A Study on Probability of Street Blockade at a Large-scale Disaster in a Historic Preservation Area

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Abstract

Most of the Historic Preservation Areas are very vulnerable to disasters. The aim of this study is to build probability of street blockade for evacuation routes planning from each house to an evacuation place at a large-scale disaster in such a historic preservation area. The study area is Hamanaka Machi Happongi Shuku in Kashima city, Saga Prefecture, which has been designated as a preservation district of traditional buildings. To achieve this aim, we referred to the formula for probability of street blockade for normal city area made by Tokyo Fire Agency. We revised it, considering the width of street under 4 m, structure of houses along the street, and the distance from the house to main street with the width over 4 m. Then, we applied the revised formula to the study area.

■ Keywords : Disaster Prevention, Historic Area, Probability of Street Blockade.

1. Introduction

1.1 Background of Study

Historic areas are extremely vulnerable to disasters because many vulnerable people live there, and many wooden houses stand close together. On the other hand, even if the streets have problems on evacuation, they are valuable to preserve especially in the historic preservation district. In this issue, to secure evacuation routes at a large-scale disaster that is able to bring street blockade, it is necessary to consider a probability of street blockade. Although the probability was designed by Ministry of Land, Infrastructure, Transport and Tourism (hereafter, MLITT), it is just for normal urban areas and most of the streets in the historic preservation areas are narrower than 4 m of width, and such streets are out of under consideration. For an evacuation route planning for the historic preservation area without widening the streets, we should consider the probability of street blockade of the narrower street than 4 m to find vulnerable streets and the alternative solution methods. The lead author has ever studied the fire disaster dangerousness in the study area [1], and has studied the evacuation route planning for the historic area [2]. But the probability of street blockade in the historic preservation area has been never studied.

1.2 Aim of Study

The aim of this study is to build probability of street blockade for evacuation routes planning at a large-scale disaster in a historic preservation area.

1.3 Method of Study

▶▶ Figure 1. Study area.
Hamanaka Machi Happongi Shuku, characterized with tile-roofed wooden town houses along the Nagasaki Road.

The study area is Hamanaka Machi Happongi Shuku located in Kashima City, Saga Prefecture in Japan, which has been designated as an important preservation district of traditional buildings under the Act on Protection of Cultural Properties since 2007. The district is characterized as a sake-maker town with tile-roofed wooden townhouses and storehouses that stand along the Nagasaki Road, which was built to connect Kokura and Dejima in Nagasaki in the Edo era. To achieve this aim, 1) we investigate the probability of street blockade designed by MLITT, which has been used to evaluate the vulnerability of normal urban areas, 2) build the probability of street blockade for the historic preservation area, considering the evaluation method for the street narrower than 4 m, and 3) apply it to the study area to find the vulnerability of the street.

2. Investigation of the Probability of Street Blockade

2.1 Probability of Street Blockade by MLITT

MLITT defines the probability of street blockade (hereafter, PSB) as follows:

a. In case of the street over the width of 8 m: PSB = 0.0
b. In case of the street of the width between 4 and 8 m: PSB = 1 − (1 - r2)n , where n is the number of the buildings facing to the street, and r is the rate of the old buildings, namely the number of the wooden buildings facing to the street built before 1971 divided by the number of the buildings facing to the street.
c. In case of the street narrower than 4 m: PSB = 1.0

This equation indicates that the street narrower than 4 m is defined as easy blocked at a disaster such as an large earthquake.

2.2 Probability of Street Blockade for Historic Preservation Area

Although all of the streets narrower than 4 m are defined as entirely blocked in adopting the method defined by MLITT, the street should be preserved in historic preservation area as mentioned above. In other words, the narrower street should be evaluated as usable one at a disaster, instead of preparing alternative methods.

We defined PSB of the narrower street than 4 m as follows:

PSB = 1 − (1 − r'2)n' * (4 / w), where n' is the number of the buildings facing to the street classified by the width, and r' is the rate of the old buildings facing to the street classified by the width.

3. An Application to the Study Area

3.1 Calculation of PSB

We applied the formula of PSB to the study area. Table 1 shows the result with the width of the street, n', r', and PSB. Although there are some streets with 100.00% of PSB, we could have the probability according to the current condition of each street.

3.2 The street part over 70 % of PSB

Using the result of the calculation of PSB, we check the part of the street over 70 % of PSB. The result is shown as Figure 2. The colored buildings are that built before 1945. The black number is the width of the part of the street. From this figure, we can know that even Nagasaki Road has the parts over 70 % of PSB.

4. Conclusion

Table 1. Probability of street blockade of the study area.

Street No	w (m)	n'	r'	PSB
①-1	3.60	7.00	0.14	14.93%
①-2	4.00	5.00	0.60	89.26%
①-3	4.30	7.00	0.14	12.50%
①-4	2.00	5.00	0.60	100.00%
①-5	3.00	6.00	0.17	20.73%
①-6	3.50	2.00	0.00	0.00%
①-7	3.00	5.00	0.20	24.62%
①-8	3.50	11.00	0.18	35.33%
①-9	4.00	4.00	0.50	68.36%
②-1	4.10	2.00	1.00	97.56%
②-2	4.70	2.00	0.50	37.23%
②-3	10.00			0.00%
②-4	2.20	2.00	0.50	79.55%
②-5	4.20	11.00	0.64	94.92%
②-6	3.70	6.00	0.50	88.87%
②-7	3.50	2.00	0.00	0.00%
②-8	4.20	2.00	0.50	41.67%
②-9	2.90	4.00	0.50	94.29%
③-1	3.00	1.00	1.00	100.00%
③-2	4.00	1.00	1.00	100.00%
③-3	3.80	2.00	0.50	46.05%
③-4	1.78	1.00	1.00	100.00%
③-5	2.65	2.00	1.00	100.00%
③-6	4.00	9.00	0.44	86.20%
③-7	2.80	2.00	1.00	100.00%
③-8	1.68	2.00	1.00	100.00%
③-9	1.73	3.00	0.33	68.82%
④-1	1.60	2.00	0.00	0.00%
④-2	2.20	6.00	0.50	100.00%
④-3	4.70	13.00	0.50	83.08%
④-4	5.30	12.00	0.50	73.08%
④-5	1.70	2.00	0.50	100.00%
④-6	1.70	7.00	0.29	100.00%
④-7	3.00	2.00	0.00	0.00%
②-5	4.50	7.00	0.43	67.42%
	4.50	6.00	0.83	88.82%
③-6	4.00	2.00	0.50	43.75%
	4.70	7.00	0.43	64.55%

4.1 Discussion

We have studied the probability of street blockade in a historic preservation area, referring the equation showed by MLITT, and have applied to our study area to make sure the usefulness of the PSB.

4.2 The possibility of the future

We can use this result to check the dangerousness of the street in the evacuation, calculating the evacuation time from each house to the designated evacuation place.

References

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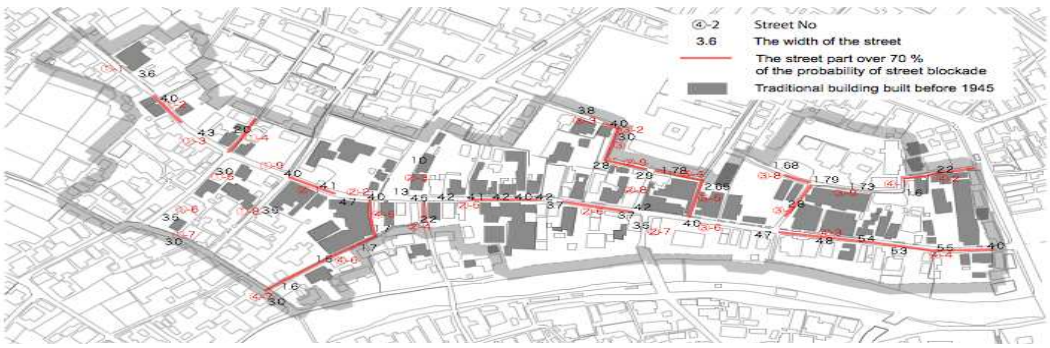

▶▶ Figure 2. The street part over 70 % of probability of street blockade.