

SURVEY ON RESIDENTS' ATTITUDES TOWARD RETROFITTING OF EXISTING SEISMIC VULNERABLE HOUSES IN JAPAN

Miho YOSHIMURA¹, Kimiro MEGURO² and Masayuki KOHIYAMA³

ABSTRACT: From recent damaging earthquakes, it is clearly found that retrofitting of seismic vulnerable houses is the key issue for earthquake disaster reduction. However, homeowners do not retrofit their houses for various reasons. In this research, a questionnaire survey was conducted among homeowners in Japan in order to find out more effective strategies for promotion of retrofitting of seismic vulnerable houses based on residents' needs. The main factors that encourage or discourage homeowners to retrofit their houses were identified. Moreover, their anxiety over the uncertainty of building strength after retrofitting and dishonest contractors was also pointed out. Finally, based on the homeowners' attitudes, some suggestions were presented to improve the current strategies for promotion of retrofitting of seismic vulnerable houses.

Key Words: Retrofitting, Earthquake Risk Reduction, Seismic Vulnerability

INTRODUCTION

Even if a very good disaster response system and/or disaster recovery and reconstruction plan is available, it is impossible to reduce earthquake damage without implementing proper mitigation techniques. The 1995 Kobe earthquake caused 6,433 dead and 43,792 injured people. It is reported that 87% of the people were killed in their own homes due to the collapse of structures or falling furniture, as the occurrence time of the earthquake was early in the morning, 5:46 am. Considering this fact, the only way that would have saved these lives was to increase the strength of their residences by retrofitting or rebuilding them before the event.

Based on the actual earthquake damage, the structural seismic design code has been revised several times in Japan. The final code revision (before the Kobe Earthquake) was done in 1981. The structures that were constructed using this code performed well even under the strong ground motion of the Kobe earthquake as shown in Figure 1. However, there are many vulnerable structures among those constructed before the 1981 code revision. According to the Ministry of Land, Infrastructure and Transport Government of Japan, the number of vulnerable timber single-family houses is estimated to be 10 million out of 11.5 million houses constructed before 1981. In spite that these structures need to be retrofitted before the next big event occurs in order to reduce the earthquake damage, retrofitting activities are not carried out widely especially for private houses. Some municipalities or local governments have conducted systems to promote retrofitting activities such as, the assistance system and the low interest loan for seismic evaluation or retrofitting of structures. Unfortunately, so far, there is no municipality in which the retrofitting activities have been successfully carried out in Japan.

¹ Research Associate

² Professor

³ Assistant Professor, Keio University

Homeowners have various reasons why they do not retrofit their houses. In this research, a questionnaire survey was conducted among homeowners in Japan in order to find more effective strategies for promotion of retrofitting existing vulnerable houses based on residents' needs. The main factors that encourage or discourage homeowners to retrofit their houses were identified. Moreover, their anxieties over retrofitting works were analyzed. Finally, based on the homeowners' attitudes, some suggestions are discussed to improve the current strategies for promotion of retrofitting existing seismic vulnerable houses.

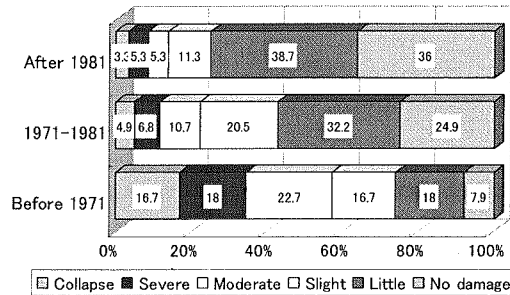


Figure 1. Damage ratio of pre-code and current-code structures during the 1995 Kobe Earthquake

Table 1. Estimated number of vulnerable pre-code houses in Japan

| Number (Million) | Houses (including all the construction type) | Timber single-family houses |
|---|--|-----------------------------|
| Total number | 46.9 | 24.5 |
| Number of houses constructed before 1981 | 17.6 | 11.5 |
| Number of vulnerable houses constructed before 1981 | 11.7 | 10.0 |

OUTLINE OF THE QUESTIONNAIRE SURVEY

A questionnaire survey was conducted among heads of households (or their spouses) living in owner-occupied houses in Tokyo Metropolitan region through the Internet. Respondents' age varied from 30 to 69 year old. The investigation period was from December 17 to 23, 2004 and 2,604 answers were obtained. The number of respondents is classified according to their house construction year in Fig. 2. The rate of respondents who live in the pre-code houses was 17.1%. Considering that the rate of pre-code houses is 50.7% according to the national statistics of building stocks, the observed rate of pre-code houses was smaller than the real situation because the survey was done using Internet environment. 1,596 respondents who lived in timber single-family houses were selected. The relation between their age and the construction year of their houses is shown in Fig. 3. The respondents between 50 and 59 years old had the highest annual incomes as described in Fig. 4.

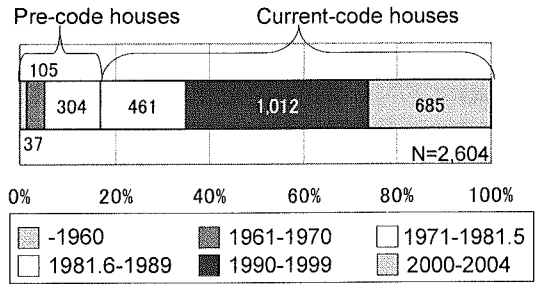


Figure 2. Number of respondents classified by their age and construction years of the houses

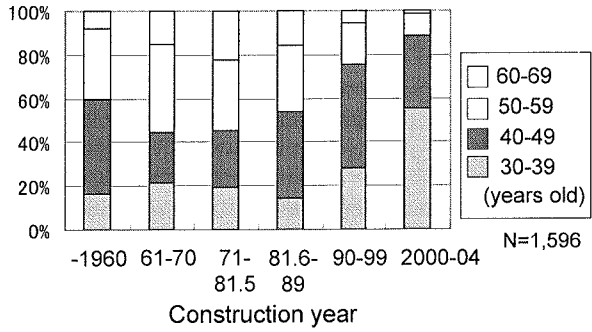


Figure 3. Number of respondents classified by annual incomes levels

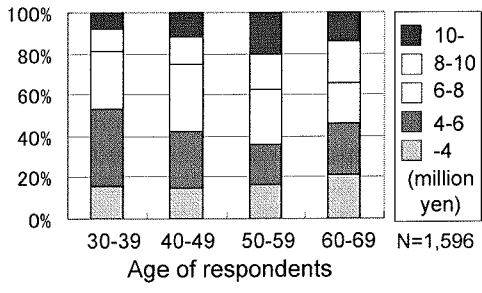


Figure 4. Relation between the age and the annual income level of respondents

HOMEOWNERS' INTENTIONS TO RETROFIT THEIR HOUSES

First, homeowners' earthquake risk perception was observed. Figure 5 shows their expectation of the occurrence of an earthquake similar to the 1995 Kobe Earthquake classified by their house construction year. No statistically significant difference is seen for different construction years. Figure 6 shows the expectation of structural damage to their houses when a great earthquake of the 1995 Kobe Earthquake level occurred. Homeowners with older houses expected severer damage. More than 50% of homeowners whose houses were constructed before 1970 anticipated severe damage.

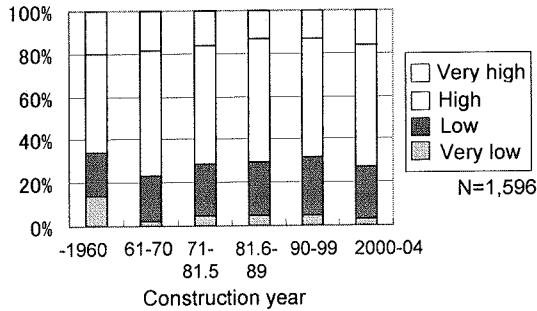


Figure 5. Homeowners' expectation of earthquake occurrence classified by construction year

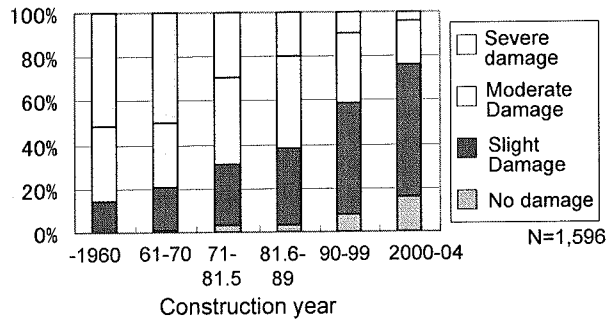


Figure 6. Homeowners' expectation of structural damage to the houses classified by construction year.

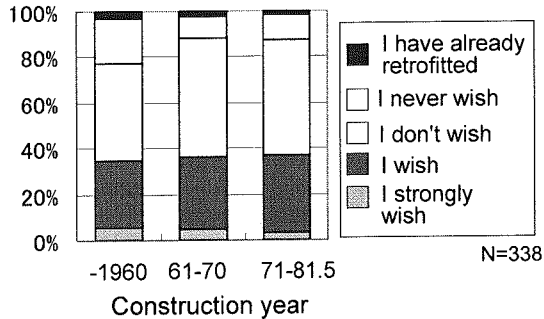


Figure 7. Homeowners' intentions to retrofit pre-code house.

Then, homeowners' intentions to retrofit their pre-code houses were investigated considering five categories: "I strongly wish", "I wish", "I do not wish", "I will never retrofit my house", and "I have already retrofitted my house". Regardless of the house construction year, the rate of homeowners who "strongly wish" or "wish" to retrofit their houses was about 35% as shown in Fig. 7. Usually, the cost of retrofitting is remarkably reduced (to half or one third of the price) if retrofitting and remodeling are done simultaneously because the cost for restoring the interior is not required. Then, the homeowners were asked whether they wished to retrofit their houses in case that low-cost retrofitting techniques (half or one third of the current price) were available. Compared with Fig. 7, the homeowners who wished to retrofit increased by 9%, 17%, and 13% in each construction year category (Fig. 8). This confirmed that high cost is one factor that discourages retrofitting. On the other hand, the rate of the homeowners who would never retrofit was almost the same between Figs. 7, 8.

This means that these homeowners do not wish to retrofit due to reasons other than economical problems.

Figure 9 shows the relation between homeowners' expectation of earthquake occurrence and their intention to retrofit pre-code houses. As the homeowners recognized the high risk of a huge earthquake, their wish to retrofit increased. The relation between homeowners' expectation of structural damage in case of a huge earthquake and their wishes to retrofit pre-code houses is also analyzed in Fig. 10. It is observed that about 50% of homeowners do not wish to retrofit their pre-code houses even if they expect severe damage in case of a huge earthquake.

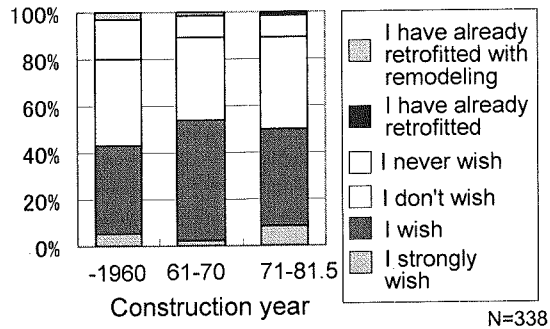


Figure 8. Homeowners' intentions to retrofit pre-code houses in case of low retrofitting cost.

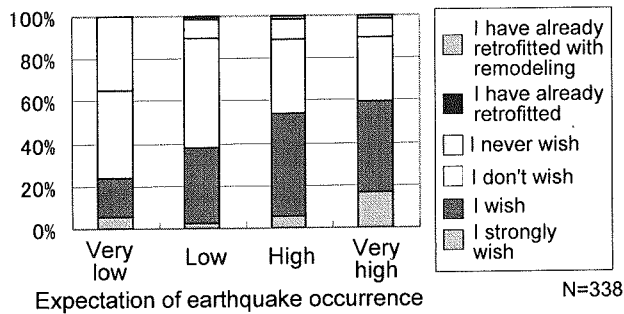


Figure 9. Relation between homeowners' expectation of earthquake occurrence and their intentions to retrofit their pre-code houses.

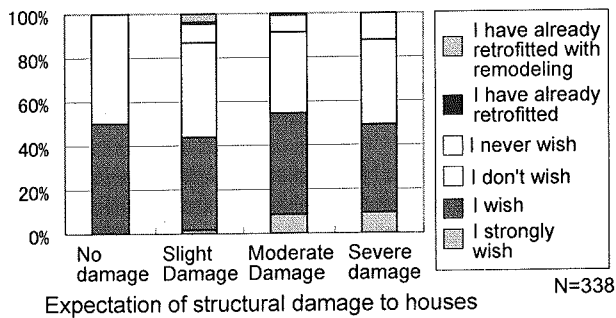


Figure 10. Relation between homeowners' expectation of structural damage and their intentions to retrofit their pre-code houses.

MAIN FACTORS THAT ENCOURAGE OR DISCOURAGE HOMEOWNERS TO RETROFIT THEIR HOUSES

In the previous section, the various reasons that may affect the decision-making of homeowners to retrofit their pre-code houses were analyzed. Here, main factors that encourage or discourage homeowners to retrofit their pre-code houses are discussed. First, various facts that may affect their decision-making were given to respondents and they characterized their attitudes to each of them as: "I strongly agree", "I agree", and "I do not agree". Then, the reasons that encourage/discourage retrofitting were identified. For this, the difference of the rate of "I strongly agree" for each fact between homeowners who consent or oppose retrofitting was calculated. The obtained difference is regarded as an index that shows how much each fact affects the retrofitting decision-making. If this index is positive, the fact is classified as encouraging retrofitting whereas it discourages retrofitting if it is negative.

Both factors were described in Figs. 11, 12. The main factors that encourage homeowners to retrofit their houses were the wish to save their families and properties and the fears of a sudden earthquake. The key factor that influences homeowners not to retrofit was their hesitation between retrofitting and rebuilding. The pre-code houses were built more than 24 years ago. Considering that the average lifespan of a timber house in Japan is 26 years, it is

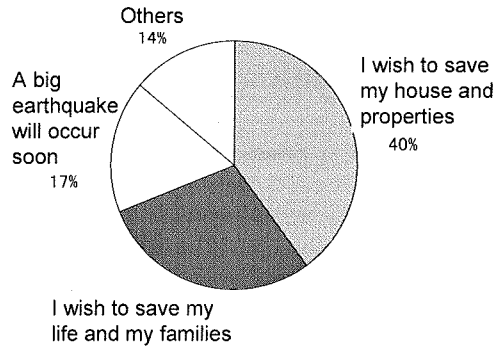


Figure 11. Main factors that encourage homeowners to retrofit their houses

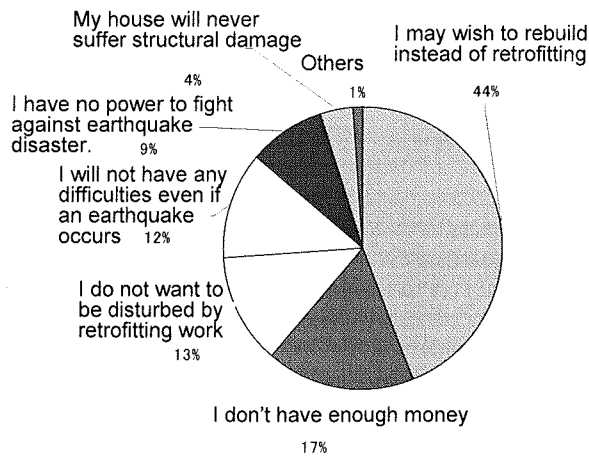


Figure 12. Main factors that discourage homeowners to retrofit their houses.

reasonable that the decision-making between retrofitting and rebuilding is difficult. Other negative factors were: lack of money, fears of being disturbed, optimism in case of an earthquake disaster, feeling of helplessness during an earthquake disaster, and confidence in building strength. The latter was only 4% among all the factors that discourage retrofitting. The respondents had severe economical, physical, and mental problems compared with their perception of structural damage risk. Through the survey it was confirmed that the reasons why homeowners do not wish to retrofit their vulnerable houses are very complex. This fact implies that a combination of strategies for eliminating or reducing the factors that discourage retrofitting is necessary.

HOMEOWNERS' ANXIETY OVER RETROFITTING OF THEIR HOUSES

The homeowners who wished to retrofit their pre-code houses were asked whether they had any anxieties over the retrofitting works. The rate of the homeowners who did not have any anxiety was around 15% of the total respondents as shown in Fig. 13. The principal anxiety was "My house may suffer structural damage even if it is retrofitted". When answers are compared by the respondent age, the rate of the homeowners who were skeptical increased up to about 65% in case of the respondents between 50 and 69 years old. Another big anxiety related to technological issues was "Seismic diagnosis may not be trustworthy". In order to lessen these anxieties, developing safer retrofitting techniques and proving the safety of retrofitted houses to homeowners through experiments, demonstration, and simulations are very important.

Dishonest contractors were also a concern for the respondents. Many homeowners feared that "the contractor may do unreliable work" or that "the contractor may charge unreasonable retrofitting cost". These fears were stronger especially among young homeowners as shown in Fig. 13. On the other hand, these fears were relatively weak among elder homeowners. Recently in Japan, a lot of crimes in which dishonest contractors deceive elder homeowners into retrofitting their houses at unreasonably expensive cost have been reported. The carelessness for the existence of dishonest contractors among elder homeowners, as observed in Fig. 14, may be one reason for these crimes. Through this questioning, it was verified that raising homeowners' knowledge regarding retrofitting cost and techniques is important in order to help them distinguish dishonest contractors. Constructing a database of retrofitting works including detailed information such as average costs and characteristics of construction may be useful for this.

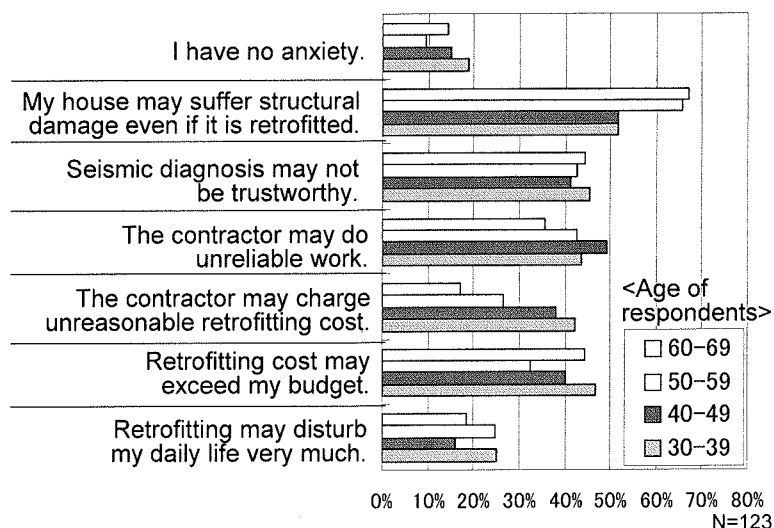


Figure 13. Homeowners' anxieties over retrofitting their houses.

HOMEOWNERS' ATTITUDES TOWARD INCENTIVE SYSTEMS FOR RETROFITTING OF THEIR HOUSES

Finally, homeowners' attitudes toward the governmental systems that give incentives to retrofitting vulnerable houses were discussed. Six typical incentive systems were selected. Providing free seismic vulnerability diagnosis using a simple flowchart, financial assistance for seismic diagnosis by special engineers, financial assistance for retrofitting work, and recommendation of honest contractors, which are currently put into practice in some municipalities in Japan, were considered. In addition, two newly-proposed systems, "A system for providing non-financial incentive by retrofitting assurance" and "tax exemption", were also taken into consideration.

"A system for providing non-financial incentive by retrofitting assurance" is a new idea proposed by the authors for promoting retrofitting. The concept is illustrated in Fig. 14. Under this system, the government bears a portion of the building repair and reconstruction expenses if retrofitting is implemented by the owner following the guidelines before an earthquake and in spite of this the structure is damaged. It has the great merit that the government does not need to prepare a huge budget before the disaster, as is the case with the current financial assistance system. In previous articles, the authors proved with simulations that the earthquake damage and the governmental cost burden after the earthquake can be reduced with this system even if the government provides the incentive money described in Fig. 14.

The homeowners' attitudes towards incentive systems for retrofitting are shown by the age of respondents in Fig. 15. Homeowners 50 to 59 years old thought little of the financial assistance for seismic diagnosis and retrofitting as compared with the system for recommendation of honest contractors and free seismic vulnerability diagnosis using simple flowchart. They did not seem strongly attracted to financial assistances due to their high income. On the other hand, homeowners 60 to 69 years old thought highly of all the incentive systems except for recommendation of honest contractors. The reasons for this were their low income, high fear of insufficient structural strength after retrofitting and carelessness for unreliable contractors as shown in Figs. 4, 13.

These generation gaps suggest that the strategies for providing suitable incentives for retrofitting considering differences in homeowners needs is very useful for promoting retrofitting houses.

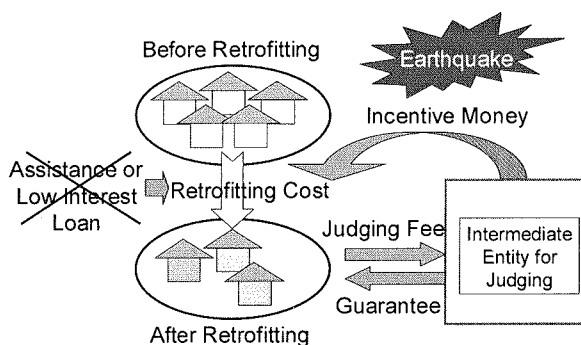


Figure 14. Concept of a system for providing non-financial incentive by retrofitting assurance.

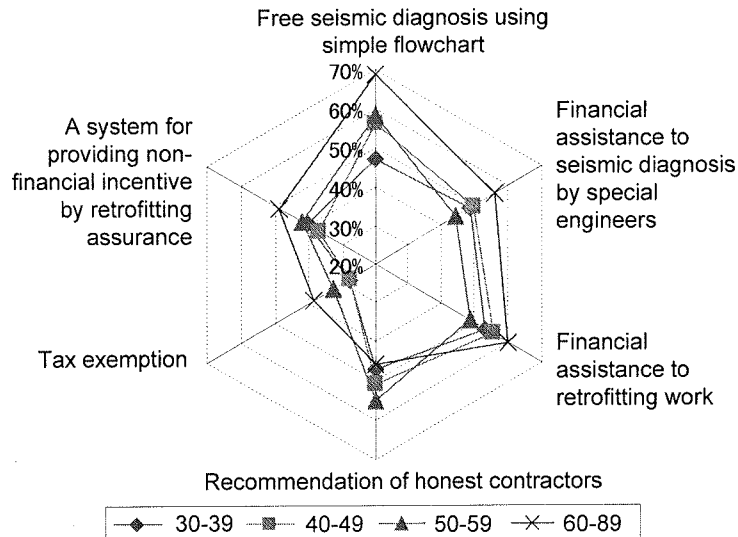


Figure 15. Homeowners' attitudes toward incentive systems for retrofitting their houses classified by their age.

RECOMMENDATIONS

In this research, a questionnaire survey was conducted among homeowners in Japan in order to propose more effective strategies for promotion of retrofitting of existing vulnerable houses. Based on the obtained answers, we recommend some improvements listed below.

- Various reasons related to homeowners' earthquake risk perception, their economical and social situation may affect the decision-making to retrofit their pre-code houses. Among all the factors, the main factors that discourage homeowners to retrofit their houses were identified. The respondents had severer economical, physical, and mental problems compared with their perception of structural damage risk. Improving these factors could be effective to promote retrofitting of vulnerable houses.
- Moreover, their anxieties over uncertainty of building strength after retrofitting were observed. In order to lessen these anxieties, developing safer retrofitting techniques and proving the safety of retrofitted houses to homeowners through experiments, demonstration, and simulations are very important.
- Their anxieties over the existence of dishonest contractors were also pointed out. Raising homeowners' knowledge regarding retrofitting cost and techniques is important in order to help them distinguish dishonest contractors.
- Finally, homeowners' attitudes toward governmental systems that give incentives to retrofit vulnerable houses were discussed. The preferences for particular incentive systems varied according to the respondent age. As a result, the importance of developing suitable strategies for improving incentive system considering these differences was suggested.

ACKNOWLEDGMENT

This study was conducted as a part of the Special Project for Urban Earthquake Disaster Mitigation: Study for Integration of Earthquake Disaster Reduction Countermeasures – Pre-Event Measures, which was organized by Professor Kimiro Meguro of Institute of Industrial Science, The University of Tokyo and funded by Ministry of Education, Culture, Sports, Science and Technology, Japan.

REFERENCES

- Kobe City, (1996). *Hanshin-Awaji Earthquake Disaster –Record of Kobe City*, Japan.
- The Ministry of Land, Infrastructure and Transport Government of Japan, (2005). *A proposal for promoting disaster mitigation countermeasures for structures*, Japan.
- Yoshimura, M., and Meguro, K. (2003). “Proposal of Retrofitting Promotion System (RPS) for Low Earthquake-resistant Structures in Shizuoka Prefecture, Japan.” *7th US/Japan Workshop on Urban Earthquake Hazard Reduction, Hawaii, USA*.