ASSESSMENT OF TRAFFIC DISTURBANCE CONSIDERING EARTHQUAKE IN SNOW SEASON

Toshihiko MIZUTA [1]

[1] *Associate Professor, Dept. of Civil and Environmental Engineering , Akita National College of Technology, 1-1, Bunkyo-cho Iijima, Akita, Japan*
Email:t-mizu@ipc.akita-nct.ac.jp

ABSTRACT :

Snowy district should pay extra attention to the complex disaster of snow and earthquake. We are holding many problems due to enlarged seismic disaster by collapse of piled snow on streets and roofs, moreover, securing escape route and space for the fire control and the rescue activities are the big difficulties. However, current disaster prevention measures are mostly considered for summer, and there are few studies of seismic disaster assessment for snow season.
In this study, simple model that predicts street blockage in snow season is constructed, and simulation system that expresses the impact of snow is developed. Therefore, traffic disturbance considering both snow and earthquake is estimated. As a result, reality of current problems over disaster prevention activity in snow season are extracted as follows: street blockage increases about three times more than the time when earthquake occurs without snow, and some districts are suspected to be forced to take detour and be isolated for emergency activity after earthquake. Also consideration of such detail investigation for emergency transportation route, priorities to set snow removable vehicles and seismic retrofitting are possible by the developed system in this study.

KEYWORDS: earthquake in snow season, street-blockade, earthquake disaster prevention, GIS, simulation

1. INTRODUCTION

Regionally matched measure is necessary because piled snow on streets or roof snow may spread the damage and escaping and emergency activity may be interfered in case of earthquake in winter. Especially it is the most important subject to secure road traffic in snow season.
In snow season, caved street and wrecked houses by ground collapse, narrowed streets by fall of roof snow, frozen street surface, and blinded drive way by blizzard are thought to be as the cause of traffic disturbance at earthquake. These can induce street blockage and speed degradation, and also they expand disaster and affect badly the disaster prevention measure after earthquake as the additional serious problems. In this study, street blockage simulation system which represents influence of snow is developed and simple model of street blockage prediction system is constructed.

2. RESCUE ACTIVITY IN SNOW SEASON IN AKITA

To figure out the actual condition of street blockage in snow season, investigation was held on the time distance by checking the time of incoming call and arrival time of the rescue in Akita city against the case in 2004 and 2005. Snow in 2005 was the second remarkable heavy snow since 1973. Because Akita was not fully ready for plowing, it affected many streets in residential area in shamble and gave anonymous impact on the daily life of local residents. The comparison of the amount of snow in 2005 and 2006 is shown in Figure 1 that tells the fallen snow was 50 to 70cm deep which is 2 to 4 times more than the previous year.
The average time distance of rescue arrival in between 2002 and 2004, in 2005, and also the time in 2006 are summarized in Figure 2. Comparing previous year, it proved that rescue activity in 2005 was interfered by snow since the most rescue needed more than 10 minutes among the few needed 3 to 5 minutes.

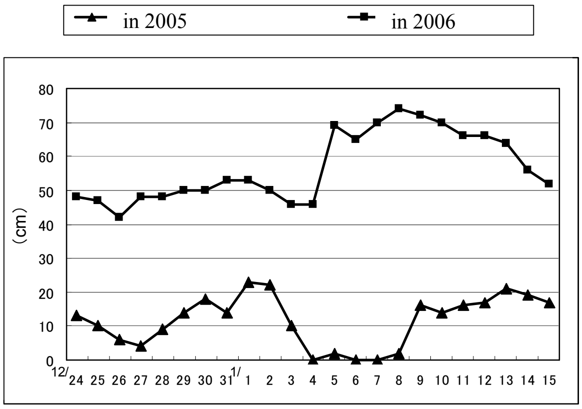


Figure 1 Comparison of snow level in fiscal year of 2005 and 2006

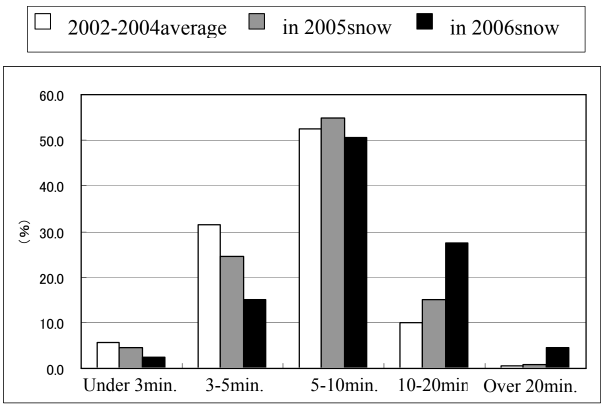


Figure 2 Comparison of time required for ambulance to reach the objective point

3. OUTLINE OF THE SYSTEM

Street blockage is evaluated based on the database of the house age and road width by considering decreased road width caused by wreck houses and piled snow. Figure 3 shows the flowchart of the street blockage prediction system.
First, database of house age and road width is constructed for this system. Then house which may collapse when earthquake occurs are picked up by ingenerating random number using Monte Carlo method based on the damage function. Finally, street blockage is evaluated by using the street blockage prediction model constructed by the database of collapse situation and road width. Also, data must be considered to increase damage percentage of house because of roof snow and to decrease road width because of piled snow.

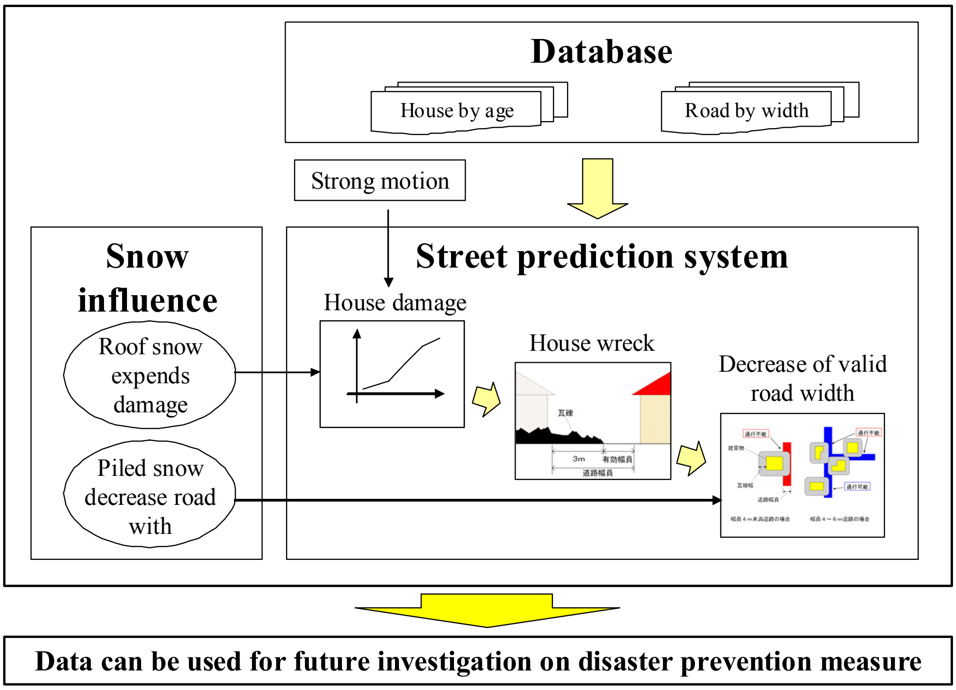
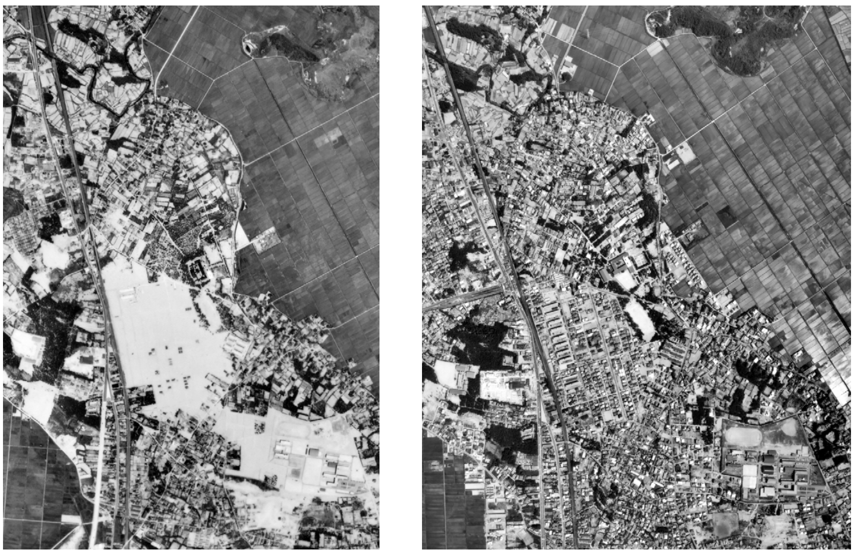


Figure 3 Outline of street blockage prediction system

4. STREET BLOCKAGE PREDICTION SYSTEM

4.1. Extract the basic data

The database of house and road width is constructed based on the map (1/2,500) to evaluate the street blockage. Then along the amendment of the quake-resistance standard, house age is configured by using aerial Photograph1 as; before 1970, 1971-1980 and after 1981. House ages are classified as follow; “before 1970” for houses existed in the photograph of 1967, “1971-1980” for houses newly added in the photograph of 1979, and “after 1981”for the houses added on the map. Road width is classified in 4 levels for the database as; “under 4m”, “4-6m”, “6-8m”and “over 8m”. Figure 4 shows example database constructed in this study with classification of houses by age and roads by width.



Photograph 1 Sample aerial photograph used to classify house age
(Adjacent area of Iijima district in Akita city Left: 1967 Right: 1979)

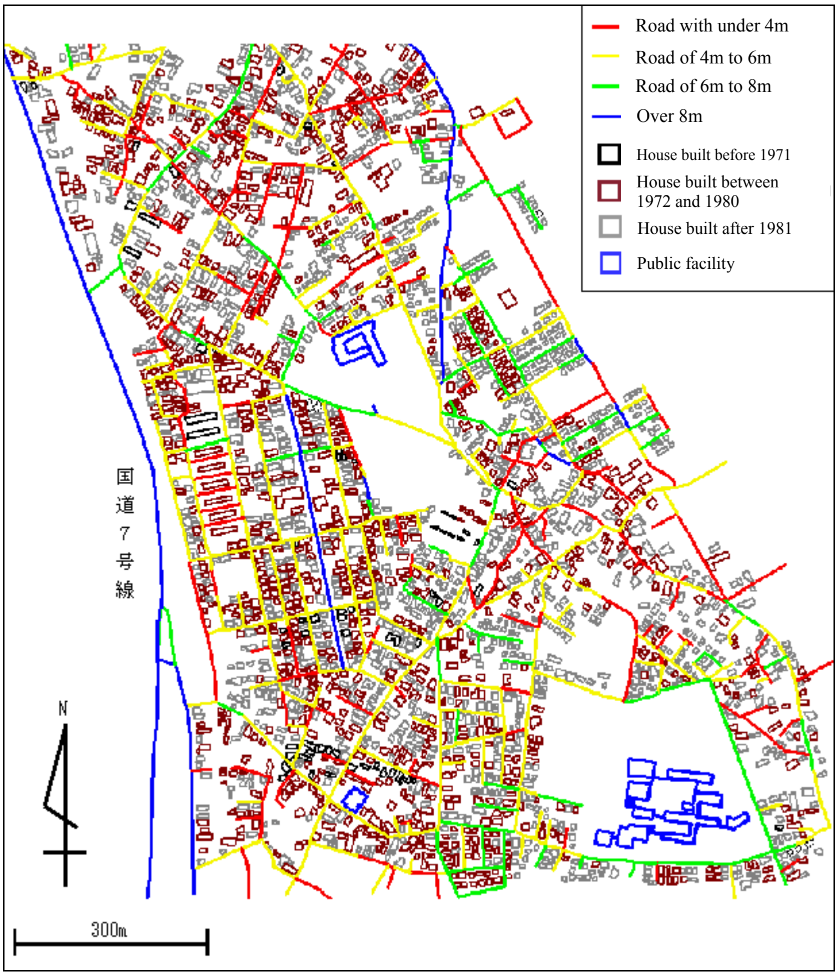


Figure 4 Example database with classification of houses by age and roads by width

4.2. Street blockage prediction model

Structure of house and its floor number, road width and intensity of seismic motion are highly concerned to induce street blockage. We assumed that the collapse of house causes the street blockage because 91% of street blockage is induced by house wreck in Kobe earthquake of 1995 (Akakura et al, 1999). Also, this prediction model detects totally blocked streets which allow no vehicle (valid width of under 1.0m). The hypothesis is shown below.

1) Based on the damage function of low and stand-alone houses (Hasegawa et al, 1998), houses which may collapse when earthquake occurs are picked up by ingenerating random number using Monte Carlo method. And because roof snow affects as load, house damage can be spread and collapse percentage is increased (data can be appropriately settable).
2) Wreckage width by house collapse is set as 3m (Figure 5).
3) At the road width of under 4m, it's considered as "blocked" if single house along the street collapses. Also, at the road width of between 4m and 6 m, it's considered as "blocked" if houses collapse at both sides. The road width of over 8m isn't blocked (Figure 6).
4) In snow season, it considers snow to pile 1m at the both side of the street (Photograph 2). Therefore 2m decreases from original road width.

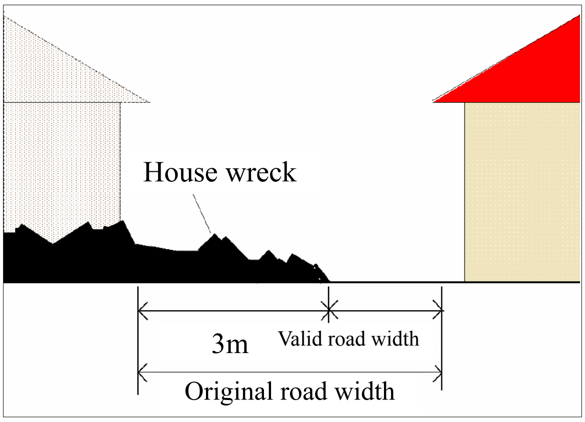


Figure 5 Decrease of valid road width with wreckage

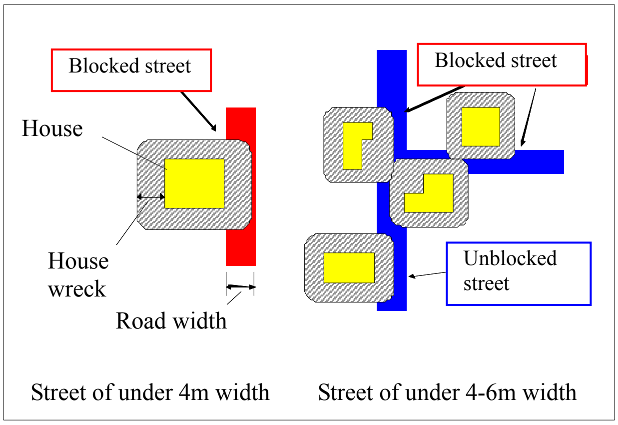
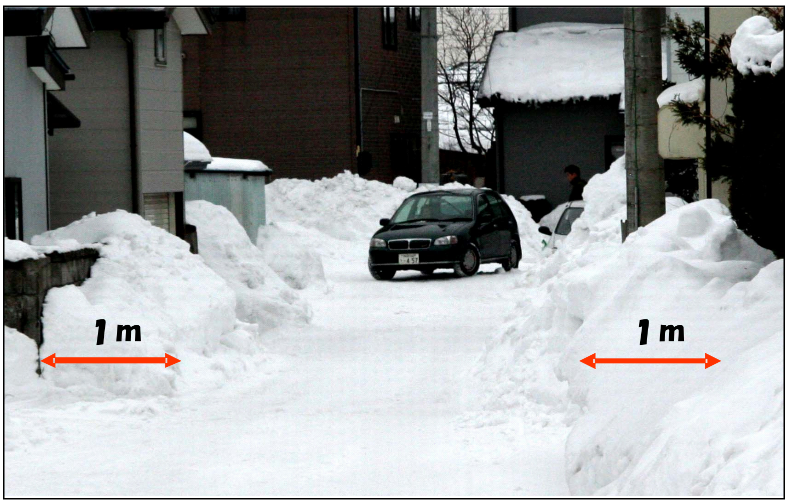


Figure 6 Example of closed street by house collapse



Photograph 2 Picture of piled snow narrows the street

4.3. Extension of road network analysis

Each node and link has identification number in addition to its coordinates and information of road width. This will help road network analysis possible on GIS to identify the shortest exit route and unreachable streets due to street blockage. Moreover, setting identification number and age data on each house make analysis possible for the positional relation between street and house. As a result, isolated house by the street blockage can be possibly identified. Figure 7 shows the experimental street blockage prediction system. This system can indicate streets by the width and houses by the age. The simulation can be held with selection regarding earthquake occurred when snow and when it doesn't snow, and also number of simulation and house collapse percentage can be set as necessary (see upper left in figure). The map shows simulation results under those conditions (see right in figure), street blockage percentage is calculated and indicated automatically (see left-center in figure). Moreover, unreachable streets and houses due to street blockage are possible to be searched and be indicated by using road network analysis.

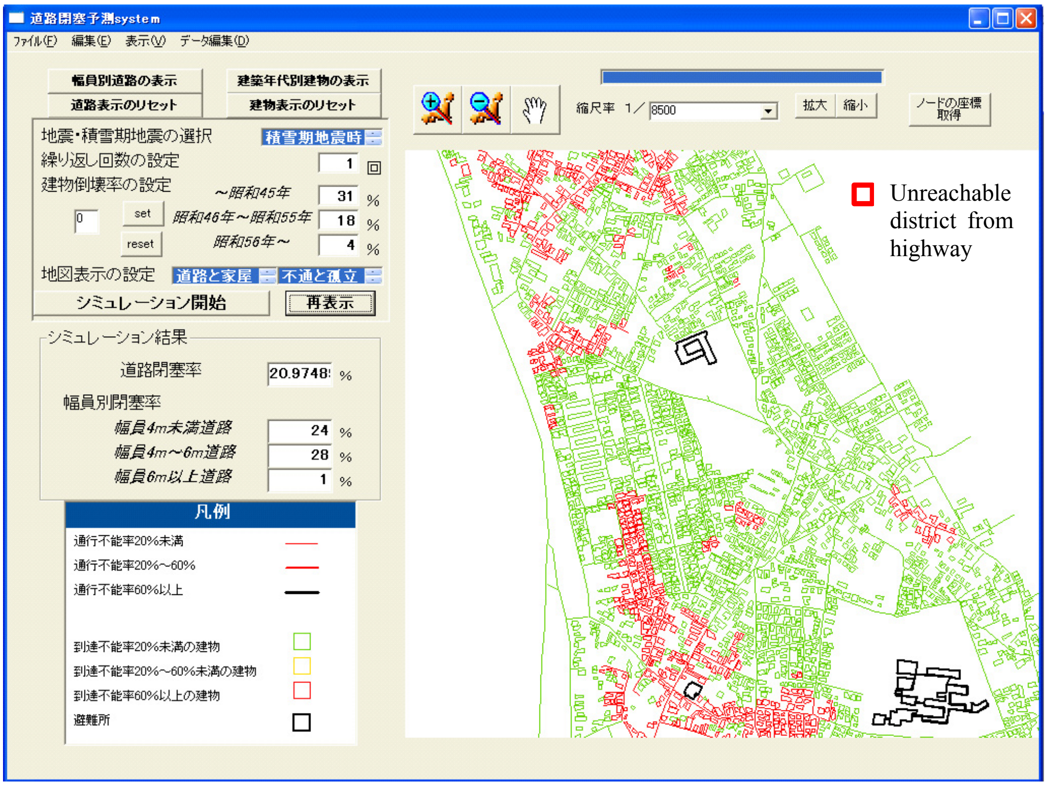


Figure 7 Street blockage prediction system
(Example indication of the district allows no vehicle when earthquake occurs in snow season)

5. ASSESSMENT OF TRAFFIC DISTURBANCE CONSIDERING EARTHQUAKE IN SNOW SEASON

Street blockage simulation was held in Izumi, Iijima and Tsuchizaki district in Akita, against earthquake influence with and without snow to investigate how snow affects on street blockage in snowy region.
Considering Akita epicentral earthquake (Tencho model, M=7.2 in JMA scale) which is predicted in Akita earthquake disaster report, intensity 6 upper (Japanese scale) shall be ranged equally over intended region. And assumption of house collapse percentage is 40% increase (collapse percentages are; 31% before 1970, 18% between 1971 and 1980, 4% after 1981) because of being affected by roof snow. Percentage of street blockage is defined as A/B x 100 regarding 100 times repeated simulation with A for the number of blocked street and B for number of repetition of the simulation.

Table 1 shows the percentage of road width and house age in intended region. Figure 8 shows street blockage distribution in snow season which is obtained by street blockage simulation in Izumi district. This tells that street blockage percentage comes to under 30% most the time when earthquake occurs, but 80% of streets could be blocked in snow season where many houses built before 1970 exist. From the overall point of view of this result, there are differences to how street blockage is induced by earthquake in snow season and in other season, the district with many 4m to 8m streets are considered as high-potential with traffic disturbance especially when earthquake occurs in snow season.

Table 1 Ratio of road by width and house by age in intended district

		Izumi	Iijima	Tsuchizaki
Percent of street by width (%)	Under 4m	5	28	27
	4m to 6m	29	50	41
	6m to 8m	45	17	17
	Over 8m	21	5	15
Percent of house by age (%)	Before 1971	25	19	46
	1972～1980	41	40	33
	After 1981	34	41	21

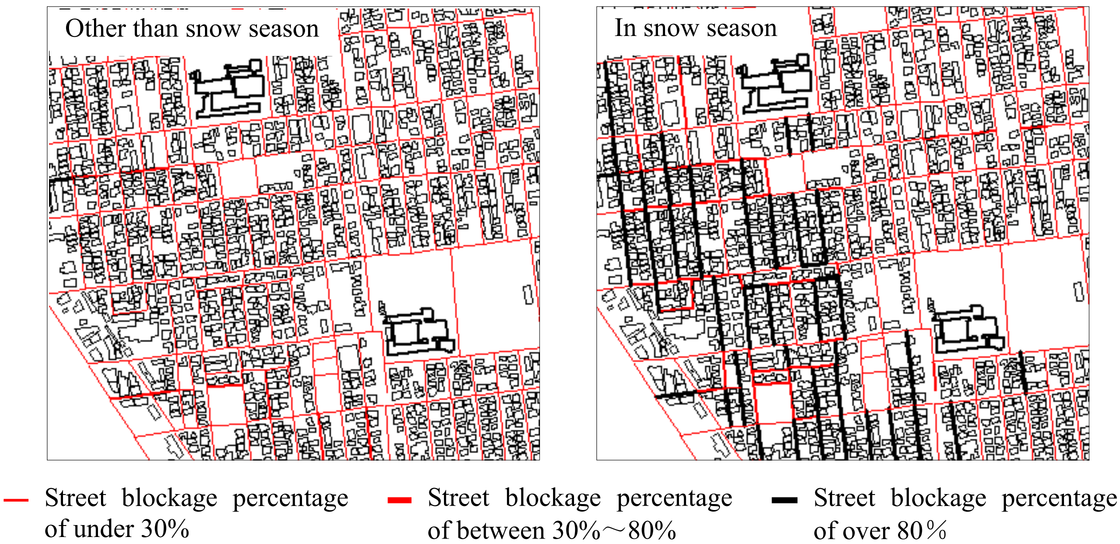
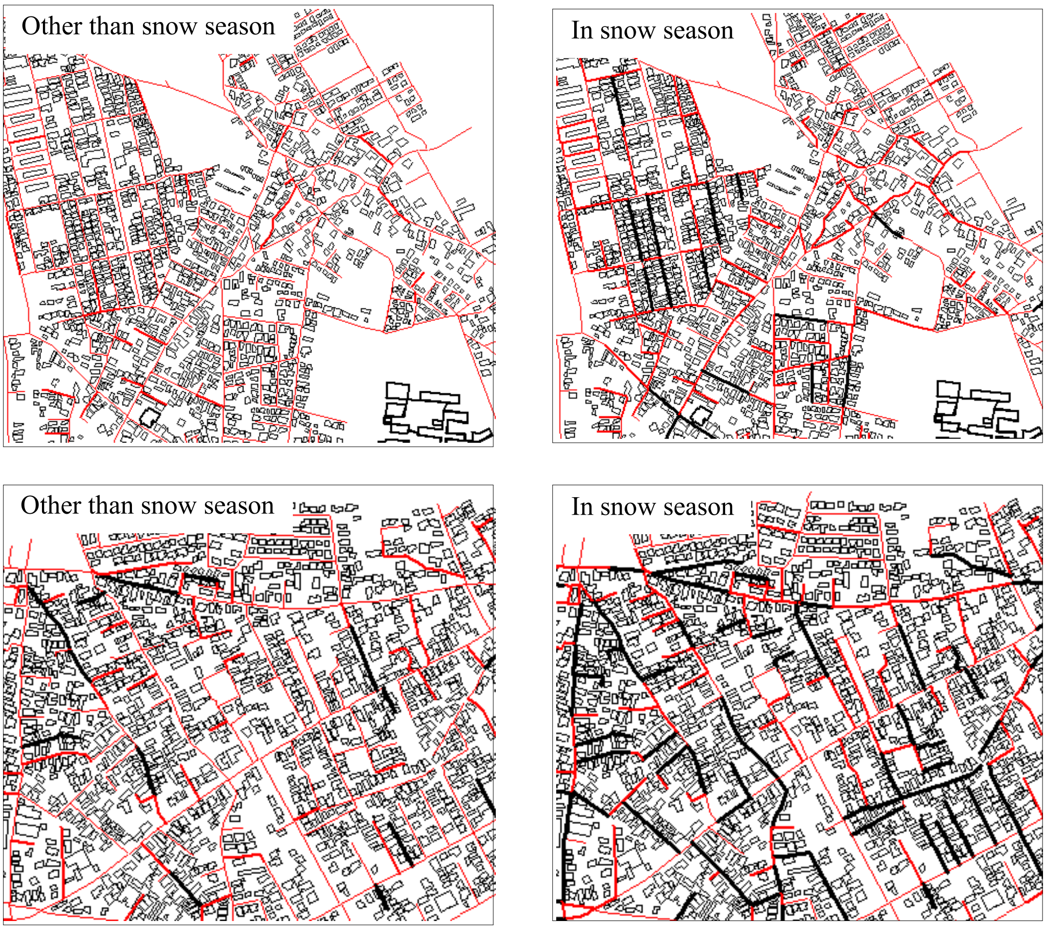


Figure 8 Distribution of street blockage percentage in Izumi district

Figure 9 shows the distribution of street blockage percentage in Iijima and Tsuchizaki district when earthquake occurs in snow season and other than snow season. This also shows that most of the street blockage is less than 30% within 30% to 80% of under 4m streets are partially blocked. On the other hand, over 30% street blockage is suspected to occur on many streets in snow season, and over 80% street blockage is also indicated. As seen in Iijima, the district which has many new houses but small width of streets are thought to be high potential for street blockage. In Tsuchizaki, the seaport from old days, many streets blockage are induced in snow season since there are many houses built before 1970 and streets under 4m. Over 80% of streets can be blocked especially when earthquake occurs in snow season.

Moreover, comparing three districts with street blockage percentage at the earthquake occurred in snow season and in other season, street blockage percentage in snow season is 28%, which is 3.5 times more than 8% in other season. Also, it proved that there are major difficulties from the point of view of disaster prevention since there are path to the residential area from highway within 80% streets which are predicted to be blocked, and some districts are suspected to be forced to take detour and be isolated for emergency activity after earthquake.



— Street blockage percentage of under 30%   — Street blockage percentage of between 30%～80%   — Street blockage percentage of over 80％

Figure 9 Distribution of street blockage percentage in Iijima（top）and Tsuchizaki（bottom）district

6. CONCLUSION

Street blockage prediction system, which can reflect the distribution of house and road width and can represent influence of snow in rescue activity when earthquake occurs in snow season, was constructed then assessment of traffic disturbance was held. By this system, future specific investigation on the rescue activity and action against earthquake by considering emergency transport route, priority of ploughing, and building quakeproof houses is possible.

REFERENCES

Akakura, Y., Takahasi, H. and Nakamoto, T. (1999). Simulate of street blockages caused by great earthquake. *Journal of Infrastructure Planning and Management*, 632, IV-45, 77-92. (in Japanese)

Hasegawa, K., Midorikawa, S. and Matsuoka, M. (1998). Seismic risk mapping of wooden house in large area using the grid-square statistics Part2 Vulnerability functions od wooden houses with different construction age and example of seismic risk mapping. *Journal of Structural and Construction Engineering*, 505, 53-59. (in Japanese)