelter location, these designated shelter should be the nearest one from a certain evacuee's house.

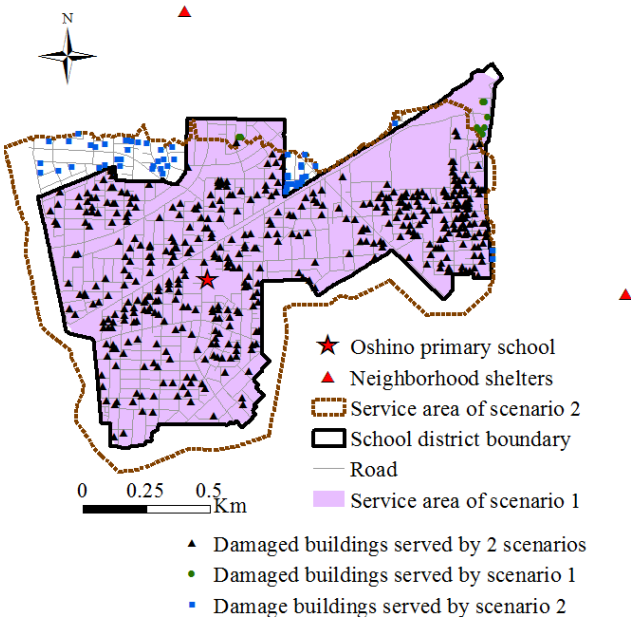

Fig. 2 – Service areas of Oshino primary school (shelter 57) in two scenarios

Besides that, based on the shelter choice simulation for evacuation, the total evacuation distances from damaged buildings to each main shelters according to two scenarios were calculated (figure 7). From the figure 7, in many shelters, the total evacuation distance of scenario 1 were 20km longer than that of scenario 2, such as shelter 4, 15, 34...Although the reason was that there were more evacuees in these shelters of scenario 1 than that of scenario 2, it indicated that locating

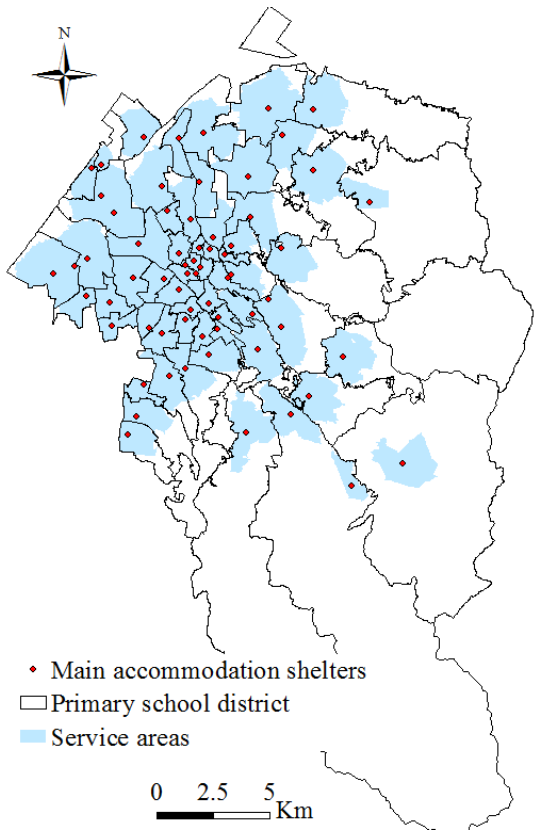

Fig.3- Service areas of shelters in scenario 1

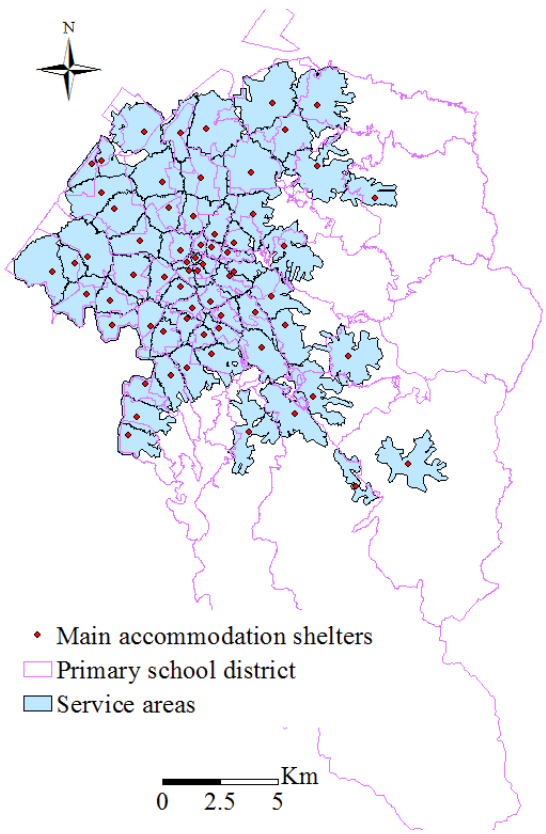

Fig. 4 – Service areas of shelters in scenario 2

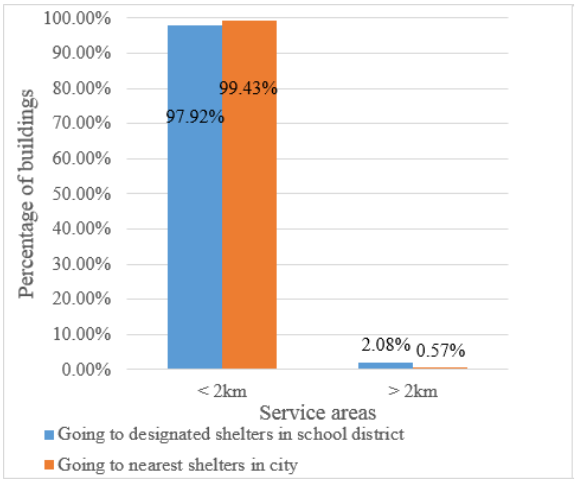

Fig.5 – Percentages of buildings inside and outside of service areas

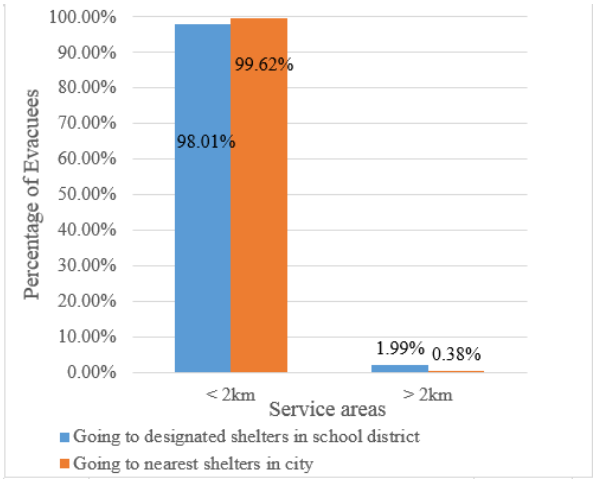

Fig.6 – Percentages of evacuees inside and outside of service areas

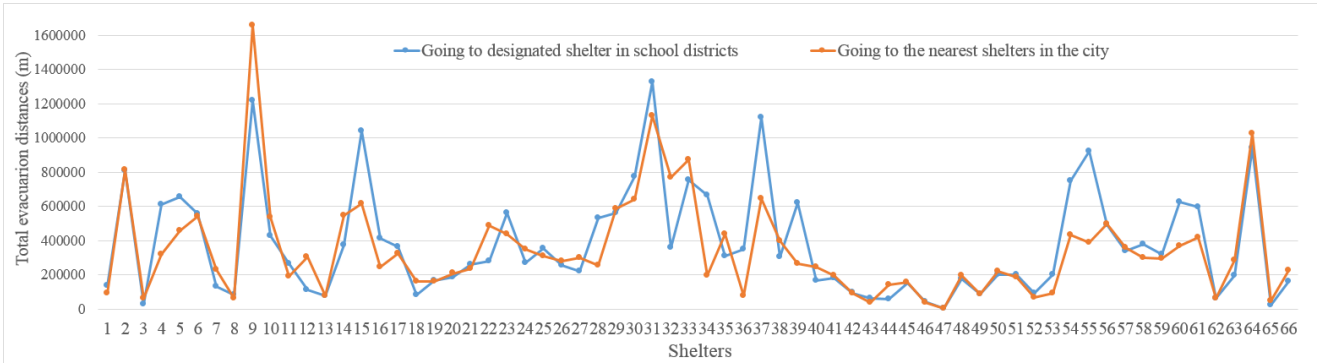

Fig. 7 – Total evacuation distances at each main shelter

main shelters was not reasonable because there were so many people required to these shelters instead of other shelter which would be nearer to evacuees' houses.

Moreover, the results pointed out that in the scenario1, all evacuees had to travel about 2511.7 km to arrive 66 main shelters in 62 school districts. While in the scenario 2, the total evacuation distance from all evacuees' houses to the same number of main shelters was 2273.3 km. It means that, in the current evacuation strategy in Kanazawa City, the total evacuation distances from all evacuees' houses to shelters in school districts was not a minimum distances. This could not reflect the planning standard for shelter location choice which expected that the total evacuation distances from all evacuees' houses to main shelters should be the minimum.

From above explanation, by comparing two factors that are total evacuation distance from damage buildings to main shelters, and service areas of main shelters in two scenarios, the research represented that the scenario 2 that are going to nearest shelter is better and more convenient than scenario 1 that are going to designated shelters in school districts. The reason for that is that many people went to designated shelters in school districts for evacuation although there were other shelters that was the nearest one from their houses. Therefore, they had to use longer routes to arrive at the main shelters.

5. CONCLUSIONS AND FURTHER RESEARCH

This research conducted a comparison between two evacuation scenarios that were going to designated shelters in school districts and going to nearest shelters based on the total evacuation distances and service areas of shelters. The results showed that the scenario 2 is better and more convenient to evacuees than the scenario 1 for some reasons: firstly in the scenario 2, the service areas of shelters covered most of evacuees, nearly 99.62% of total evacuees while in the scenario 1 it was 98.01%; secondly, the total evacuation distances was shorter than that of scenario 1

The research's results may provide a useful reference to planners and local government for reviewing the current shelter planning and evacuation strategy in practice as well as advantage of going to the nearest shelters.

For the further research, we will focus on how to improve the current evacuation strategy by using advantage of going to nearest shelters. Besides that, the road blockade caused by damage buildings' debris as well as burned buildings that were not considered in this research will be considered in our future research in order to make our simulation on shelter choice more reliable. Moreover, estimation of living and continuing evacuation as well as community function at evacuation shelters also are remained in our further research.

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小学校区域内にある指定避難場所と最短避難場所への避難行動
- 金沢市を事例として-

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キーワード:　拠点避難場所、指定避難場所、最短避難場所、小学校区域、避難距離

概要:

都市計画の基準によると,震災時の避難は指定避難場所から 2km 以内までが到達可能範囲となっている. この基準から,地震が発生したとき,人々は最も近い避難場所に避難する.しかし金沢市においては,住んでいる小学校区域内にある避難場所が最も近い避難場所ではないにもかかわらず,小学校域内にある指定避難場所に避難しなければならないケースがみられる.よって本研究では,小学校区域内にある指定避難場所に避難する場合と最も近い避難場所に避難する場合を,避難場所と倒壊した建物とのそれぞれの避難距離の合計とそれぞれの避難場所のサービスエリアの観点から比較した.その結果, 金沢市において最も近い避難場所に避難する場合の方が小学校区域内にある指定避難場所に避難する場合に比べて,より良い避難をすることができることがわかった.

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