EARTHQUAKE HAZARD MITIGATION OF EXISTING WOOD HOUSES
- OUTLINE OF RESEARCH PROJECT -

Chikahiro MINOWA[1], Isao SAKAMOTO[2], Hiroshi ISODA[3], Takahiro TUCHIMOTO[3]
Mikio KOSHIHARA[4]

SUMMARY

The research project of earthquake hazard mitigation of existing wood houses is described in this paper. In the project, shaking table tests, static loading tests up to falling down, investigation of effect of aging and deterioration for structural performance, seismic response observation and evaluation of seismic performance of existing wood houses. In the shaking table tests and static loading tests, the collapse characteristics of existing wood houses are investigated experimentally. Retrofit methods are evaluated experimentally and analytically and one of the retrofit methods is investigated with a real-size aged wood house on the table. The outcome from tests is designed to take over the preparation of E-defense largest shaking table test.

INTRODUCTION

In Recent Earthquakes, the old small houses damaged very much. In Hanshin Great Earthquake Disaster, 80% of deaths in the earthquake were caused by damages of old small houses which built by wood frames or light steel frames. Now, in Japan, there are many houses of old and poor quality. The houses were called existing ineligible houses. It is required to make diagnoses on old houses. As results of diagnoses, the house retrofit might be recommended. In Japan, many local governments promote the seismic diagnosis and seismic retrofit. However, many residents don't intend to try requesting diagnosis and retrofit for his house. Many people are wondering the governmental warning of the great earthquake hit to his house in its life duration. If the possibilities of strong earthquake hits were given in stochastic value, the meaning of value would be vague and unreliable. The residents have attachments on their existing houses. The elderly people will take much effort to settle in the new house. The practice of seismic retrofit would depend on the philosophy of residents. There are many issues in the promotion of the existing house retrofit. The seismic engineer must present the reliable and economic seismic diagnosis

[1] Advisor, National Research Institute for Earth Science and Disaster Prevention, Tsukuba, JAPAN

[2] Professor, University of Tokyo, Tokyo, JAPAN

[3] Senior Researcher, Building Research Institute, Tsukuba, JAPAN

[4] Assistant, University of Tokyo, Tokyo, JAPAN

and retrofit methods for the existing wood houses.

The Ministry of Education, Culture, Sport, Science and Technology initiated Special Project for Earthquake Disaster Mitigation in Urban Area. The seismic diagnosis and retrofit of existing wood houses are included in the project. There are some subprojects in the main project. Two sub-projects are related to the seismic performances of existing wood houses. In 2005, the big shaking table of 20m by 15m will be completed near Kobe City. The purpose of a subproject of "Tests of Wood structure" is to decide the specimen and schedule as the preparation. In this paper, outline of the subproject and future plan of E-defense is presented.

RESEARCH PLAN AND THE ORGANIZATION

Research Organization

Two subprojects relate to disaster mitigation for existing wood houses. One is "Wood House Tests" which covers evaluation of seismic performance of aging wood houses and analytical study to trace seismic behavior. Another is "Promotion of Retrofit" which covers digenesis, retrofit methods and policy to promote seismic rehabilitation. Major purpose of the project is to increase the count of retrofit works. It is therefore important that two subprojects work together. The leader of Wood House Tests is Professor Sakamoto. The leader of Promotion of Retrofit is Associate Professor Meguro. The leader of joint research group is Professor Sakamoto. Figure.1 shows outline of research organization.

Research committee of subproject "Wood House Tests" established in NIED. The chair of committee is Professor Sakamoto. The members of committee are various scholars and persons of experience, structural engineers. University of Tokyo, University of Kyoto, Building Research Institute, Forestry Forest Products Research Institute, and private company (Nippon System Design) are involved in the subproject. Foreign Advisory Committee is prepared.

Special Research Project of Earthquake Disaster Mitigation in Urban Area
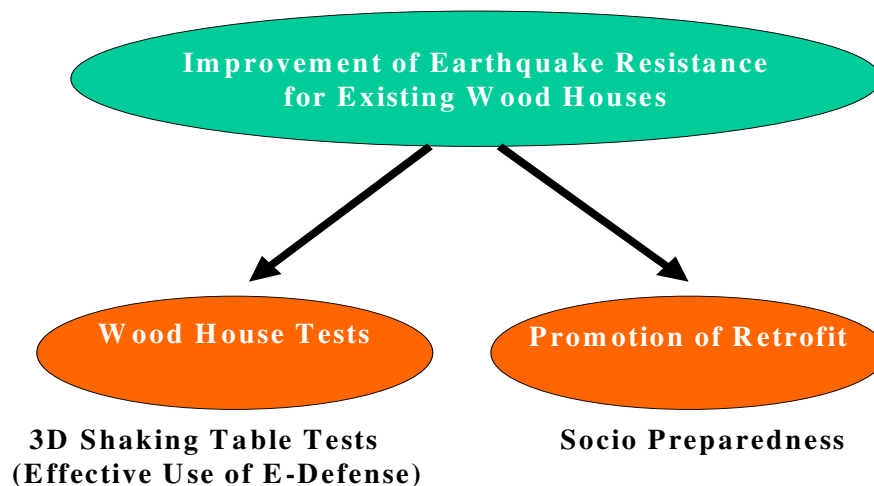
5 years project from 2002

Improvement of Earthquake Resistance
for Existing Wood Houses

Wood House Tests

Promotion of Retrofit

3D Shaking Table Tests
(Effective Use of E-Defense)

Socio Preparedness

Figure 1   Outline of the Project Organization

Research Plan

The Research term of the project is 5 years, which initiated in 2002. The research term divide to two ones. First one is from 2002 to 2004, second one is 2005 and 2006. In the first research term, the seismic test methods of the existing wood houses are studied. In the second research term, the seismic performances of existing wood houses will be investigated by the use of E-Defense

Table 1 Research Plan

ITEMS	F.Y. 2002	2003	2004	**2005**	**2006**
1) Earthquake Response Observation of Existing Wood Houses	███████	███████	███████	███████	███████
2) Site Investigation of Aged Existing Wood houses	████	████	████		
3) Horizontal Loading Tests of Wood Frame	████	████	████		
4) Development of PC Simulation Program on Existing Wood House Collapse	███████	███████	███████		
5) Lessons of Wood House Collapse Tests using Middle Size 3D Shaking Table	████	████	████		
6) Existing Aged Wood Houses and Retrofitted Wood Houses Using E-defense				███████	███████
Socio Preparedness	███████	███████	███████	███████	███████

Table 1 shows the annual plan in the every fiscal year. There are 5 themes in first research term. The outline of research items are shown in the following.

PREPARATION RESEARCH FOR E-DEFENSE TESTS

Earthquake response observation of existing wood house

In Japan, much earthquake response observations of building have been carried out from 1960 approximately. The conventional earthquake response observations of buildings are arranged for engineering structures, such as high-rise buildings. There are consequentially scarce observations for non-engineering such as wood houses. The earthquake response observations of existing wood houses are initiated in the project. Target houses are aged traditional houses in Tokyo and Kyoto, and a house, which has been already rehabilitated using shear walls and visco-elasticity dampers, in Shizuoka prefecture and recent constructed wood houses in Tochigi Prefecture. Figure 2 is the photo of an aged wood house in Tokyo. The observation will continue to 2006.

BRI, University of Tokyo, University of Kyoto

Figure 2 The Photo of Aged Wood House for Earthquake Observation

and Utsunomiya University are involved in the earthquake response observation of existing wood houses. The response characteristic variations with accordance to ground motion intensity for wood houses will be investigated.

Site Investigation of Aged Existing Wood houses

Site investigations of exiting aged wood houses are already started. The actual relationship between horizontal loads and deformation will be presented. The data concerning about aging of wood materials and houses are obtained. Wood houses were tested in Kanagawa Saitama, Niigata and Shizuoka Prefecture. In the tests of Shizuoka Prefecture as shown in Figure 3, three old houses of one story were pulled down and collapsed. The collapse data of static load–deformation relationship were measured as shown in Figure4. Maximum story is beyond 1m at every house. The test house of Kanagawa Prefecture had the exterior wall of cement plastering. The walls tested on the shaking table. The cement plastering of walls tore off by vibrations. This behavior is similar to observations after previous quakes. The dynamic horizontal load-deformation data were obtained in the test. BRI, FFPRI, NIED, and University of Tokyo are involved in the project.
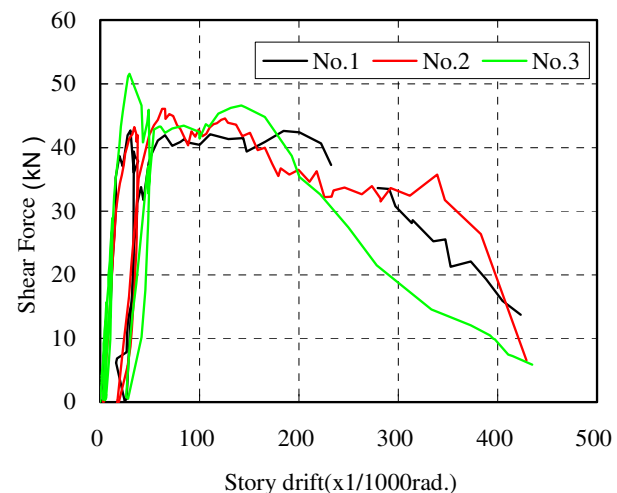

Figure 3   Pull Down Test of Aged Wood House

Figure 4 Test Results

Horizontal Loading Tests of Wood Frame

Shear walls with poor quality joint, old type joint system and so on which have been used before current building standard law are tested. This wall is also conducted by the shaking table. The performance of the structural element is obtained from joint tests. The fundamental data is applied to the simulation program mentioned in the next. BRI is involved in the project.

Development of PC Simulation Program on Existing Wood House Collapse

A developer of PC simulation program on existing wood house collapse was selected from among applicants. Nippon System Design Corporation has been involved as the developer. The PC simulation will make a seismic diagnosis for existing wood houses. Three-dimensional analysis assuming the truss or frame members will be used. At first, the collapse simulation results are compared with the video records of shaking table tests including E-defense tests. If the collapse simulation will show good agreement with the shaking table tests, the PC simulation software can be used by seismic diagnosticians. Figure 5 is an example of collapse simulation.

Figure 5 An Example of Collapse Simulation

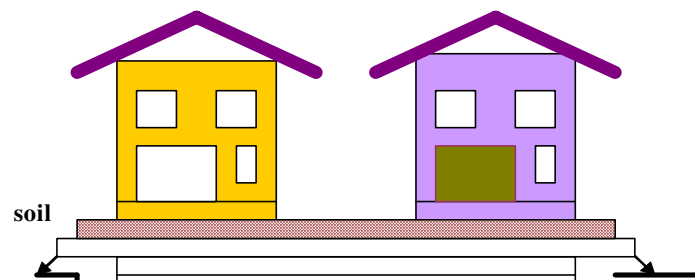**Lessons of Wood House Collapse Tests using Middle Size 3D Shaking Table**

Three-dimensional exciting methods of shaking tables have to practice before E-defense tests. The wood house collapse tests were therefore conducted by the use of the middle-size shaking table Four wood house which built in the same way according to the old building code, tested on the table. The shaking table tested four times to obtain the data about multi-directional excitations. The displacements of dynamic collapses were obtained by video measurement systems.   University of Tokyo, NIED, and BRI are involved in Lessons of wood house overturning tests using middle size 3D shaking table. In Figure 6, the collapsing wood house frame is shown.


Figure 6 Collapse Test by Middle Size Shaking Table

E-DEFENSE TEST PLAN

Referring the preparation research, the E-defense tests of wood houses will be conducted in Oct-Dec. 2005 and Jan-Mar.2007. Six kinds of wood house group will be tested. One kind will take about one month. Wood houses will be excited to collapse. The most wood houses shaking table tests were already conducted without foundation and soil. However, some E-defense tests will consider the foundation and soil as shown in the figure7. Some existing wood houses will be moved on E-defense from all region of Japan. The

Figure 7   Scheme of E-defense Wood House Test

damage risk of wood houses will be estimated by the diagnostician and PC simulation.   The various retrofit methods for aged wood houses will be investigated. Figure 8 is the scheme of the tests of retrofitted wood houses
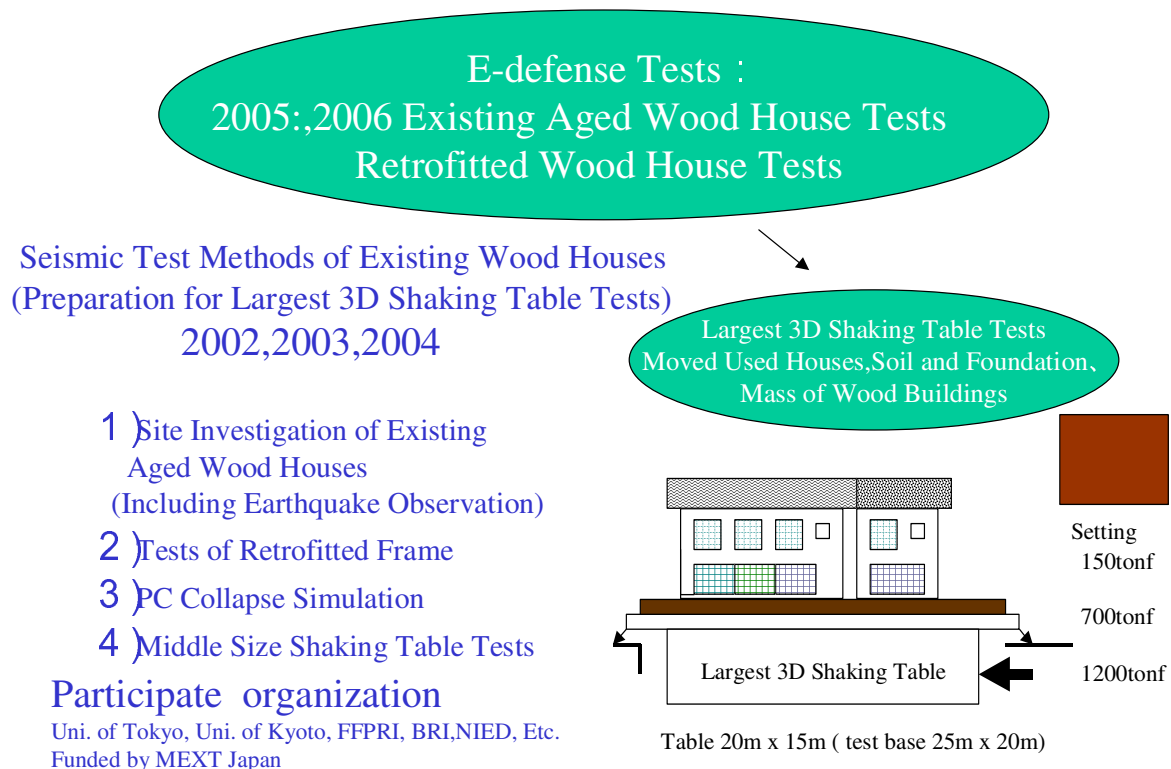
Figure 8 Outline of the Project

CONCLUSIONS

The research project for earthquake hazard mitigation of existing wood houses has initiated. In the project, the seismic diagnosis and retrofit method will be verified experimentally by using real-size shaking table:

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ACKNOWLEDGEMENTS