A STUDY ON SCENARIO-TYPE SEISMIC DAMAGE ESTIMATION BY USING GIS

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SUMMARY

We experienced many big earthquakes in the past, and local government takes countermeasure recently by using GIS. These counter measures are only calculating numerical value by using limited factors in the cities, which is lack of time scale and many complicated relationships in human activity. In this study, we examine factors (natural, artificial and human factors) in the cities that effect earthquake disaster and examine how to estimate damage in Yokohama City based on analysis of past big earthquake such as Kanto Big Earthquake Disaster and Hanshin Awaji Earthquake Disaster using GIS. We examine how to do damage estimation of not only quantitative analysis but also qualitative analysis and scenario-type damage estimation. This study aims at the development of the method of the "Regional Characteristic Evaluation", using the GIS. It will make the first action after an earthquake disaster attacked quickly. First of all, we selected the three wards (Asahi ward, Naka ward, Tsurumi ward) in Yokohama City as the study areas, and extracted the elements that will make disasters escalated in the wards. Next, classified the elements into the two types (Type1 and Type2). Type1 is the data handled as the mesh data, and Type2 is the data handled as the reality data. We analyzed Type1, using the factor analysis. And then, we evaluated disaster dangerousness in each area from the results and Type2.

INTRODUCTION

The city is composed by various elements, such as a man and a building, and they combine intricately. They go on increasing year by year caused by the change in the city. And, the aspect of the damage by the earthquake calamity also has a high possibility that damage new type will happen.

Because an earthquake occurs well in Japan, various measure have been done for this by a local government and so on. It is a measure that against disaster until now is based on against disaster plan of the cities, and is the same in the Japanese whole country. For example, as for the measure, the damage assumption that "Seismic intensity is expected with this degree.", "The number of the house which damage is suffered in can be estimated" are quantitative is most. As a result, We were made to realize the weakness of the modern city due to "Hanshin Awaji earthquake disaster". Therefore From now, we must do the earthquake measure that the various elements of a city were put in the consideration.

Then, by research, the use method to the measure against an earthquake of GIS(Geographic Information System) was considered. First, the factor which affected damage from the past earthquake disaster example was discovered. And the database for evaluating city Regional Danger on a macro was built, and the method of evaluating that was considered.

Former, in the measure against an earthquake, the research and the measure on condition of using GIS (a series of flow in GIS----Classification of data, database creation after considering the setup of a city or a scale, examination of method of Regional Danger by various elements, the concrete correspondence method in the case of urgent, and so on)are not carried out. Therefore, the contents of this research are very important as what considered the method of the future measure against an earthquake using GIS.

The macro regional of Earthquake Calamity Generating Danger considered by this research is the evaluation method that the regional character of the earthquake hazard of Yokohama city can be grasped relatively. And, it is thought that that GIS is helpful as the time of a local government deciding concrete correspondence immediately after earthquake generating ,and an index which can be used for micro measure(fire-fighting activity, rescue activity, etc).

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EARTHQUAKE DISASTER AND ARBAN INFRASTRCTURE DATABASE

First, it was assumed that the element and the phenomenon which has caused a phenomenon could be selected out of investigation of Large-Scale Earthquake Disaster in Urban Area which happened in the past. And, the earthquake disaster chart was created about *six past typical examples(Kanto earthquake 1.Sep.1923, Fukui earthquake 28.Jun.1948, Niigata earthquake 16.Jun.1964, Tokatioki earthquake 16.May.1968, Miyagikenoki earthquake 12.Jun.1978, HanshinAwaji earthquake 17.Jan.1995).* an earthquake disaster chart is classified into natural element, artificial element, human element, and a time element, and is arranged, according to the composition element of the city used as a phenomenon and its factor. An example in *Kanto earthquake* is shown in Table 1.

Consequently, the composition element of the city which will affect the phenomenon and it which are first generated at the time of an earthquake disaster is clarified. From these elements, when using GIS, we created Urban Infrastructure database. It is important in case GIS is used. And, it is useful to assumption of the phenomenon which may happen to an earthquake disaster which will be generated from now on. And, it is thought by laying a different element that a new phenomenon can be predicted. The form of a database classified the earthquake disaster into four(structure thing destruction, foundations damage, tsunami, fire), and arranged like an earthquake disaster chart. Here, an example is shown in Table 2 about structure thing destruction.

Table 1 : Earthquake Disaster Chart on Kanto Earthquake

Earthquake Phenomenon		Natural Factor	Artificial Factor	Human Factor	Time Factor
Structure Thing Destruction	Collapse of Buildings	Alluvium Geology	Brick Structure		
		Reclaimed Land	Wooden houses		
		Landfill Area			
		Cliff Area			
Foundations Damage	Upheaval				
	Cave-in				
	Liquefaction				
	Landslide				
Fire	Outbreak of Fire				From Restaurants
	Spread of a Fire		High-Density City Area		
			Narrow Roads		
			Heavy Oil in river		
			Collapse Buildings		
			Collapse Bridges		
			The Burst of a Water-Servise Pipe		
			Suffering a Calamity of A Fire Department		
Wounding and Killing	Death in the Flames		Igniting to Loads	Loss of a Refuge	

Table 2 : A Part of Urban Infrastructure database

	Natural Factor		
Structure Thing Destruction	Foundations	Alluvium Geology Reclaimed Land Landfill Area Cliff Area Dislocations	Position Scale Drilling Data
		Old Coastline Old River Old Paddy Field Lot	Position
		Underground Water River Pond Swamp	Position Scale

	Artificial Factor		
Structure Thing Destruction	Buildings	Wooden Houses	Style Method Roof Form Construction Age The Number of Stories The Degree of High Density
		SRC Buildings	Style Method Construction Age The Number of Stories The Degree of High Density
	Traffic	Rail Road, Subway	The Number of the Average Users by Time The Position of Tracks and Stations The Number of Routes Construction Age
		Road	Traffic Road Width Member Highway
		Bridge	Position Highbridge Structure Construction Age Width Member
	Life Line	Gas, Vertical Water, Power Transmission, Communication Servises	The Laying-Under-Ground Pipe Position The Kind of Pipes Construction Age
	Oil, Gas, RI, Chemistry Medicine, Gunpowder Possession Institutions		Position Structure Scale
	Underground Center		Position Scale

	Human Factor		
Structure Thing Destruction	Population	Permanent Residence Night Day Time By Age	
	Calamity Weak	Old People Hndicapped People Sics People Small Children	Place-of-Residence Region
	Set Institution	Set Institution Apartments Hospitals	Kinds Scale Position

Thus, when an earthquake breaks out, there are a lots of city composition elements used as the factor which causes a disaster. In this research, many phenomena and element are chosen in the example of the six past from the factors, and The Regional Characteristics was evaluated.

EXAMINING REGIONAL CHARACTERISTICS IN YOKOHAMA CITY

Analysis From Macro View

Examining by 250m Mesh Data:

First, especially we extracted the element considered to work to danger or control out of the whole database created for the preceding chapter was extracted ,and it classified into the element which treats them as mesh data ,and the element treated as real data.

Elements ,such as the population and a building with which the city is dotted, are treated as mesh data, and such as the surface geology and dangerous object possession institution considered that there is a problem making it a mesh used elements, as real data, and it treated them in the form of each the point, the line, and the polygon.

Moreover, in order for a man to enable it to understand exactly and for a short time, relative comparison of the whole needs to be carried out and it needs to intelligibly expressed as a macroscopic viewpoint on a map.

Then, the minimum scales of a mesh was set up with 250m, and it planned to perform relative comparison. It is for a macroscopic viewpoint comparing that we used the mesh, and 250m, when it was not suitable for relative evaluation since it would become fine too much, if it becomes smaller than it, and it became conversely larger than it, it was determined from the reason for the ability to be unable to throw dangerous area into relief.

Next we chose data used in this chapter. Data which we treat as mesh data is as follows.

1. Total number of Ridges of Building
2. Number of Ridges of Wooden Building
3. Number of Ridges of Wooden Building built before 1981
4. Number of Ridges of Wooden Building of a pile roof
5. Number of Ridges of a residence
6. Number of Ridges of a non-Wooden Building
7. Population of the night
8. Population of the night of 19-25 years old
9. Population of the night of 65 years old or more
10. Population of the night other than 19-25 years old and 65 years old or more
11. The total extended distance of a road
12. The total extended distance of a road with a width of a road of 6m or less
13. The total extended distance of a road with a width of a road of 6m or more
14. The total area of a road

Each reason for selection is shown in Table 3

Then, we performed factor analysis in a mesh unit using these data. The reason we perform factor analysis is the following two. First, since it is difficult to give a priority which element is the most important, it is for clarifying evaluation and making it intelligible. Secondly, since various elements are intermingled in the city, it is for performing analysis which also took mutual correlation into consideration.

Moreover, as shown in Table 4, we selected the study area in addition to the reason that there is the feature that there is more population of night than daytime in the Asahi-Ward, and more population of daytime than night in the Naka-Ward, to there being no difference of the population of daytime and night in the Tsurumi-Ward not much, for the geographical conditions whether it is located in a littoral district or it is located in inland, and for the political conditions whether administration institution is concentrating. In addition, the numerical value of this table is a numerical value per 1 square km.

Table 3 : The Reason for Extraction

	The Reason for Extraction
1,2,6	It is assumed that damage occurs frequently so that it is crowded with buildings.
3	It is assumed that damage occurs frequently in the wooden building built before 1981.
4	It is assumed that damage occurs frequently in the wooden building of a heavy roof.
5	The place with many buildings where possibility that damage will occur frequently is high and residents is assumed that human damage occurs frequently.
7	When crowded night population and an earthquake breaks out at night, it is assumed that human damage occurs frequently.
8	People of 19-25 age are assumed that a possibility that a possibility of living in the old wooden lease apartment will be highly involved in building collapse is high.
9	It is assumed that people of over 65 age have a high possibility that a possibility of living in the old wooden house is highly involved in building collapse, escape, and it is behind.
10	When an earthquake also generates people of other age at night, it is assumed that a possibility oh being involved in damage, such as building collapse, is high.
11,12,14	It is assumed that the use as open spaces, such as the vacant lot as a glow stop, is possible.
12	It is assumed that damage, such as the passing stop by building collapse and the spread of a fire, may be expanded.

Table 4 : Statistics Data in Yokohama City

Ward	Area	Population	Wooden Buildings	Non Wooden Buildings	Residence	Daytime Population	Vacant Lot
Aoba	35.05	7103	931.44	407.17	1064.08	4909	321764.07
Tsuduki	27.89	4187	600.93	312.38	640.52	3982	280696.74
Kohoku	31.37	8904	1400.63	498.98	1530.42	8368	239698.19
Tsurumi	32.38	7759	1157.09	437.90	1265.33	7470	216503.29
Midori	25.42	5842	645.93	232.62	697.77	3990	413706.84
Kanagawa	23.40	8810	1369.52	489.58	1543.71	9061	260895.09
Seya	17.11	7100	1326.78	317.21	1414.54	5238	240852.49
Asahi	32.78	7659	1294.27	371.57	1390.02	5301	490636.65
Hodogaya	21.80	9057	1438.38	404.24	1574.60	7144	389449.48
Nishi	6.92	10948	1789.00	668.98	2055.67	22200	394520.08
Izumi	23.56	5919	1240.58	260.95	1265.25	4029	202703.04
Totsuka	35.69	6820	1065.06	360.29	1167.11	5709	260100.77
Minami	12.63	15243	2626.30	710.26	2945.37	11682	273071.92
Naka	19.24	6077	907.08	445.23	1031.37	13205	444616.56
Konan	19.87	11208	1553.23	523.72	1793.88	7798	255572.07
Isogo	19.02	8863	1193.37	422.84	1343.07	6779	469362.04
Sakae	18.55	6626	1110.32	370.81	1273.75	4447	656342.88
Kanazawa	30.52	6683	992.01	384.51	1125.50	5955	560145.65
Average	24.07	8045	1257.88	423.29	1395.66	7626	353924.33

Table 5 : Factor Analysts Result

Data	Factor• 1	Factor• 2	Factor• 3	Factor• 4	Factor• 5
All Buildings	0.57	0.33	0.27	***-0.68***	0.15
Wooden Houses	***0.91***	0.27	0.14	-0.10	0.24
Old Wooden Houses(Before 1981)	***0.90***	0.26	0.17	-0.16	0.22
Heavy Proof Houses	***0.91***	0.27	0.14	-0.11	0.24
Non-Wooden Buildings	0.10	0.27	0.29	***-0.91***	0.02
All Houses	***0.74***	0.32	0.22	-0.51	0.19
Night Population	0.55	***0.69***	0.12	-0.35	0.14
Age of Population(19 - 25)	0.52	***0.66***	0.07	-0.39	0.13
Age of Population(65 <)	***0.66***	0.57	0.17	-0.23	0.17
Age of Population(Others)	0.25	***0.86***	0.17	-0.17	0.11
Total Length of Road	0.42	0.20	***0.67***	-0.19	0.53
Length of Road(Width:0 - 6m)	0.49	0.18	0.09	-0.06	***0.84***
Length of Road(Width:6m <)	0.16	0.13	***0.92***	-0.23	-0.01
Total Area of Road	0.07	0.08	***0.94***	-0.11	0.08

Table 6 : The Rate of Contribution

	Second Power Sum	The Rate of Contribution	The Rate of Accumulation Contribution
Factor No1	4.87	0.35	0.35
Factor No2	2.58	0.18	0.53
Factor No3	2.54	0.18	0.71
Factor No4	2.05	0.15	0.86
Factor No5	1.30	0.09	0.95

	Tsurumi	Naka	Asahi
All Sum	842	501	930
Wooden Buildings	103(12.20%)	83(16.60%)	61(6.60%)
Night Population	74(8.80%)	11(2.20%)	57(6.10%)
Width Roads	1(0.10%)	74(14.80%)	1(0.10%)
Non Wooden Buildings	5(0.60%)	22(4.40%)	15(1.60%)
Narrow Roads	16(1.90%)	102(20.40%)	161(17.30%)

Here, we actually performed factor analysis. The analysis result is shown in Table 5. Each numerical value in a table shows the amount of factor loads. There is positive correlation so that the numerical value is close to 1, and it can be judged that there is negative correlation so that it is close to –1. Then, each was defined as follows from the variable judged that there is correlation.

Factor 1 The degree of high density of a wooden building

Factor 2 The degree of high density of night population

Factor 3 The degree of high density of the road of a large width

Factor 4 The degree of high density of an upper-layers non-wooden building

Factor 5 The degree of high density of the road of a narrow width

Here, although the population of the night of 65 years old or more was judged to be the degree of high density of a wooden building where people of this age are old. However, especially this point was not taken into consideration, we defined it as the degree of high density of a wooden building. Moreover, since the rate of accumulation contribution was as being shown in Table 6, we judged it as that which may analyze using these results.

Moreover, we performed cluster analysis using the factor score obtained by this analysis. The degree of high density was classified according to it into five stages, and the area where the degree of high density is the highest was extracted as a high-density area. The reason from which we extracted the high-density area is because a high-density area has the example of suffering big damage, from a past calamity.

Using this result, we performed relative evaluation by the high-density area extracted above, and examining regional characteristics. At first, we show the study area set up by this study in Fig. 1. The high-density area of a wooden building is shown in Fig. 2 among the high-density areas extracted for every factor. According to the result, it turns out that the high-density area of a wooden building spreads out over the large range in Naka-Ward and Tsurumi-Ward area. Moreover, we performed the work with the same said of other factors (Fig.3□6).

From attached figure 3, the population high-density area of night is collected into Tsurumi ward and Asahi ward. When the damage of collapse of a building arises in this area, it is thought that *human damage (for example, the man who because the underlay of a house)* starts mostly.

From attached figure 4, an extensive width road high-density area is in the upper part of Naka ward with the government agency. In this area, since there is a road vacant lot which prevents the spread of a fire when a fire occurs, it is thought that there is little danger of the spread of a fire. Moreover, if traffic congestion does not occur, it can use as an important point of traffic.

From attached figure 5, it has gathered in Naka ward like the factor 3. Although this can expect the effect which prevents the spread of a fire as well as the result of previously, however if an upper houses damage, it can be called the area which may change to the obstacle of traffic.

From attached figure 6, the road area of narrow width has a small unites of a large number in Asahi ward, and a somewhat large unites is also in the central part of Naka ward. This unites is considered to be the place which may cause the spread-of-a-fire expansion at the time of a fire, and the confusion of traffic.

Next, the high-density area of the road where width is narrow is put on the high-density area of a wooden building, it will become as it is shown in Fig.7. It can be said that the area where it is both crowded with a wooden building and the road where width is narrow is a high area of the risk of a fire being expanded since existence of the road vacant lot which prevents the spread of a fire cannot be expected, either, when a fire occurs. Furthermore, it can be said that not only an overlapping area but the adjoining area also has the same danger.

Then, we performed examination of the number of meshes of each high-density area for every area, and its rate on the basis of these data. The result is shown in Table 7.

Consequently, Tsurumi-Ward shows the highest rate of three area in the high-density area of wooden building, and the high-density area of the population of night, and a role of a place-of-residence region is understood that

it came sure enough. In the high-density area of the road where width is wide, the high-density area of the road where width is narrow, and the high-density area of the upper-layers non-wooden building, a rate is comparatively high in Naka-Ward. It can be said that this is the influence of development of a traffic network and standing close together of a building since Naka-Ward is developed as a center of Yokohama-City.

Moreover, Asahi-Ward shows a little high rate in the high-density area of the population of night, and the high-density area of the road where is narrow. This shows that Asahi-Ward has played the bedroom town-role of Yokohama-City secondly Tsurumi-Ward.

The Introductory Notes of Figure 1

- Prototype Area
- The Boundary of Wards

The Introductory Notes of Figure 2 6

The Degree of High Density

Low

High

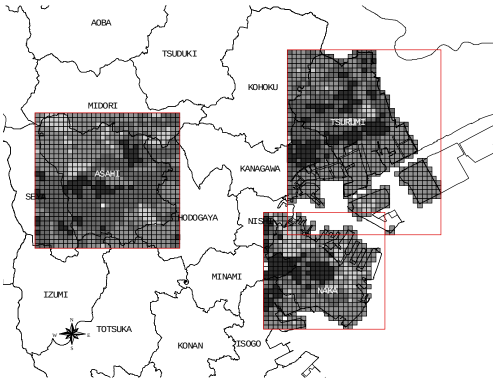
- High-Density Area

The Introductory Notes of Figure 7

High Density Area

- Wooden Buildings
- Narrow Roads
- High Danger Area

Figure 1: Yokohama City



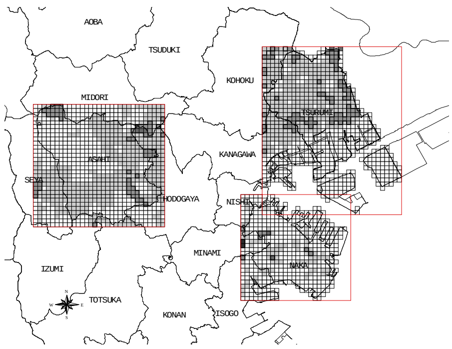
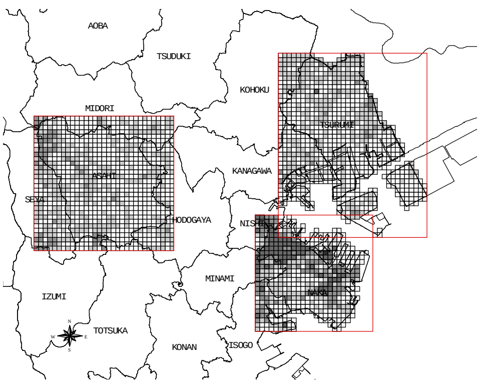


Figure 2 : Wooden Building High-Density Area **Figure 3 : Night Population High-Density Area**



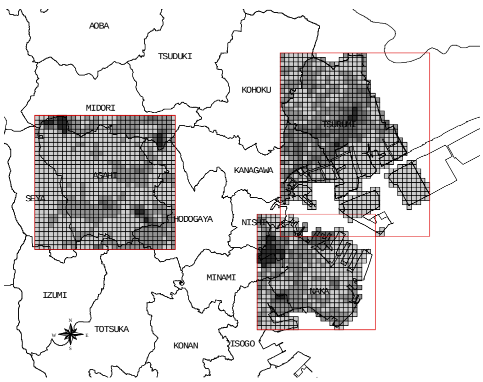
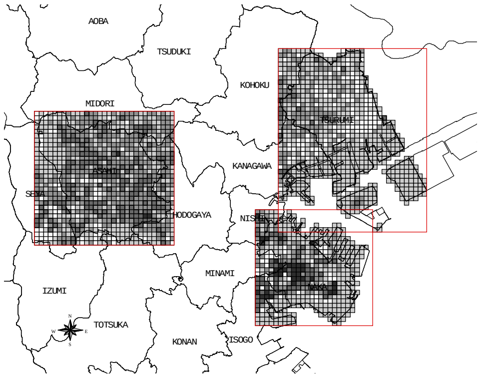


Figure 4 : Broad Road High-Density Area **Figure 5 : Non-Wooden Building High-Density Area**



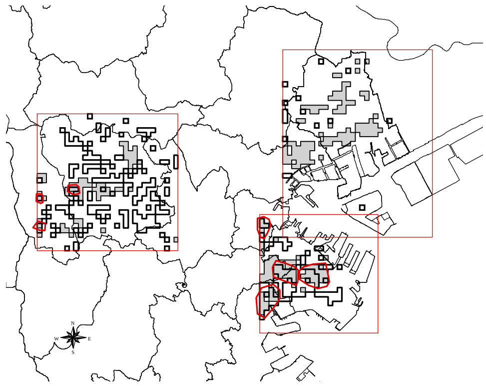


Figure 6 : Narrow Road High-Density Area

Figure 7 : The Danger Area of a Spread-of-a-Fire Expansion

3.2 Examining by Analyzed Data and Real Data:

In this clause, we performed evaluation which piles up real data as a result of being the danger evaluation by the mesh-data analysis performed for the preceding clause. First, we show some examples about the damage which can be evaluation by superposition.

- The weak ground (1) + The degree of high density of a wooden building
  → Collapse of a wooden building
- The area where liquefaction is assumed + The high-density area of a upper-layers non-wooden building → Collapse of the non-wooden building by the liquefaction of ground
- Steep-slope area + The high-density area of a wooden building + The high-density area of the population of night → The underlay of the collapse building by cliff collapse or the landslide

(Introductory notes) Real data + Mesh data → Damage

Then, especially we describe the risk of being related with a fire here.

First, we extracted the high-density area of a wooden building and the high-density area of the road where width is narrow in the mesh data, and the weak ground ,fire handing store, dangerous object possession institution and the wind for every season as the element in connection with fire generating and the spread of a fire. However, with the example of a past earthquake disaster, since the fire from a general home had occurred each time, we omitted a fire handing store and dangerous object possession institution, and imagined the outbreak of fore from a general home here.

Moreover, we extracted the high-density area of the road where width is wide and the high-density area of the upper-layers non-wooden building in the mesh data.

On the basis of these data, we actually performed evaluation danger and control.

The area regarded as danger being high about a fire is shown in Fig. 8. The area enclosed with the thick line is the high-density area of a wooden building on the weak ground. At the time of earthquake generating, it is easy to generate collapse of wooden building, and if fire breaks out there, the tiles and pebbles of wooden building are filling the road in these areas.

Therefore, these areas do not bring a fire truck close, either, but it is supposed that the spread of a fire is expanded. If Fig.8 is expanded and seen, in order that a wind may change with seasons, the danger of the spread of a fire can be referred to as being also in the area not made into the dangerous area. Moreover, the area considered that there is control power of the spread of a fire is shown in Fig. 9. It is because a possibility of stopping the spread of a fire can be considered since these areas fully have the road vacant lot.

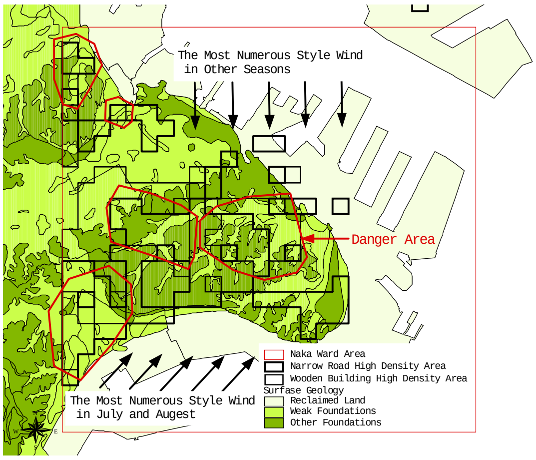


Figure 8 : The Danger Area of a Spread-of-a-Fire Expansion

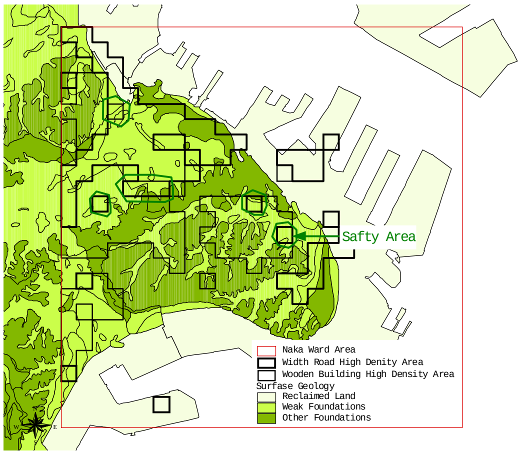


Figure 9 : The Safety Area of a Spread-of-a-Fire Expansion

CONCLUDING REMARKS

This research estimated Examining Regional Characteristics in Tsurumi-Ward, Naka-Ward, Asahi-Ward in Yokohama City experimentally. The method of relative evaluation was considered. Thus, by evaluating a city by the macro viewpoint, it is thought that it is enabled to form the effective prior measure for every area by administration. Furthermore, immediately after earthquake generating, all the information on areas is not transmitted at once. And, it can expect that confusion in an information side occurs, and it is thought that this has bad influence on the quickness of initial correspondence. When informational confusion has happened and a part of information enters, it is useful by performing such relative evaluation beforehand, because it can work for a part of information and initial correspondence can finally be performed quickly.

Inhabitants' consciousness increases by telling not only administration but inhabitants about the information obtained by GIS. For example, "Inhabitants get mental attitude to an earthquake.", "When an earthquake happens, flexible and quick action can be performed.", "Inhabitants understand the characteristic of an area that they live.", "The opportunity discussed about an area by inhabitants is made.".

This time, it evaluated using digital data which it has. So, if it evaluates using much more data, analysis will be made in detail.

REFERENCES

Weak foundations are defined as the rank A of week. Moreover, it is foundations which consist of landfill, *fusyokudo, sashitsudo, and* the viscous ground(alluvium) among the surface geology which exists in Yokohama.