

## MACRO-ZONATION OF POTENTIAL SEISMIC RISK IN URBAN CITIES

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### SUMMARY

This study aims at evaluating factors related to potential seismic risk in a city or a group of cities based on the concept of "macro-zonation". These factors are associated with regional characteristics including natural features such as topography, climate and location of active faults, human features such as population and population density and artificial features such as buildings and roads. Countermeasures such as disaster measure of local government in Japan were uniform all over Japan, so we focused on "Regional characteristics" of each cities and necessity of index to compare each cities. The main objective of this study is to develop a countermeasure system utilizing macro information of urban cities to mitigate earthquake disaster, especially near-field earthquake, considering their regional characteristics. We defined four categories to evaluate cities considering times scale. Four categories are "Damage of Cities", " Potential of mitigation of cities", "Accessibility and Supportability from other cities", " Potential of Recovery of cities". In order to evaluate cities relatively, we extract data by researching the Hyogo-Ken Nanbu Earthquake(1995) and so on. Also we extracted scale of data as we can evaluate cities in Japan relatively. One example (Accessibility and Supportability from other cities) of process in this study is as follows. In order to evaluate accessibility and supportability between cities, it is necessarily to consider as three things, (1)Marine and Land Transportation (2)Quantity for support around devastated city (3)Reliability (Accessibility between cities etc). And we extracted factors to evaluate cities. In this study, we could classify cities in each axis. These grouping shows mass of similar characteristics in each axis and leads to concrete and detail countermeasure in a city.

### INTRODUCTION

In Japan, compared with the world, a disastrous earthquake often cause damage to each place in the whole country. The aspects of the damage by the earthquake also differ in generating area, the city structure by the building and the structure thing and population, times, and so on. That of Kobe-shi in the Hyogo-Ken Nanbu Earthquake(1995) brought the result which showed the frailty by the earthquake of a modern big city. Moreover, it cannot predict whether near-field earthquake will occur in which city in Japan from now on, so it is thought that a possibility of suffering large-scale in the larger cities is high.

However, the old measure against earthquake is the uniform measure which set the cities area disaster-prevention plan on the statement of principles. Therefore, the measure in which made regional character in Japan whole country reflect is required for the future measure against an earthquake. It is thought that it becomes indicators, such as the policy of each local government, to stand on macro view, and to clarify regionalism in the Japan whole country.

In this study, the purposes is to evaluate and compare with urban cities relatively and in order to achieve above, we defined four categories to evaluate cities considering times scale. Four categories are "Damage of Cities", " Potential of Mitigation of Cities", "Accessibility and Supportability from Other Cities", " Potential of Recovery of Cities". Our focused " Evaluation by Macro view" is to create the index that we can compare relatively and we evaluate cities by common factor of cities. We pick up factors that seem to affect disaster of earthquake deep among common factors they have and make clear the regional characteristics of distributed cities all over Japan. Index of Macro leads to countermeasure of Micro into each city. Index of Macro is placed Fig2.1 as follows by

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considering times scale and "Damage of Cities" is involved the many kind of seismic risk collapsed building, fire and so on) and " Potential of Mitigation of Cities" is human power, for example, community and conscious, that reduce damage by earthquake and is potentiality in cities. "Accessibility and Supportability from Other Cities" is emergency support that is focused short time after earthquake happens around cities. " Potential of Recovery of Cities" is the speed of recovery after suffering damage.

And in this study we are studying three categories, " Potential of Mitigation of Cities", "Accessibility and Supportability from Other Cities", " Potential of Recovery of Cities". And as Fig.1.2, we selected ordinance-designated-cities and another cities which suffered the damage by the big earthquake to which the damage of dead generated by the Hyogo-Ken Nanbu Earthquake.

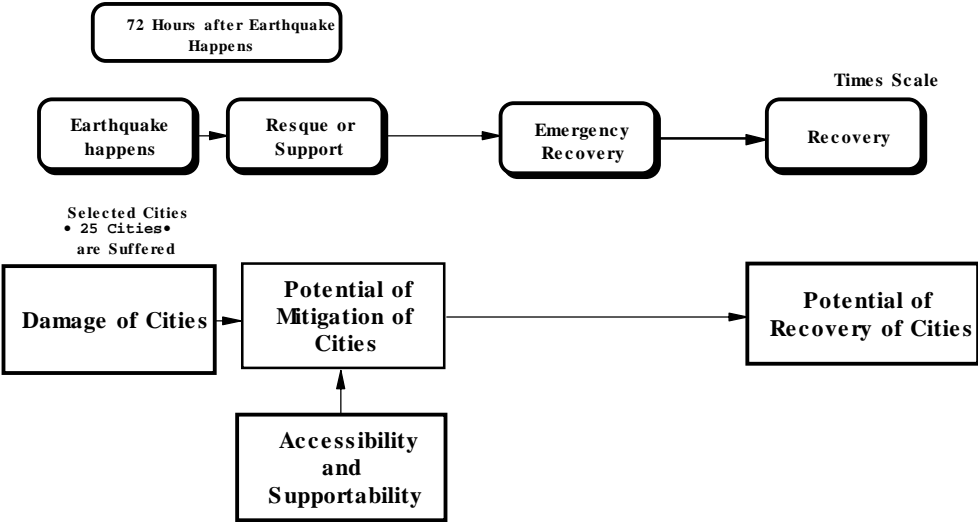


Fig.1.1 Category for Evaluation from Marco

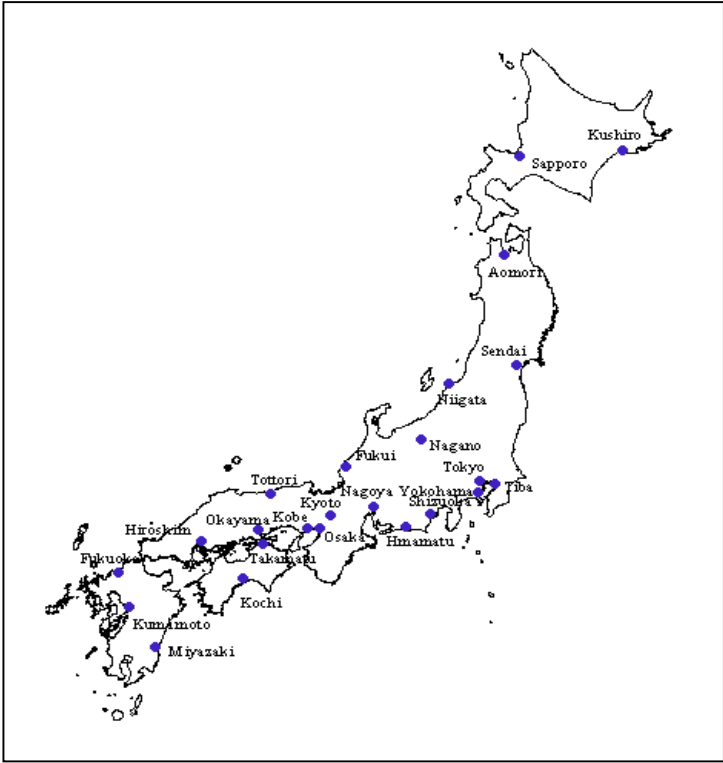


Fig.1.2 Location of Investigated Cities

## POTENTIAL OF MITIGATION OF CITIES

### Introduction

In this research, the focus is put to potential capability that the damage of the casualties and the injured by near-field earthquake is decreased as much as possible. It is not what is depended on a policy by the country and the local government, but the power by the residents who live in each city. Specifically, it is the disaster-prevention consciousness to an earthquake disaster and the community of the local residents. While disaster-prevention consciousness and a local community have regionalism in the Japan whole country, since they serve as big power on the scale of the set object of a city, they think that the damage by earthquake is reduced.

Until now, investigation research about disaster-mitigation consciousness was performed. But, they were restricted to investigation for the disaster city after earthquake generating and the thing, in the high area where the danger of earthquake generating, such as Tokai earthquake, and since the investigation item and the contents are not unified, comparison and examination are difficult for it.

Then, by the research, it is thought the potential capability that the damage by the earthquake disaster which is inherent in a city is decreased is produced from the consciousness of the residents and a local community to an earthquake, investigation research about a city resident's disaster-mitigation consciousness and local community was advanced. By the questionnaire, while regionalism of each Japanese city is clarified, the correlation with existing statistics data was analyzed, the technique of the quantification which can compare the Japan whole country relatively about disaster-prevention consciousness and a local community was examined. In the Japan whole country, since research like this research as which quantification estimated quantitatively the item of difficult disaster-mitigation consciousness or a local community is not carried out conventionally, it is thought that the result of this research is useful to decision-making of the policy of a country and the measure against an earthquake in each city.

### Outline of Research

In this research, a city resident's "potential reductive capacity of damage" can roughly two divide 1. Capability which mitigates the direct damage by the earthquake motion by the consciousness to earthquake, such as the sense of impending crisis to earthquake generating, and measures against prior disaster prevention, such as furniture fixation and preparation of an extraordinary article, 2. Capability which mitigates damage by temporary correspondence of rescue activity of residents and so on. In this research, the factor considered to influence these 1. and 2. is made to call it "disaster-mitigation consciousness" and "a local community". From various investigation after the Hyogo-Ken Nanbu Earthquake(1995), damage by the fall of furniture, the rescue activity by local residents, fire extinguishing by bucket relay, are reported. A focus is put on disaster-mitigation consciousness and a local community, the city and ordinance-designated-city 25 city notes which suffered the damage by the big earthquake to which the damage of dead generated by the Hyogo-Ken Nanbu Earthquake came from the Great Kanto Earthquake are chosen **Chart.2.1**, the questionnaire was carried out. Moreover, disaster-prevention consciousness set up the question which considered two stages of a conscious thing called the recognition of danger to an earthquake, and the concrete thing which gives physical measure called furniture fixation and preparation of an extraordinary article **Chart.2.2**. And the investigation result was collected the investigation result of this questionnaire on two axes of a city resident's disaster-prevention consciousness, and a local community by main-ingredients analysis, the regional character of the city in the Japan whole country was clarified by performing detailed analysis of an investigation result and city comparison. On the basis of the investigation result, the factor which has influenced a city resident's disaster-prevention consciousness and local community was extracted, and the technique of presuming those by pile regression analysis was examined.

**Chart.2.1 Summary of Questionnaire**

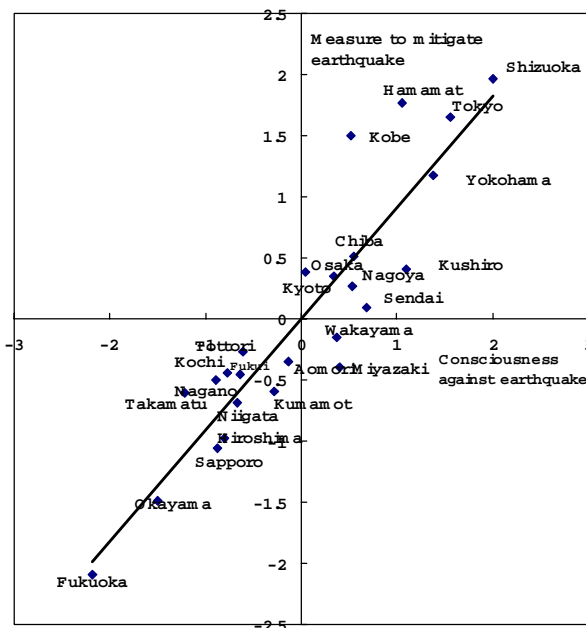
<b>Objects</b>	Junior high school teachers who reside in 25 cities(150 copies for each city)
<b>Objects-cities and The collection number of copies</b>	Sapporo 110 jKushiro 116 jAomori 113 jSendai 14 jChiba 16 jTokyo(Ward) 10 jA Yokohama 126 jNiigata 115 jFukui 121 jNgano 121 jShizuoka 109 jHamamatu 97 jA Nagoya 113 jWakayama 93 jKyoto 97 jOsaka 83 jKobe 96 jTottori 109 jA Okayama 109 jHiroshima 97 jKochi 97 jTakamatu 107 jFukuoka 116 jKumamoto 124 j Miyazaki 136 j
<b>Enforcement periods</b>	September, October(1998)
<b>The total number of copies</b>	, RPT@copies
<b>The total number of collections</b>	, QTV@copies Rate of collection , WPDS "Average , PQQD@copies j

**Chart.2.2 Contents of Questionnaire**

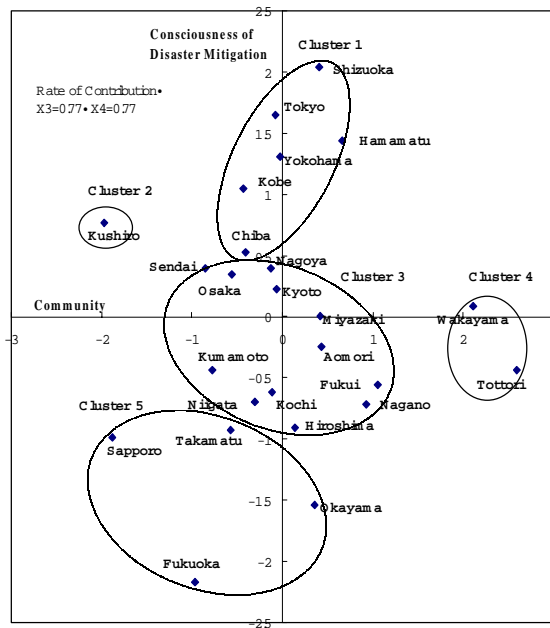
Face Sheets		Sex, Age, Adess, Style of Family, Style of house, Periods of resident
Consciousness of Disaster Mitugaton	Consciousness against earthquake	Have you ever experienced the earthquake? Do you fell that your city often shakes by earthquake? Do you have a sense of crisis that the big earthquake happns like the Hanshin-Awagi greate earthquake for several years? Do you have a sense of crisis that you will suffer from earthquake? Did you have interest in earthquake when he Hanshin-Awagi greate earthquake happened and Did you have interest in earthquake just now?
	Measure to mitigate eathquake	Do you prepare food and equipment for emergency? Do you fix all furniture or one part of furniture? Do you kow the place of evacuation that the local government specified? Do you care your place for sleeping? Have you ever discussed with family about emergency response?
Community		How often do you meet neighborhood? How often do you have conversation with neighborhood ? How often attend the activity of your town?

**A Questionnaire Result And Analysis of An Investigation Result**

We performed consideration from the result which receives each question, and clarified disaster-prevention consciousness (consciousness to an earthquake, prior measure to disaster prevention), and the regional characteristic of a local community. Especially, be shown in Fig.2.1, it turns out that height of the sense of impending crisis to big earthquake generating and fixation of furniture which is the prior measure to disaster prevention has strong correlation. In Kobe-City, the rate of enforcement of the furniture fixation for the influence of Hanshin-Awaji earthquake is high. Moreover, in other cities of the Kansai district, it turns out that the rate of enforcement of fixation of furniture is high although the sense of impending crisis of big earthquake generating was low. Next, in order to clarify the relation of “the consciousness to an earthquake”, and “the prior measure to disaster prevention”, as shown in Fig.2.2, by using main-ingredients analysis, we collected the questionnaire item, and we classified the city according to disaster-prevention consciousness and the local community. By this, the feature of each cluster about the capability which mitigates potential damage became clear.



**Fig.2.1 Relationships between Conscious and Preparation**



**Fig.2.2 Classification of Urban Cities**

**The Influence Attribution Analysis And Pile Regression Analysis To Disaster-Mitigation Consciousness And A Local Community**

From the investigation result, as shown in a Chart.2.3, we analyzed the influence factor for presuming the disaster-prevention consciousness and a local community of other cities, and performed the pile regression analysis about the disaster-prevention consciousness and a local community from extracted data. From a pile correlation coefficient( the disaster-prevention consciousness:R1=0.87, a local community:R2=0.83), it is also possible to be able to explain to some extent from extracted data by influence attribution analysis, and to presume the situation the disaster-prevention consciousness and a local community about other cities.

**Chart.2.3 Multiple correlation and correlation efficient**

	Correlation between consciousness of disaster mitigation	Correlation between community
Total number of more than seismic intensity of 4	0.43	
Total number of seismic intensity(1991-1997)	0.46	
Total number of seismic intensity(1996-1997)	0.57	
Regulation and system of local government	0.51	
Total number of big earthquake	0.51	
Population ratios( Age 0-14)	-0.39	0.30
Population ratios( Age 15-64)	0.32	-0.56
Population ratios( Age more than 64)	-0.10	0.53
Total number of nuclear family	0.20	-0.01
Total number of other family	0.04	0.67
Total number of No family(Single)	0.19	-0.47
Population		-0.18
Population density		-0.18
Ratios of detached house		0.48
Ratios of cooperative house		-0.53
Ratios of own house		0.54
Multiple correlation coefficient:R1, R2	0.87	0.83

**Conclusion**

The result of this research grasps the regional characteristics about the potential damage mitigation capability which the city resident of Japan whole country has, and has presented fundamental data which can be utilized for the measure against disaster prevention of administration, local government, and a residents of future

**ACCESSIBILITY AND SUPPORTABILITY FROM OTHER CITIES**

**Introduction**

This study evaluates “Accessibility, Supportability” relatively. “Accessibility, Supportability” means the possibility that the damaged city chosen from seaside and inland can receive, or accept relief from a circumference city in a short time (about 72 hours is assumed) when it is assumed that the city suffered by near-field earthquake.

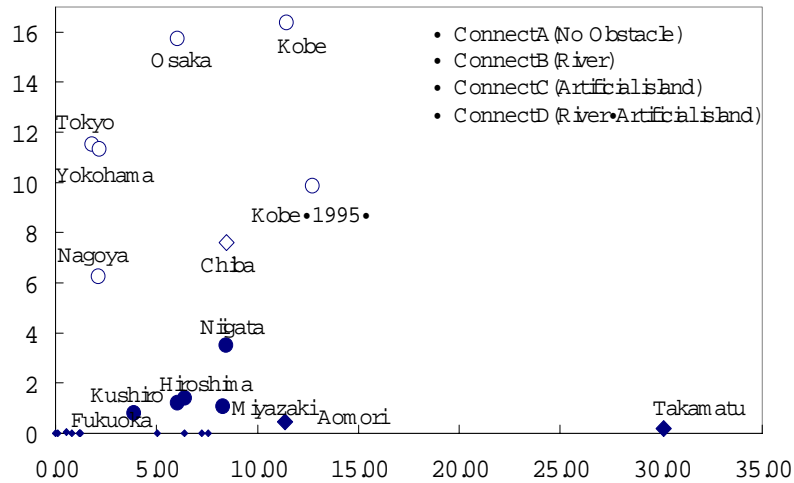
**Evaluation about Accessibility, Supportability of the city**

In order to evaluate Accessibility and Supportability, we defined a possibility that an object city could receive relief from a circumference city as “Support Potential”, and defined a possibility that an object city could accept relief from a circumference city as “Reliability”.

About support potential and reliability, we evaluated and classified the city about marine transportation and land transportation using data shown in **Chart 3.1**. Accessibility evaluation by marine transportation is shown in **Fig.3.1** (we evaluated by same method also about land transportation). It turned out that each city had regional characteristics such as the scale of the support which can received from a circumference city and dependence on marine transportation about relief and rescue from a circumference city reasons such as city location condition.

**Chart.3.1 Items of Data for Evaluation**

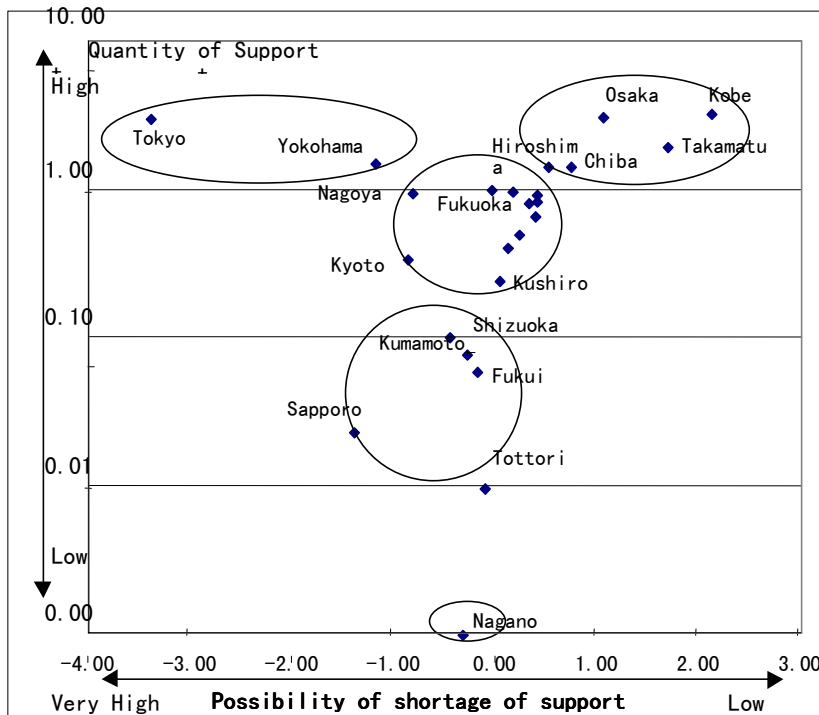
	Influenced Factor	Data
Support Potential	Important Harbor	Seats of ship of Important Harbor
	Ferry routes	Area of Deck
		Passengers in it
	Route of others	Total tonnage of commercial ship
Scale of city	Population	
Reliability	Earthquake-resistant harbor	Seats of ship of Earthquake-resistant pier
		Seats of ship of high depth pier
Support Potential	Location around cities	Length of bad
	Scale of city	Population
	Scale of another cities	Population
Reliability	Possibility of using road	Number of roads
		Number of bridges



**Fig.3.1 Accessibility and Supportability by Marine Transportation**

**Consideration of the measure from a national land-viewpoint**

Since support potential in the foregoing paragraph is revealed by population as a relative index, we defined that multiplied population as the quantity of support. And we verified the city which needs preponderant measure about relief by setting up the quantity (needs) of relief which an object city needs. Moreover, we showed the relation of the insufficient possibility of support and the absolute quantity of support in **Fig.3.2** in consideration of the needs population) of relief which a city needs. And we created the spraying figure using the difference of needs and support absolute quantity in a horizontal axis, and using the logarithm of support absolute quantity in a vertical axis. The city where the possibility is high that support absolute quantity runs short (located in the left-hand side of a horizontal axis) needs immediate measure, the city that where support absolute quantity is low (located in the vertical-axis bottom) needs radical reinforcement of support. We think that this result can be used as an indicator of measure of national land-level about relief.



**Fig.3.2 Quantity of Support and Shortage of support by Marine Transportation**

**Conclusion**

To incorporating relief and rescue from a circumference in the measure against disaster prevention of each autonomy in consideration of each regional characteristics is desired. Moreover, we think that this research is

important as an index to which the indicator of national measure is urged.

## POTENTIAL OF RECOVERY OF CITIES

### Introduction

This research purpose to make it clear from macroscopic viewpoint whether it is having what the characteristic of a city zone influence in process of restoration and revival with the middle by arranging phenomenon from a view over a very wide area that is indispensable when seeing a present-age city.

### The Set Up of A City Zone

In order to investigate the long influence factor from near-field earthquake generating to revival, we need to observe the situation and its relation of circumference autonomies in consideration of not only the thing in damaged area but also the activity range of man. As shown in **Fig.8.1**, we set up as follows the city zone formed of strongly economical connection and usual employment activity, and considered.

Conditions 1 Municipalities which flow out for employment of 1% or more of the worker which settles permanently in a central city

Conditions 2 Municipalities which flow in for employment of 1% or more of the worker which settles permanently in the municipalities to a central city

Conditions 3 Municipalities which do not fulfill the conditions 1 and 2 surrounded by the municipalities chosen on conditions 1 and 2

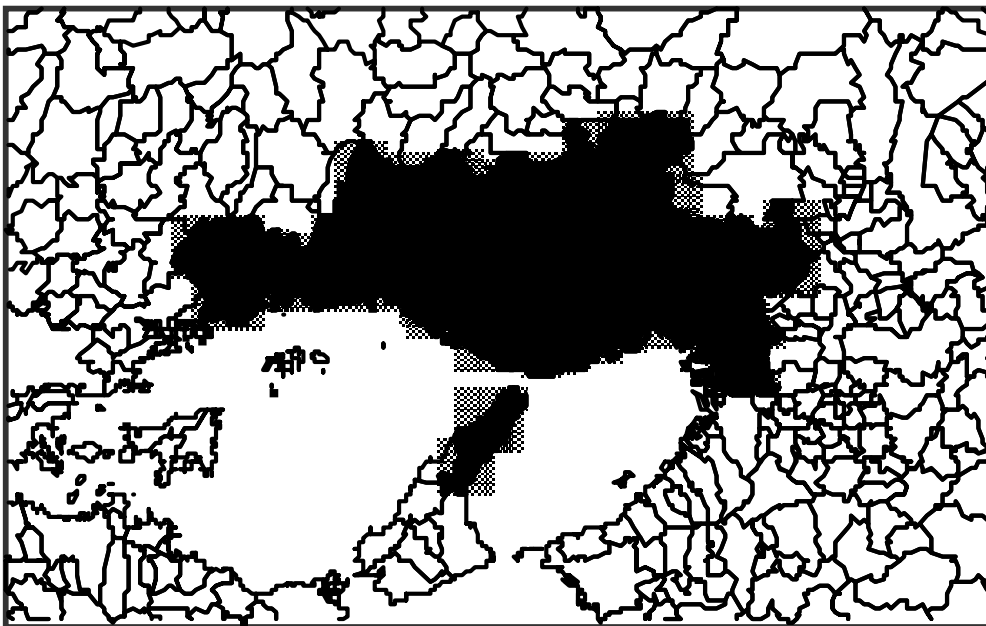


Fig.4.1 Kobe City Area

### Consideration of The Influence By The City Near-field Earthquake of The City Zone Characteristics

About the influence by the city near-field earthquake, we made the case study about HanshinAwaji earthquake, and performed various consideration which observed the Kobe city zone. Osaka-City is located in the Kobe city zone, when the city where a scale is larger than a central city is located in a city zone, it turns out that a possibility of causing hollowization in the population and industrial hollowization is high.

### Grouping of A City Zone of Japan And Consideration of The Long Risk of Being Based on An Earthquake

As shown in a **Chart 4.1**, we performed factor analysis using the variable considered to affect recovery of a city.

It can be guessed that factor No.1 is a measure showing a city scale, factor No.2 is the measure which shows the degree into which worker flows, and factor No.3 is a measure showing growth of economy or population. Moreover, we classified cities and we considered the long risk of being based on the earthquake about cities that are same kind type of Kobe-City.

**Chart.4.1 Kobe City Area**

Variables			Factor Loading		
			Factor# 1	Factor# 2	Factor# 3
‡ @	Population	1995'	0.98	0.16	-0.05
‡ A	Total number of houses	1993'	0.98	0.17	-0.05
‡ B	Retail trade sale sums	1994'	0.97	0.21	-0.04
‡ C	Total number of built houses	1996'	0.96	0.17	-0.05
‡ D	The industrial shipment sums	1995'	0.81	0.25	-0.10
‡ E	Number of employees/number of resident	1995'	0.14	0.88	-0.13
‡ F	Rate of inflow/Rate of outflow of population	1995'	0.52	0.75	-0.04
‡ G	Production increase rates	1990-1995'	-0.08	0.01	0.75
‡ H	Population increase rates	1990-1995'	-0.02	-0.14	0.74

### Conclusion

It is difficult to explain a phenomenon clearly since the phenomenon after an earthquake is realized by composite of various elements. But in this research, we can assume roughly the situation where the characteristic of a city zone influences after earthquake generating

### CONCLUSION

In this study , we focused the analysis by macro view and we are trying to have relationships between macro and Micro. Firstly, Macro analysis is very important index we can use easily and this macro analysis leads to micro analysis for each cities.