A STUDY ON THE EFFECT OF LAND USE CONTROL BY ACTIVE FAULT ZONING IN JAPAN

M.Y OHARA[1] and K. MEGURO[2]

[1] *Associate Professor, Center for Integrated Disaster Information Research, Interfaculty Initiative in Information Studies, The University of Tokyo, Japan*
Email: ohara@iis.u-tokyo.ac.jp
[2] *Professor, International Center for Urban Safety Engineering, Institute of Industrial Science, The University of Tokyo, Japan*

ABSTRACT :

Japan entered an expected longstanding depopulation process in 2006. In this situation, it is important to avoid disaster social impacts due to the disaster by guiding population from vulnerable area to safer areas. This research focused on the risk of active faults among various kinds of natural hazards and studied on the effect of the land-use control along active faults in Japan. First, the meaning of land-use control by active fault zoning in the society whose population started to decrease was discussed. Japan has not adopted earthquake fault zoning act due to several reasons. However, considering the current depopulation process, introduction of the fault zoning act becomes meaningful. Then, the distribution of population and buildings in the neighborhood of active faults was analyzed based on GIS databases of active faults, population and building stocks. The effect of land-use control using fault zones was discussed based on the obtained results. If a fault zone with 0.4km width was decided, referring to the fault zoning act in U.S., it was estimated that the population living inside the fault zone was 2.3% of the total population in Japan. The effect of land-use control was different according to the region. The population living inside the fault zone increased in proportion to the width of the zone.

KEYWORDS: land-use control, active fault zoning, disaster mitigation planning

1.INTRODUCTION

Japan entered an expected longstanding depopulation process in 2006. According to the report by The National Institute of Population and Social Security Research, the total population after 50 years is expected to decrease to about 70% of the current one as shown in Figure 1. In this situation, it is important to avoid disaster social

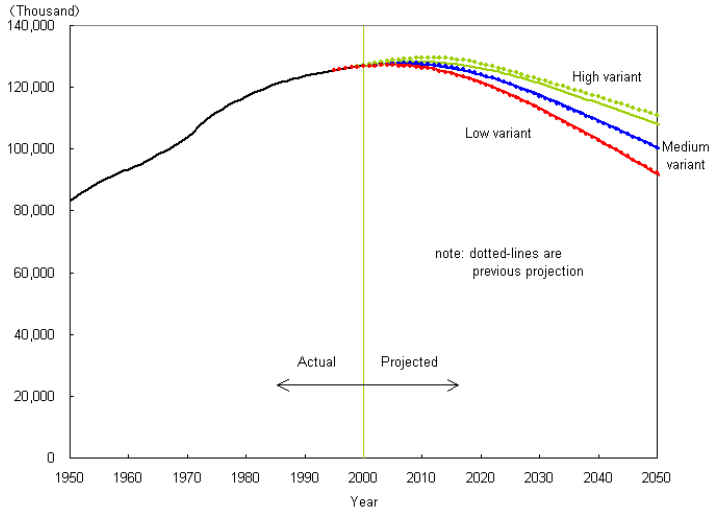

Figure 1 Population projections for Japan: 2001-2050

impacts by guiding population from vulnerable to safer areas.
Recently, Japan suffered the 2004 Niigataken Chuetsu Earthquake, the 2007 Noto Hanto Earthquake and the 2007 Niigataken Chuetsu-oki Earthquake. These earthquakes reminded the danger of active faults in Japan. This research focused on the risk of active faults among various kinds of natural hazards and studied on the effect of the land-use control along active faults in Japan. First, the meaning of land-use control plan along active faults in a society whose population started to decrease was discussed. Then, the distribution of population and buildings in the neighborhood of the active faults was analyzed based on GIS databases of active faults, population and building stocks. The effect of land-use control using fault zones was discussed based on the obtained results.

2. MEANING OF LAND-USE CONTROL PLAN ALONG ACTIVE FAULTS

When the total population decreases, part of the existing building stock becomes unnecessary, and the number of vacant houses and lands increases. If residents in the seismic vulnerable areas along active faults are relocated to safer areas by a land-use control plan, these vacant lands could be effectively used as disaster-prevention facilities having open spaces and warehouses for emergency supplies. These processes are illustrated in Figure 2.

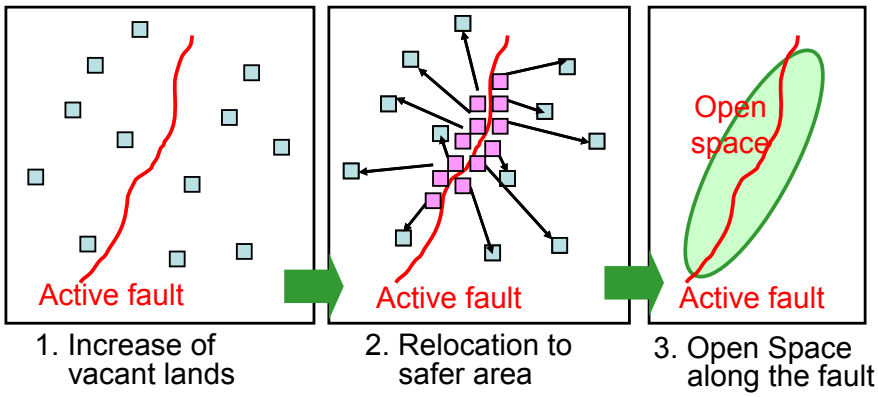

Figure 2 Process of land-use control

Table 1 Conceivable policies for controlling land use

	Direct policy	Indirect Policy
Repression of population inflow	Regulation of ner construction*	Increase in tax for new construction
	Profibition of new construction	Increase in property tax for existing buildings
		Disclosure of seismic risk information on property sales
		Disclosure of seismic risk information on rental agreemet*
		Publicity of seismic risk information*
Promotion of population outflow	Relocation of existing buildings	Grant for relocation
	Regulation of extension or reconstruction of buildings*	Preferential tax treatment for relocation
	Prohibition of extension or reconstruction of buildings	Increase in property tax for existing buildings
	Regulation of rental agreement	Disclosure of seismic risk information on property sales
	Prohibition of rental agreement	Disclosure of seismic risk information on rental agreemet*
		Publicity of seismic risk information*

Table 1 shows the conceivable policies for controlling land use. The lands along active faults could be controlled by the repression of the population inflow and the promotion of the population outflow. These could

be achieved by direct methods such as prohibition and regulation of land use or by indirect methods such as disclosure of seismic risk information and tax control. The policies marked with * in Table 1 are being enforced in California, U.S. by the Alquist-Priolo Earthquake Fault Zoning Act enacted in 1972.
While the earthquake fault zoning act has been carried out in U.S. for 30 years, Japan has not adopted it. There are several reasons why most of the Japanese specialists have opposed fault zoning. First, introduction of the fault zoning could have huge social impact because Japanese population density is high and a lot of people live on active faults. Next, most of active faults in Japan are dip-slip faults and there are many cases in which fault traces do not appear on the surface. Even if the traces on the surface are estimated, uncertainty of the position should be considered. On the other hand, active faults in California, U.S., are strike-slip faults and traces on the surface are easier to identify. However, considering that more lands will become vacant due to depopulation in the future, the possibility of introducing fault zoning act will increase and the discussion on the land-use control plan along active faults becomes more meaningful.

3. DISTRIBUTION OF ACTIVE FAULTS IN JAPAN

First, a GIS database of the active faults was developed by adding several data to the existing digital active fault map. The total length of active faults in Japan is about 10,300 km. When active faults are classified, it is found that 34% of them are dip-slip and 4% are strike-slip as shown in Figure 3. "Mixed " in Figure 3 means a fault that has both strike-slip and dip-slip parts. In case of "Mixed I", the length of dip-slip part is more than 70%. In case of "Mixed II", the rate of dip-slip part is between 30% and 70%. Figure 3 shows the distribution of active faults in Japan.

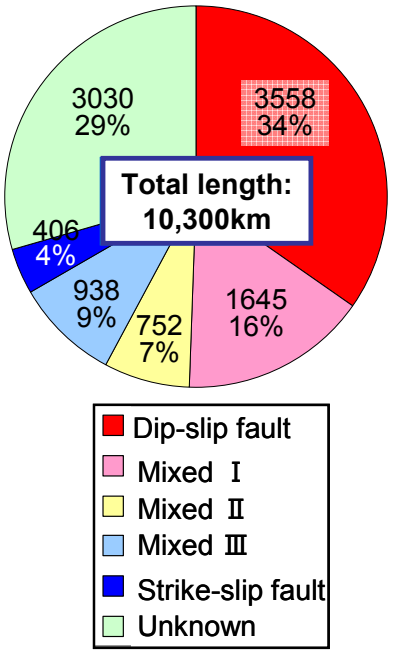

Figure 3 Composition of active fault types

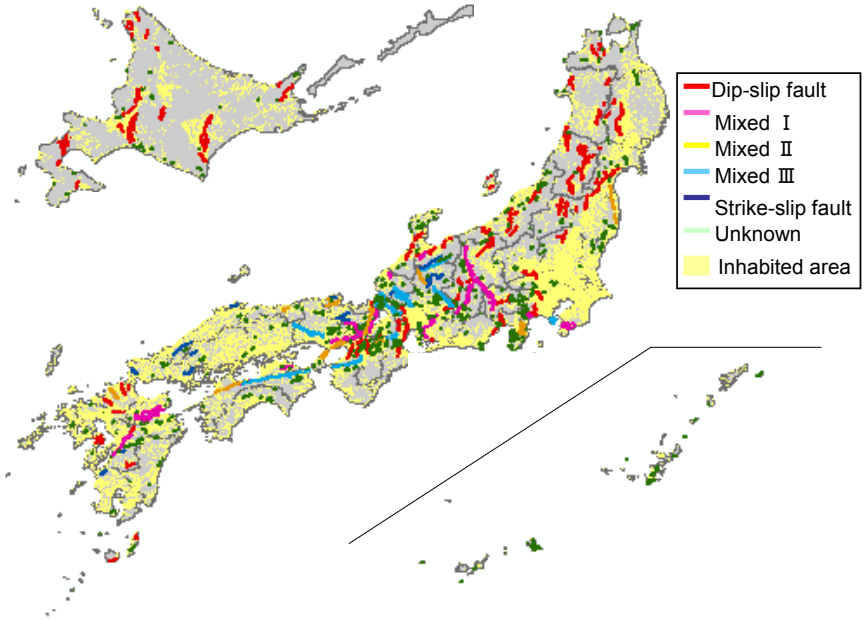

Figure 4 Distribution of active faults in Japan

4. ESTIMATION OF THE EFFECT OF LAND-USE CONTROL ALONG ACTIVE FAULTS

The distribution of population and buildings in the neighborhood of the active faults was analyzed based on GIS databases of the active faults, population and building stocks. Then, the effect of land-use control using fault zones was discussed.

The GIS databases of population and building stocks were developed based on a 1km mesh data from the Housing and Land Survey. The fault zones were hypothetically set along the active faults as shown in Figure 5. In California, the average width of fault zones is 0.4km. Referring to it, the width of the fault zone was first set to 0.4km. In this case, the population inside the fault zone was 2.89 million and it corresponded to 2.3% of the total population in Japan. 0.62 million timber residential houses were located inside the zone. Although 4% of the active faults were strike-slip as shown in Figure 3, the rate of the population living along the strike-slip faults were only 0.4% as shown in Figure 6. Figure 7 describes the regional tendency of population distribution along the active faults. Half of the population living along the faults was located in Kinki area while 40% of the faults were located in Hokkaido-Tohoku or Hokuriku-Koshinetsu Area. It was verified that the effect of land-use control was different according to the region.

If the width of the fault zone was increased to 0.8km, 2km, 4km, the population inside those zones was estimated as 4.5%, 10%, 18% of the total population, respectively. Population increase was almost in proportion to the width of the fault zones.

Considering the uncertainty of the traces of active faults, setting larger fault zones is safer. However, this causes a larger social impact on the population living along the active faults as confirmed in Figure 8. In order to implement land-use control along active faults in Japan, the appropriate width of fault zones should be discussed considering several factors such as lessons from past earthquake damage, uncertainty of the traces of both strike-slip and dip-slip faults, social impact of the fault zones, etc.

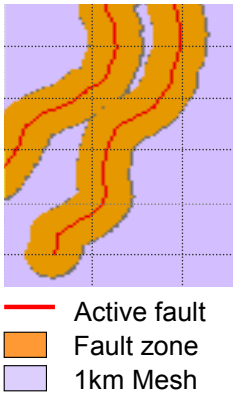

Figure 5 Example of fault zone

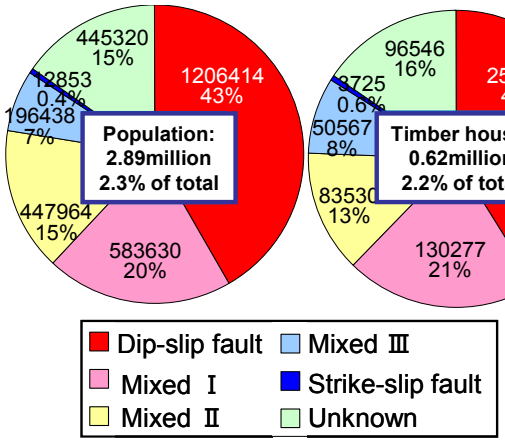

Figure 6 Population and buildings inside the fault zone

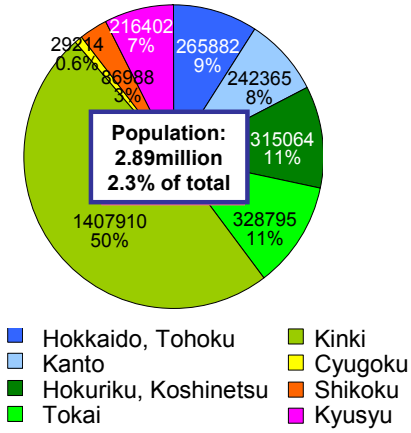

Figure 7 Regional tendency of population distribution

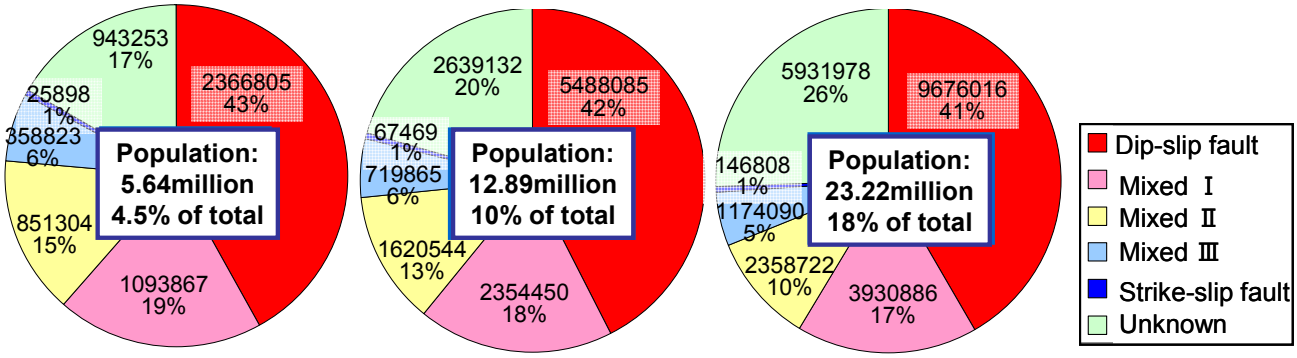

Figure 8 Population inside the fault zone when the zone width is changed

5. CONCLUSIONS

Japan entered an expected longstanding depopulation process in 2006. In this situation, it is important to avoid disaster social impacts by guiding population from vulnerable to safer areas. This research focused on the risk of active faults among various kinds of natural hazards and studied the effect of land-use control along active faults in Japan.

First, the meaning of land-use control plan along active faults in a society whose population started to decrease was discussed. While fault zoning has been carried out in U.S. for 30 years, Japan has not adopted it due to several reasons. Considering that land will become vacant due to depopulation in the future, the possibility of introducing a fault zoning act increases and the discussion on land-use control plans along active faults will become more meaningful.

Then, the distribution of population and buildings in the neighborhood of the active faults was analyzed based on GIS databases of active faults, population and building stock. In case of a 0.4km-width fault zone it was found that 2.89 million people or 2.3% of the total population in Japan live inside the fault zone. Half of the population living along faults is located in Kinki area and therefore, the effect of land-use control was different according to the region. The population inside the fault zone increases in proportion to the width of the zone.

The appropriate width of fault zones should be discussed considering several factors such as lessons from past earthquake damage, uncertainty of the traces of both strike-slip and dip-slip fault, social impact of the zones, among others. In the future, a study of the social impact of risk information of active faults is necessary.

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