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DECISION-MAKING METHOD IN THE EARTHQUAKE DISASTER PREVENTION ADMINISTRATION BASED ON AN ECONOMIC MEASURE

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SUMMARY

In a usual seismic damage estimation by a local government, relations between its damage estimation and a local disaster prevention plan or earthquake disaster prevention are not always clear, and it often depends on precedent examples or individual policiestor experience and intuition of a person-in-charge to select countermeasures in such a plan or policies. From a viewpoint of the so-called accountability of a local government we need to establish a practical and rational decision making method for earthquake disaster prevention planning. Here we take Fukuoka City, one of twelve designated big cities in Japan, as a target of our case study. First we estimate the building damage from a hypothesized earthquake on the Kego fault, which is running across Fukuoka City. Then we consider various investment plans against the estimated building damage. Finally, we perform the cost-benefit analysis for these plans and show how to choose a most efficient plan from an economical point of view. As a result, we found that we can decide priority of different plans in a united matter based on the aseismic safety improvement per unit cost for each plan.

INTRODUCTION

When it thinks about damage due to the earthquake and that countermeasure, the examination related to the cost of the countermeasure and that effect can't be missed from the point of view of administration and of control. Most fundamental countermeasure against earthquake disaster is rebuilding or seismic repairing old buildings. But about that actual case, It can think about various combinations by the ratio by the structure type, construction generation, area and the quantitative scale of rebuilding or seismic repairing. Here we take Fukuoka City, one of twelve designated big cities in Japan, as a target of our case study. First we estimate the building damage from a hypothesized earthquake on the Kego fault, which is running across Fukuoka City. Then we consider various investment plans against the estimated building damage. Finally, we perform the cost-benefit analysis for these plans and show how to choose a most efficient plan from an economical point of view.

ESTIMATION METHOD OF EARTHQUAKE DAMAGE

Earthquake damage is estimated by the method that developed by Disaster Prevention Bureau, National Land Agency government of Japan[1)], as a matter of convenience. The unit area of damage estimation is made primary school districts. A topographical map of Fukuoka City with the Kego fault is shown **Figure 1**. There are 145 primary school district in Fukuoka City, it is 117 school district that is being covered within the figure 1. The Kego fault is running across the neighborhood of the central part of the city. First, the earthquake of the magnitude 7.0, the depth of the hypocenter by 10km is supposed to appear on this fault. Then peak velocity at standard soil where shear wave velocity is about 640m/s is calculated by using equation of attenuation in distance by Midorikawa (1993)[2)]. The calculation result of peak velocity distribution at standard soil is shown **Figure 2**. Next, maximum velocity amplification rate is calculated in Matsuoka and Midorikawa's method[3)]. This amplification rate is multiplied by

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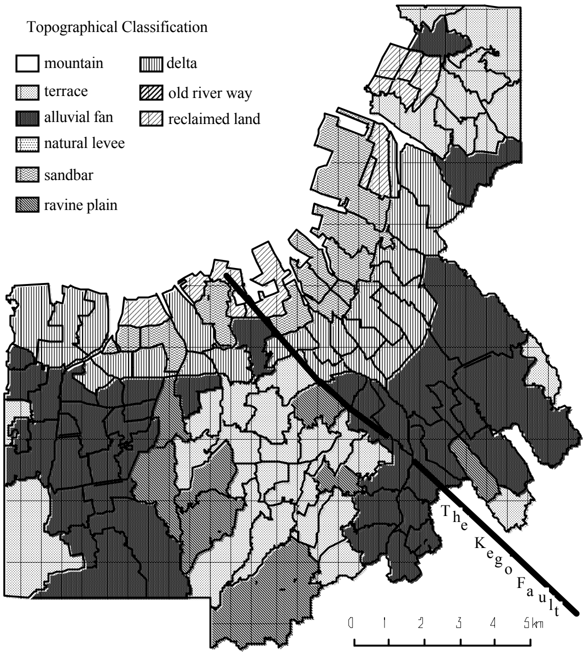

Figure 1: A topographical map of Fukuoka City with the Kego Fault

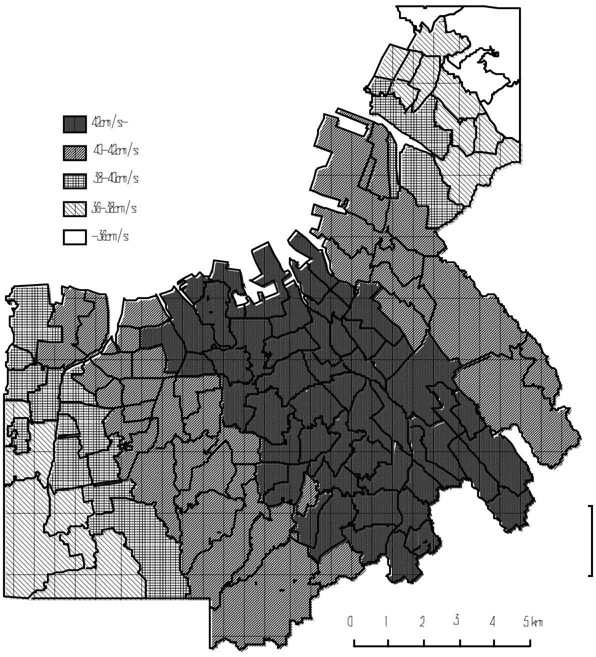

Figure 2: Peak velocity distribution at standard soil (M=7.0,D=10km)

peak velocity at standard soil, and peak ground velocity is calculated. This result of peak ground velocity distribution is shown **Figure 3**. When it is compared with a **Figure 2**, it is understood that the influence of the difference in the amplification rate by the topographical features appears well. Then vulnerability function[1)] is used to calculate the total collapse rate of buildings by structure type, construction generation, soil type. A vulnerability function to use here is shown in the **Figure 4**.

ESTIMATION METHOD OF THE AMOUNT OF BUILDING ASSETS DAMAGE

It is assumed that the cost of new construction or rebuilding of wooden building is 150 thousand yen/m^2, non-wooden building is 300 thousand yen/m^2, and the cost of seismic repairing of wooden building is 10 thousand yen/m^2, non-wooden building is 40 thousand yen/m^2. To calculate building assets, we think the concept of present value rate of building. Building assets is shown by the thing that the present value rate of the building is multiplied by the new construction value. Here, it is assumed that present value rate of building decrease 50% by 25 years in wooden building case, and 50% by 40years in non-wooden building case. Depreciation rate in a year is 0.97265 in wooden building, and that is 0.98282 in non-wooden building. Using this present value rate, building assets at present are estimated by the structure type (wooden or non-wooden) and the construction generation. Then total collapse rate by the structure type and the construction generation is found by using vulnerability function in the **Figure 4**, this collapse rate is multiplied by building assets, the amount of property damage of buildings by the structure type and the construction generation is estimated. And whole amount of building property damage of the primary school district is found by the whole's summing this up. Classification of construction generation is before 1959, 1960-1980, after 1981 in wooden buildings, and before 1980, after1981 in non-wooden buildings.

THE OUTLINE OF THE RESULT OF THE EARTHQUAKE DAMAGE ASSUMPTION

Building distribution by the structure type and the construction generation in Fukuoka City

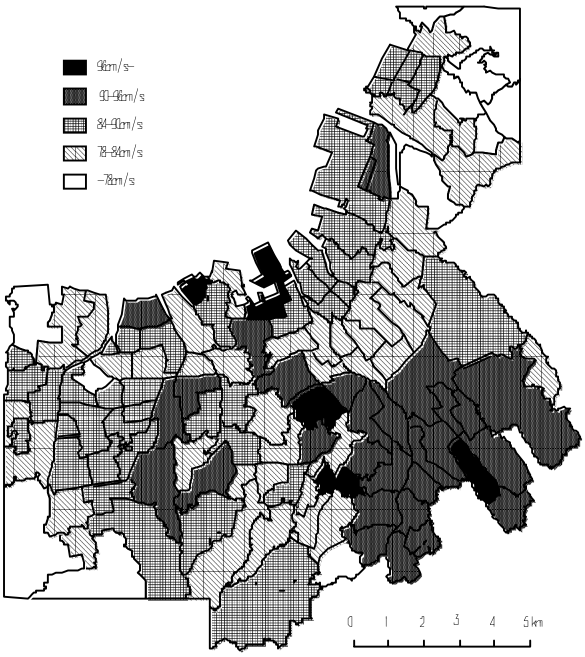

Figure 3: Peak ground velocity distribution (M=7.0, D=10km)

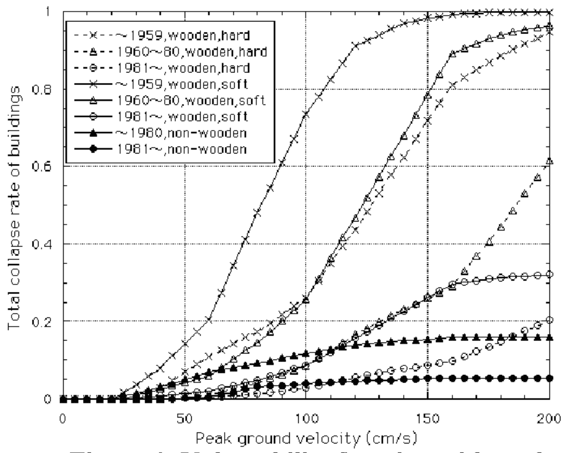

Figure 4: Vulnerability function with peak ground velocity

We show the state of building distribution by the structure type and the construction generation in Fukuoka City. In reason of lack of the paper, distribution of total floor area of wooden buildings built before 1959 per unit area is shown **Figure 5**, and distribution of total floor area of non-wooden buildings built before 1980 per unit area is shown **Figure 6**. It is found that old wooden buildings are distributed around the old town area from the **Figure 5**, and it is found that non-wooden buildings are distributed around the two centers of the city of Hakata station and Tenjin from the **Figure 6**. And distribution of total assets of buildings per unit area is shown **Figure 7**. It is distributed around the two centers of the city in the shape of the letter of Y, and it looks like the distribution of the non-wooden buildings.

Estimation result of the building damage due to the earthquake

As examples, distribution of total collapse rate of wooden buildings built before 1959 is shown **Figure 8**, and distribution of total collapse rate of non-wooden buildings built before 1980 is shown **Figure 9**. The size of the total collapse rate of buildings changes greatly by the construction generation. Because there are no relations that peak ground velocity and hardness of the soil between building construction generation, which is the factor which total collapse rate is decided, a school district who have high total collapse rate in a certain generation, have high collapse rate in other construction generation relatively. Then distribution of total damage rate of assets of buildings is shown **Figure 10**. This distribution takes influences both of the strength of ground motion and composition of buildings by the construction generation and the structure type in school district.

EXAMINATION OF SEISMIC INVESTMENT'S STRATEGIES

Two categories after 1981 are removed from five categories by the structure and construction generation because the investments toward two categories are in effective. Then two ways of rebuilding and seismic repairing are decided to think about seismic investment toward the wooden buildings built before 1959, the wooden buildings built in 1960-1980 and the wooden buildings built after 1981 respectively. It thinks about the following seven seismic investment strategy including the case that a countermeasure isn't done.

case(0) : A countermeasure isn't done

case(1) : The wooden buildings built before 1959 are rebuilt in the non-wooden buildings

case(2) : The wooden buildings built before 1959 are seismic repaired

case(3) : The wooden buildings built in 1960-1980 are rebuilt in the non-wooden buildings

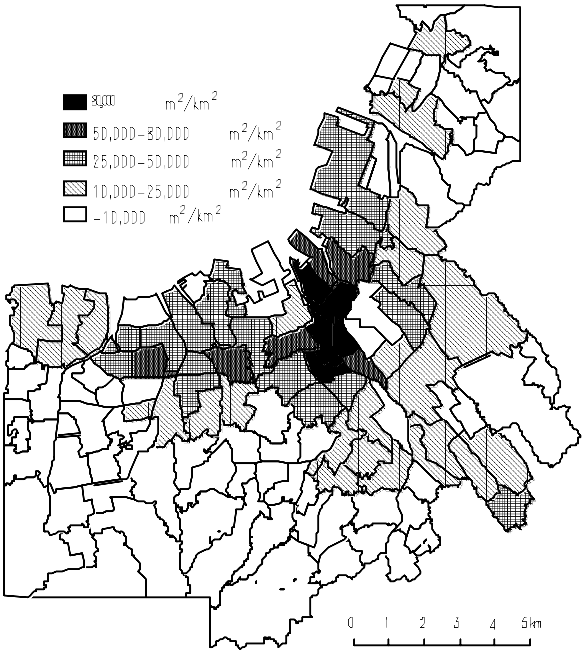

Figure 5: Distribution of total floor area of wooden

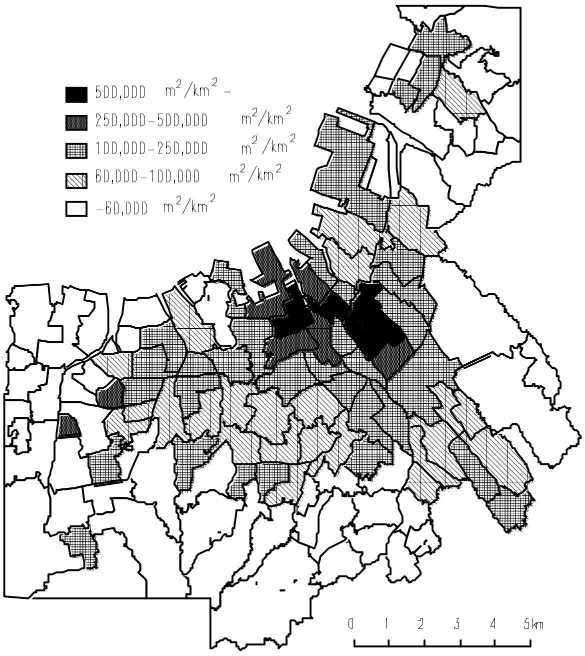

Figure 6: Distribution of total floor area of non-wooden buildings built before 1980 per unit area

case(4) : The wooden buildings built in 1960-1980 are seismic repaired

case(5) : The non-wooden buildings built before 1980 are rebuilt

case(6) : The non-wooden buildings built after 1981 are rebuilt

When it went through rebuilding it is decided that there is effect on capital multiplication of 1.5 times, in the same way 1 time when it went through repairing. And then it is decided that the building complete destruction rate when a countermeasure is done becomes it after 1981. By thinking about building complete destruction rate, building whole floorage, seismic investment cost of around the unit floorage, and effect on capital multiplication, the amount of property before earthquake, the amount of property after earthquake, the amount of damage by earthquake, benefit by earthquake, the amount of decrease of the earthquake damage by seismic investment when it went through seismic investment can be led toward each seismic investment strategy.

EVALUATION OF SEISMIC INVESTMENT'S STRATEGIES

BY USING COST-BENEFIT ANALYSIS

The amount of building total property before the earthquake in case(0)-a countermeasure isn't done- is made A_{b0}, in the same way the amount of building extant total property after earthquake is A_{a0}, the amount of damage cause of earthquake is D_0. And the amount of building total property before the earthquake in seismic investment case(i)(i=1,6) is made A_{bi}, in the same way the amount of building extant total property after earthquake is A_{ai}, the amount of damage cause of earthquake is D_i.,seismic investment cost is C_i. Then the difference in the amount of building extant total property after earthquake ,ΔA_i when it goes through seismic investment or not , is shown with (A_{ai}-A_{a0}). When seismic investment cost, C_i, is subtracted fromΔA_i, the effect of seismic investment, E_{fi}, is looked for. If this E_{fi} takes positive value, the effect of seismic investment is decided to be admitted. And, the cost of the unit area and the value of the effect don't change even if the size of the amount of investment changes as for the cost and the effect of seismic investment here if the category of seismic investment strategy is the same. Therefore, if the unit cost and effect rise rate of each investment strategy is used, it can think that the order of priority of seismic investment strategy can be decided monastically. This effect rise rate per unit cost is found by dividing investment effect E_{fi} with an investment cost C_i.

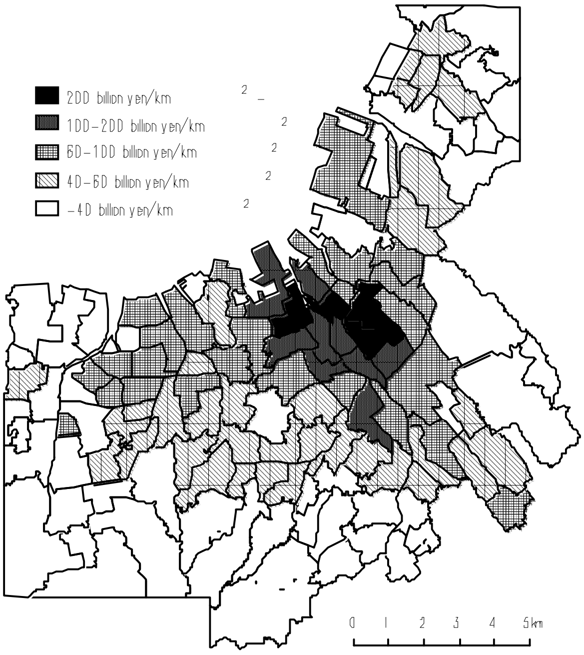

Figure 7: Distribution Of Total Assets Of Buildings

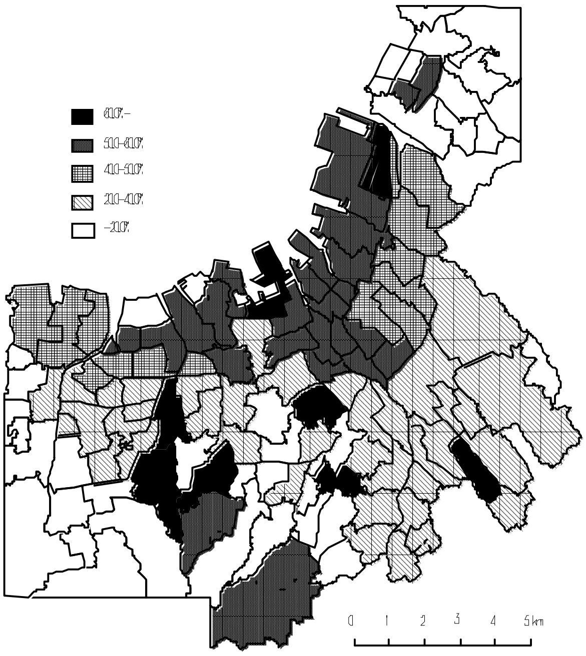

Figure 8: Distribution of total collapse rate of wooden buildings built before 1959

The calculation example is shown when an earthquake occurs in M7.0, the earthquake center depth 10km supposing Kego fault as an earthquake center. It is shown that the effect rise rate per unit cost toward each seismic investment strategy at 5 schools district, N elementary school district, D elementary school district, H elementary school district, A elementary school district, and T elementary school district in Fukuoka city . The character of 5 primary school district to use as examples to explain how to select the optimum seismic investment strategies is shown **Figure 11**. And then, in these 5 school districts, index of the rising rate of investment's effect per unit cost for each seismic investment strategies is shown **Figure 12**.

It is the investment strategy whose effect on an economy is high as much as an effect rise rate per unit cost is high. Therefore, in the case of an example to show in the figure 12, From the point of effect on investment it is desirable that Case (2) , in which the wooden buildings built before 1959 are seismic repaired, is chosen in order of N elementary school district, D elementary school district, H elementary school district. Then, the effect rise rate of Case (4) of the N elementary school district is higher than Case (2) of the T elementary school district. Therefore, it becomes next in the cost efficiency of the thing that seismic repairs of wooden buildings in 1960-1980 in N elementary school district.

Though it becomes the thing of the budget procedure where seismic countermeasure investment is done to, an efficient investment order can be decided regardless of the size of the budget monastically.

CONCLUSIONS

To show how to select the optimum seismic investment strategy, we take Fukuoka City, one of twelve designated big cities in Japan, as a target of our case study. First we estimate the building damage, and then we consider various investment plans against the estimated building damage. Finally, we perform the cost-benefit analysis for these plans and show how to choose a most efficient plan from an economical point of view. As a result, we found that we can decide priority of different plans in a united matter based on the aseismic safety improvement per unit cost for each plan.

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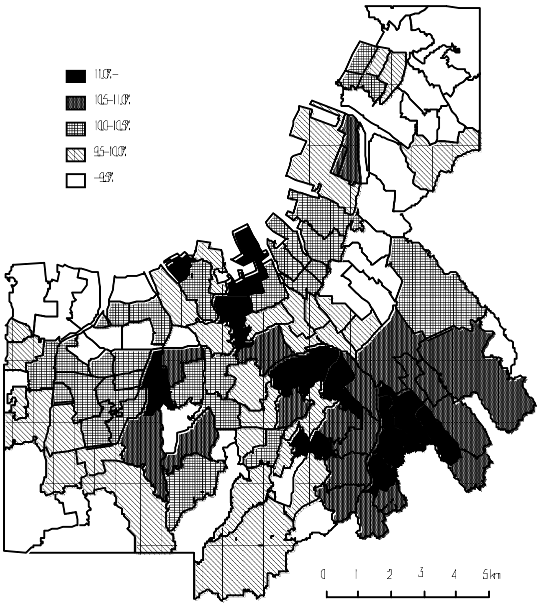

Figure 9: Distribution of total collapse rate of non-wooden buildings built before 1980

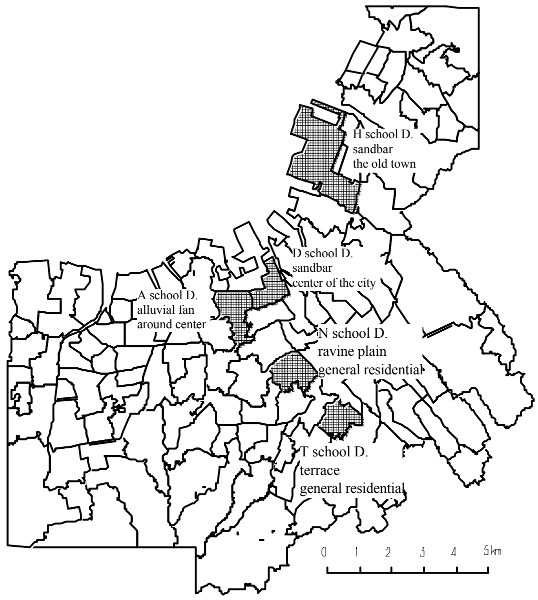

Figure 11: The character of 5 primary school districts to use as examples to explain how to select the optimum

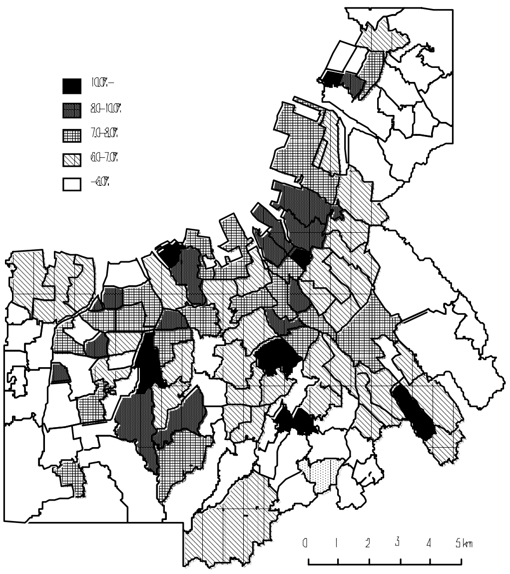

Figure 10: Distribution of total damage rate of assets of buildings

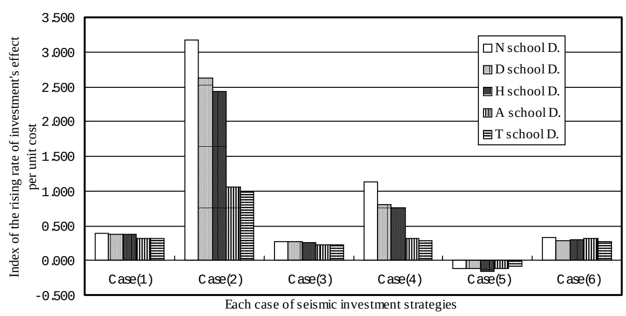

Figure 12: Index of the rising rate of investment's effect per unit cost