# A BASIC STUDY ON EFFECT OF LAND-USE CONTROL PLAN ALONG ACTIVE FAULTS IN JAPAN

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**ABSTRACT**: The population in Japan is expected to decrease after 2006. It is important to guide population from vulnerable area to safe area by proper land use control plan. In this research, land use control plan near active faults in Japan was studied. First, the meaning of land-use control in the society whose population started to decrease was discussed. Next, 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. The effect of land-use control under several conditions of fault zoning was evaluated based on the obtained results.

**Key Words**: active fault, land-use control, depopulation, fault zoning act

## INTRODUCTION

Japan entered a 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 Fig.1. In this situation, it is important to avoid social impact due to disasters by guiding population from vulnerable area to safer area. Recently, Japan suffered the 2004 Niigataken Chuetsu Earthquake, the 2007 Noto Hanto Earthquake and the 2007 Niigataken Chuetsu-oki Earthquake. These earthquakes reminded a 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 the 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 the active faults, population and building stocks. The effect of land-use control under several conditions of fault zoning was evaluated based on the obtained results.

## MEANING OF LAND-USE CONTROL ALONG ACTIVE FAULTS

When the total population decreases, existing building stocks become unnecessary, and the numbers of vacant houses and lands increase. If the residences in the seismically vulnerable area along active faults are relocated to the safer area by the land-use control plan, these vacant lands could be effectively used for disaster-prevention facilities which have open space and warehouses for emergency supplies. These processes were illustrated in Fig. 2.

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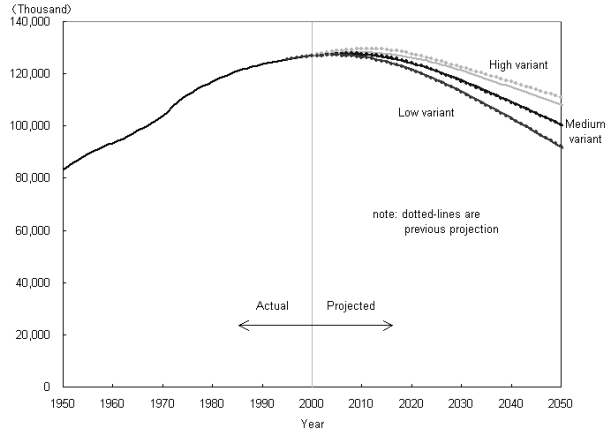


**Figure 1**. Population projections for Japan:2001-2050

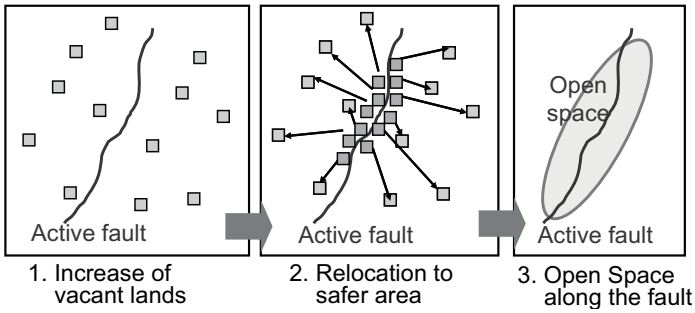


**Figure 2**. Process of land-use control

**Table 1**. Conceivable policies for controlling land use

| | Direct Policy | Indirect Policy |
|---|---|---|
| **Repression of population inflow** | Regulation of new construction* | Increase in tax for new construction |
| | Prohibition of new construction | Increase in property tax for existing buildings |
| | | Disclosure of seismic risk information on property sales |
| | | Disclosure of seismic risk information on prental agreement* |
| | | 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 prental agreement* |
| | | 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 method such as prohibition and regulation of land use or by indirect method such as disclosure of seismic risk information and tax control. The policies marked with * in the 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 for 30 years in U.S., 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 the active faults. Next, most of the active faults in Japan are dip-slip faults and there are many cases that traces of the faults don't 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 be identified. 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 will be more meaningful.

## DISTRIBUTION OF ACTIVE FAULTS IN JAPAN

First, GIS database of the active faults were developed by adding several data to the existing digital active fault map (Nakata and Imaizumi, 2002). The total length of active faults in Japan is about 10,300 km. When the lengths of active faults were classified by the fault types, 34% of the active faults were dip-slip and 4% were strike-slip as shown in Fig. 3. "Mixed " in Fig. 3 means the fault that has both strike-slip part and dip-slip part. In case of "Mixed Ⅰ", the rate of 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 4 shows the distribution of active faults in Japan.

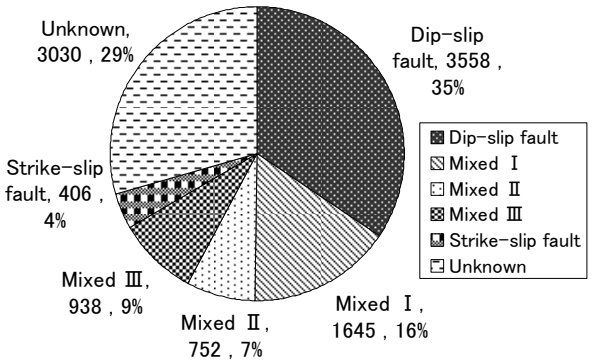


**Figure 3**. Composition of active fault types

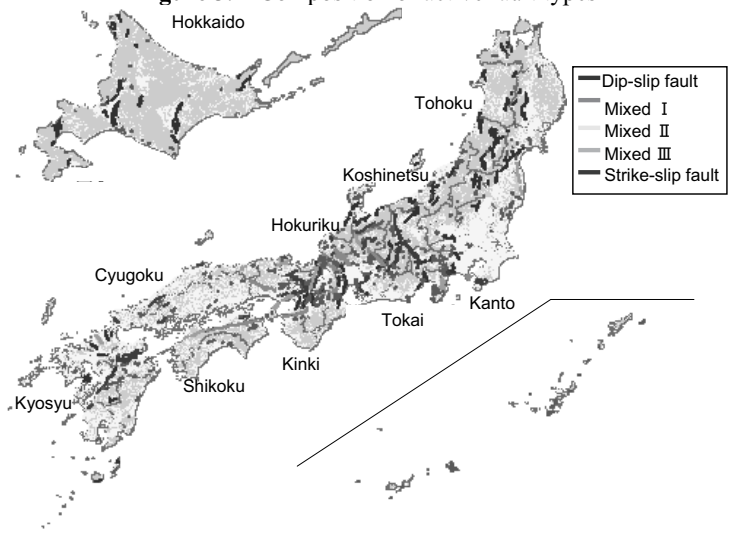


**Figure 4**. Distribution of active faults in Japan

## 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 using 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 the 1km mesh data (Housing and Land Survey, 1998). The fault zones were hypothetically set along the active faults as shown in Fig. 5. In California, average width of fault zones is reported to be 0.4km. Referring to it, the width of the fault zone was set to be 0.4km at first. In case of this width of zone, 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 estimated to be located inside the zone. Although 4% of the active faults were strike-slip as shown in Fig. 3, the rate of the population living along the strike-slip faults were only 0.4% as shown in Fig. 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 is said that the effect and the impact of land-use control are different according to the region.

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

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

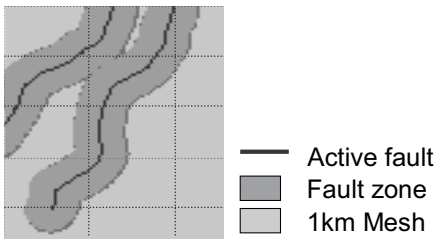


**Figure 5**. Example of fault zone

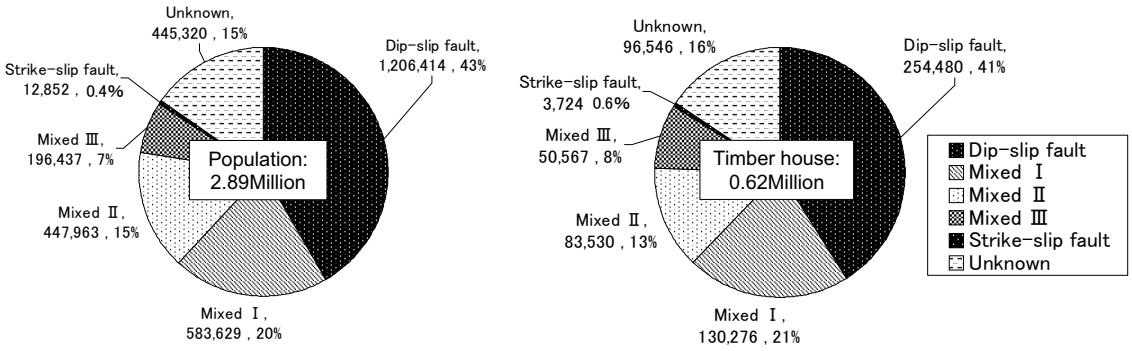


**Figure 6**. Population and buildings inside the fault zone

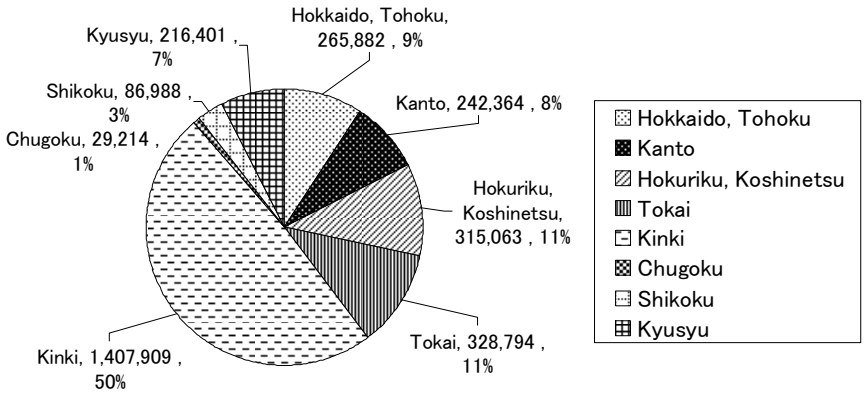


**Figure 7**. Regional tendency of population distribution

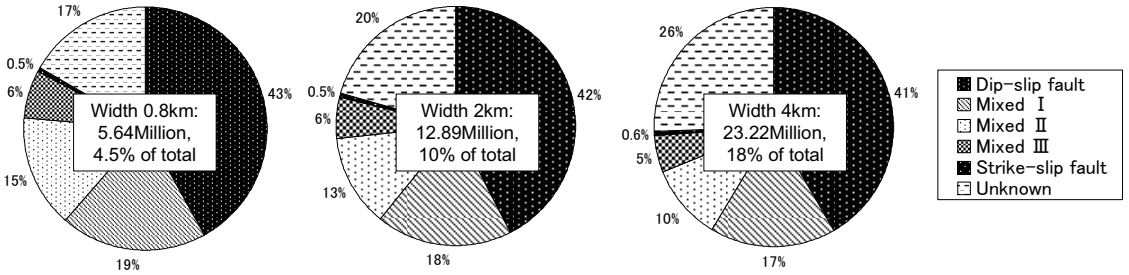


**Figure 8** Population inside the fault zone when the width of zone is changed

## CONCLUSIONS

Japan entered a longstanding depopulation process in 2006. In this situation, it is important to avoid social impact due to the disaster by guiding population from vulnerable area to safer area. This research focused 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 the society whose population started to decrease was discussed. While fault zoning act has been carried out for 30 years in U.S., Japan has not adopted it due to several reasons. 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 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 the active faults, population and building stocks. In case of the fault zone whose width was assumed to be 0.4km referring to the act in U.S., the population inside the fault zone was 2.89 million and it corresponded to 2.3% of the total population in Japan. Half of the population living along the faults was located in Kinki area and the effect and the social impact of land-use control was different according to the region. The population inside the fault zone was increased in proportion to the width of the zone. The appropriate width of fault zones should be discussed considering all the factors such as lessons learnt from past earthquake damage, uncertainty of the traces of both strike-slip and dip-slip fault, social impact of the zones.

Based on the study, the authors think that it is meaningful and possible to adopt land-use control plan along active faults in Japan for earthquake damage reduction. However, for its implementation, a study on social impact of the risk information of active faults is necessary to decide proper width of the fault zone and to get social consensus.

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