VIBRATION EXPERIMENT EDUCATION MATERIALS AND WEBGIS SIMULATORS TO PROMOTE SEISMIC RETROFITTING

N. Fukuwa[1]

SUMMARY

In the promotion of seismic retrofitting, the most important point is the development of residents' awareness. In this paper, I chiefly showed examples of development of tools for increasing residents' awareness. The tools can be roughly divided into various model vibration experiment materials that plainly show the importance of seismic retrofitting and the e-learning system that supplements the materials and uses the Internet. The experiment materials can be used according to purpose or target. Each of them consists of a vibration-producing device and various building models. I have developed various vibration-producing devices, ranging from hand-rotating ones to digitally controlled ones that use a PC. On the other hand, because the e-learning system can be used without limit on the number of persons, time, or place, it can provide information on disaster prevention through WebGIS. Residents can learn about seismic intensity in their community, the seismic capacity of buildings, and indoor safety on the Internet. To encourage residents to carry out concrete disaster prevention activities, I provided a place where they can think about familiar problems with actual feeling.

INTRODUCTION

In a country where earthquakes are expected to occur, it is impossible to protect the people without efforts to mitigate earthquake damage. Mitigation of expected earthquake disasters is the duty of earthquake engineers. Because the main reason of earthquake damage is the collapse of buildings, it is necessary to make buildings retrofit as soon as possible. However, since buildings are private assets, success in making them retrofit depends on the level of each resident's awareness.

As shown in Figure 1, it is useful to consider disaster mitigation from four aspects: person, knowledge, thing, and money. That is, the promotion of seismic retrofitting requires the development of residents' awareness (person), the establishment of laws and systems that promote seismic retrofitting (knowledge and system), the development of inexpensive and effective reinforcement methods (thing), and the creation of subsidy programs and other economic incentives (money). The most important factor is the problem of "awareness."

To develop residents' awareness, it is important to train leaders for the dissemination (person), develop effective methods for the dissemination and provide education curriculum on disaster prevention (knowledge), create education materials for the dissemination (thing), and make people feel that the process is economical (money).

Because the number of disaster prevention experts is limited, it is difficult to develop residents' awareness directly. Therefore, as shown in Figure 2, the development of each resident's awareness requires not only the cooperation and efforts of experts but also the participation of mediator that have many opportunities of contacting with residents (mass media, teachers, cooperatives, enterprise groups, and student circles). To have these media participate in disaster prevention activities, it is necessary to develop the media's awareness and create environments where the media can development residents' awareness. One of the means for creating such environments is the creation of education materials that support the development of residents' awareness.

Disaster prevention activities start with awareness of earthquake disasters. If people become aware of them, they can learn about them to understand the causes and methods to avoid them. Then, each organization or

[1] Nagoya University, Nagoya, Japan, fukuwa@sharaku.nuac.nagoya-u.ac.jp

family plans measures and implements them. After that, it is all right to repeat the PDCA cycle (Plan-Do-Check-Action) (see Figure 3). The problem is how to create an environment where people can really become aware of earthquake disasters. This requires people who can make residents have awareness and education materials that have good contents. This paper explains the vibration experiment education materials we developed and e-leaning systems that use WebGIS.

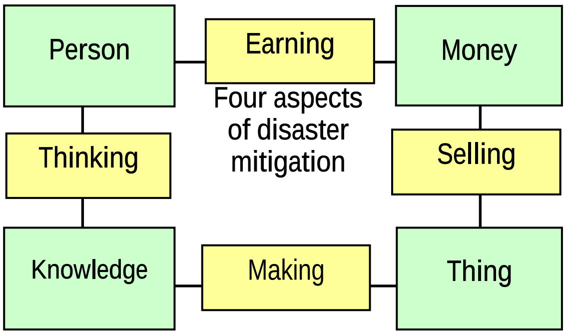


Figure 1 Four aspects of disaster mitigation

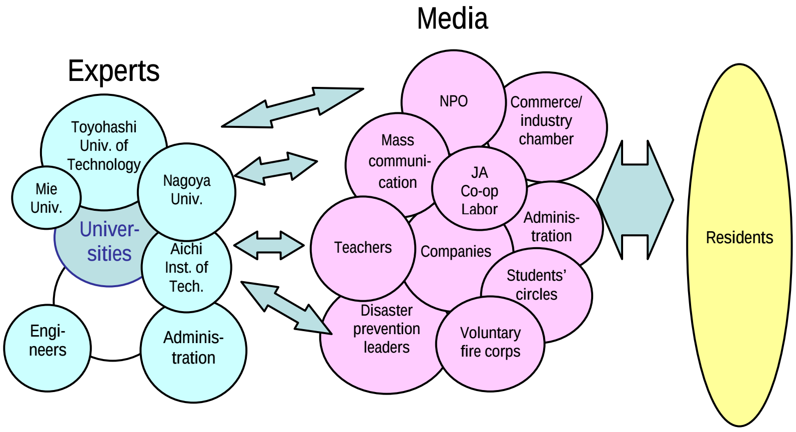


Figure 2 Development of residents' awareness by expert-media cooperation

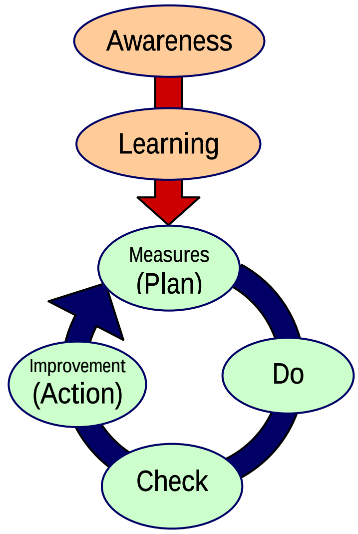


Figure 3 Procedure for disaster prevention activities

VIBRATION EXPERIMENT EDUCATION MATERIALS FOR PROMOTION OF SEISMIC RETROFITTING

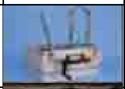
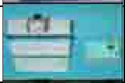
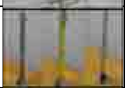
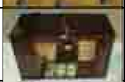
The vibration experiment education materials explained herein are collectively called "BURURU." The first one developed was a hand-rotating portable shaking table. This is a duralumin attaché case that contains a shaking table and various experimental materials. Rotating the handle by hand makes the table move translationally.

Because there had been no education material of this kind, the development created a great sensation. At present, about one hundred units are used by universities, government disaster prevention and construction bureaus, natural and science museums, volunteer groups, and construction companies. Universities use them for lectures on earthquake engineering, museums use them for showing dynamic response of buildings, and government bureaus use them for the development of public awareness of seismic retrofitting. Moreover, units are used by volunteer groups for the development of public awareness of disaster prevention in communities and by construction companies for explanation of base isolation and vibration control technologies.

We received various requests from these users, directly or indirectly. In short, they wanted the following kinds of BURURU: a more portable, lighter, and smaller one; a less expensive one; an electric one; a large one that can be used in a gymnasium; a small shaker that can be placed on the top of a building model; and one that can even show the collapse of a house.

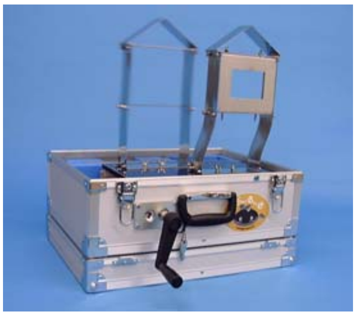
Accordingly, we decided to develop various vibration experiment education materials based on the concept of the hand-rotating portable shaking table. Table 1 shows the vibration experiment education materials we have developed up to now. I will outline each of the materials.

Table 1 BURURU series demonstrating actual shaking phenomena

Name	Image	Operations	Characteristics	Use
Hand-driven BURURU		The handle is rotated by hand, and the rotary motion is converted into translation, which shakes the table.	Many types of miniatures are contained in an attache case easy to carry. Users turn the handle by hand, so they can really feel frequency characteristics.	It can be used at many occasions, such as lectures and events. As it offers visual explanations of oscillatory phenomenon, vibration theories can be learned more effectively.
Electric BURURU		It is driven by a motor, powered by a built-in buttery. The table shakes at frequencies specified by the dial.	As its vibration frequencies can be mechanically controlled, the table can be shaken in a constant and repeatable manner. The device is light and easy to carry.	It can easily imitate continuous changes of frequencies, and shorter and longer period motions, which are difficult for a hand-driven device to simulate.
Small BURURU		The shaking machine has a battery in it, and generates horizontal vibrations. The frequency can be changed with a dial.	It can be placed on a small mock, and shake it. The device has the resonance curve understood in an effective manner.	It can be used to explain principles of vibration tests, which are often carried for vibration testing of buildings.
DIC BURURU		Driven by a pulse motor under the digital control of a PC. Possible to change the waveform freely by two horizontal axes.	Possible to reproduce the movement of two horizontal directions by digital control. Possible to make a range of models from desktop to large-sized according to the length of the rail. It can also reproduce a long period vibration.	A desktop model can be used for lectures and TV studios, while a large-sized model can be used for events.
Foldable BURURU		Swing a foldable inverted pendulum right and left by hand. Because material particles can be moved vertically, it is possible to change the position and number of particles and the mass.	Possible to convey the vibrations of the particles. Possible to change the mass, the spring constant, and the number of particles and add damping. Interaction experiment is also possible if swinging softly.	Useful for lectures on vibration theories at university. Used together with study of theoretical analysis of particles.
Furniture Falling BURURU		Swing indoor models on ball bearing horizontally by hand.	Indoor models include drawers, bookshelf, desk, TV, bed, etc. They are used for reproducing falling of furniture. There are also tools for preventing furniture falling.	Because this BURURU reproduces furniture falling, it is the most suitable for teaching the importance of preventing furniture falling.
On-cart BURURU		A cart used, ordinarily, to carry goods is equipped with a handle, which is pushed and pulled to shake the cart.	It is applicable to experiments with miniatures similar to wooden building, so it helps users really feel how effective seismic strengthening is. They can also see how decentering causes torsion. Children can stand on it to feel shakes.	It is useful in explaining how effective seismic strengthening is for wooden building in ways that ordinary people can easily understand it.
BURURU for collapsing wooden buildings		It has two different models of building on the cart, similar to that of the on-cart BURURU, and shows how different they are in ways they collapse.	Demonstrations can be carried out, for example, with or without braces and/or structural plywood, with different arrangements of walls, with or without metal connectors, with different weight of roofs, on soft or hard ground, with or without measures for preventing furniture from tumbling, and with or without concrete block walls.	It uses 1/10 scale models of conventional framework structure buildings to show how different they are in ways they collapse. It is the best tool for education about anti-seismic strengthening.
Temple Collapse BURURU		Put two temple models on a large wooden cart and examine the difference in the form of falling.	A carpenter trained in traditional temple carpentry made wooden temple models on a scale of 1:10. Detailed and elaborate models are used for comparative experiment to examine whether seismic retrofit is necessary or not.	Useful for developing awareness of seismic retrofit necessary for shrines and temples, bases for the spirit and history of communities.
Self-propelled BURURU		It has batteries in it to power a servomotor, and imitates earthquake motions according to waveforms input.	It can replicate longer-period and longer-stroke earthquake motions, which cannot be mimicked by conventional shaking tables. Users can stand on it to feel shakes.	It is useful to have high buildings residents and those concerned feel how they shake and help them improve awareness.
LunLun BURURU		Driven by a pulse motor under the digital control of a PC. Possible to change the waveform freely by a horizontal axis.	Possible to reproduce the movement of one horizontal direction by digital control. Super-long-stroke and long-period shaking table that can reproduce vibrations of 3 m, 5 m/s, and 20 m/s^2.	Useful as an ordinary digital-control one-axis shaker and for reproducing the floor response of a long-period building to long-period earthquake vibrations.
Paper BURURU		The paper model house is swung by hand from side to side.	Participants by themselves build mocks and shake them, so that they can personally see how different buildings are in natural periods and what effects braces have.	It is an effective tool at participatory workshops, and a good souvenir at lectures. It can also be used to have children interested in how buildings shake.
ParaPara BURURU		Flip through sheets of paper by hand.	A flip book illustrates an experiment on falling by the use of BURURU for collapsing wooden buildings. It is possible to understand the importance of seismic retrofitting of wooden buildings while enjoying cutoff animation.	Because the book can be used without a PC or an experimental model, it is possible to develop various people's awareness of seismic retrofitting of wooden buildings at various events.

Hand-rotating portable shaking table containing various models

This is the first education material developed for portable vibration experiments (Figure 4). It has a mechanism of changing rotary motion to translational motion via a universal joint. This allows the user to feel the vibration period by turning the handle by hand. The container includes various models. As shown in Figure 5, the use of an inverted pendulum and two-story and four-story frame models enables experiments on earthquake response including base isolation or vibration control. There is a model for experiments on liquefaction, a model for shear vibration of layered soil, and a model for experiments on falling of furniture. In addition, to shake these models, we have developed a small shaker that uses eccentric mass. It can be placed on the top of a model for forced vibration experiments on resonance curves. This enables indication of points common to the resonance by seismic ground motion and the resonance by the forced vibration. Because it is possible to change exciting frequency, it is suitable for explanations of resonance and vibration mode at lectures on structural dynamics. The Hand-rotating BURURU is used in a wide range of fields from lectures on structural dynamics at university to hands-on study at elementary school.



(a) Outer appearance

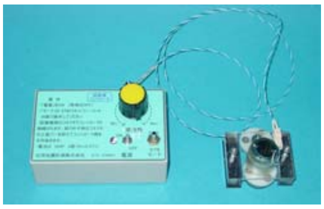
(b) Models contained

(c) Shaking table

(d) Model for shear vibrations of layered soil

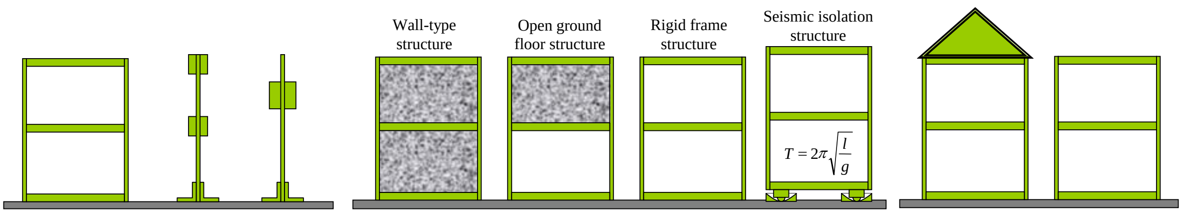
(e) Model for liquefaction experiment

(f) Model for falling of indoor furniture



(g) Small shaker

Figure 4 Outlines of the shaking table of Hand-rotating BURURU and related model



(a) Replacement of frame model with particle model

(b) Replacement of two-degree-of-freedom system to one-degree-of-freedom system

(c) Change in dynamic characteristics by earthquake-resistant wall

(d) Seismic retrofitting and isolation

(e) Change in dynamic characteristics by addition of mass

Figure 5 Examples of vibration experiment by hand-rotating potable shaking table

Electric portable shaking table

This is an electricity-driven portable shaking table based on the principle of the mechanism of the hand-rotating one. Because it is driven by rechargeable batteries, it can be used anywhere. It can easily show the difference between base isolation and retrofitting and the difference in vibration according to the balance of cross bracings and walls. Because it is light and small, it is suitable for use in classrooms.

Figure 6 Outer appearance of electric portable shaking table and magnification of seismic isolation part

Cart-type shaking table

This is a large education material developed to show many elementary school children how a building vibrates. This shaking table is a remodeled cart and can be pushed by hand. Children can step onto the table and feel earthquake vibrations. By putting a wooden building model on the table, it is possible to show children how the balance of the cross bracing and the weight of the roof influence the vibrations of the building and how furniture falls. The wooden building model is of a non-collapsible type. By attaching and removing the cross bracing, it is possible to examine the influence of eccentricity and the influence of changes in the balance of the rigidity of the upper and lower floors and changes in the weight of the roof. Because the table is large, it is suitable for the demonstration in disaster prevention training and other events held in a gymnasium or outdoors. In addition, it is also possible to reproduce long-period vibrations by tying ropes to both ends of the cart and pulling on them like in a tug-of-war.

(a) Two-story building model

(b) Experiment for feeling of seismic ground

(c) Feeling of long-period vibrations through tug-of-war

(d) Storage of model

Figure 7 Shaking table and model of cart-type shaking table

Wooden building collapse experimental model

This is an education material developed to explain the key points of seismic retrofitting of wooden buildings through collapse experiments. By shaking two elaborate 1:10-scale two-story wooden models simultaneously, it is possible to show differences in the collapse of buildings according to the balance of the cross bracing, the weight of the roof, the existence of metal joints, the supporting soil stiffness, and the existence of anchor bolts driven into the foundation, etc. Although the collapsed model can be reassembled, because the reassembly takes a lot of time, we also use a DVD video that records how the model collapses. There is also a flip book made based on the video. Moreover, we have a temple model on a scale of 1:10 to promote the seismic retrofitting of shrines and temples. These are frequently used for developing public awareness of seismic retrofitting at administrative agencies' housing fairs or on TV.

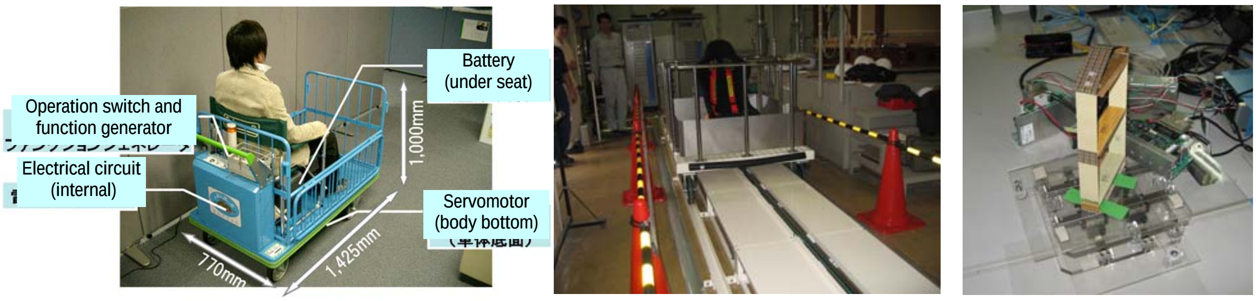
Figure 8 Models for experiments on collapse of wooden two-story houses and temples

Digitally-controllable shaking table

We developed three types of digital-controllable shaking tables, applying the concept of the cart-type shaking table. The type developed first is a controllable self-propelled shaking table, a remodeled electric cart. We developed it to reproduce floor responses in long-period buildings. It can reproduce various waveforms by a function generator and a servomotor installed on the mount of the electric cart.

A stronger shaking table the Long-Long-BURURU, which runs along rails. This long-period long-stroke shaking table uses a pulse motor and can shake with an amplitude of 3 m, a velocity of 5 m/s, and an acceleration of 20 m/s^2. It enables a PC to calculate floor responses of a certain building constructed on certain soil and reproduce them in quasi-real time. By using the shaking table, residents can feel the vibrations of their houses easily. The shaking table can be used also for reproducing a high-rise building's response to long-period seismic ground motion.

Using this idea, we developed a desktop digital-control bilateral shaker (DIC BURURU). We attached two small servomotors to a cross linear bearing that can move bilaterally, and made it possible to control vibrations digitally by PC. This shaker is suitable for indoor experiments that use a small model.



(a) Appearance of Electric Cart BURURU (b) Long-period long-stroke shaker (c) Desktop bilateral shaker

Figure 9 Digitally-controllable shaking tables

Foldable pendulum and paper building model kit

We prepared two types of models that can be used on a hand. One of them is a foldable inverted pendulum. Two or more weights that contain magnets are attached to a leaf spring, and the pedestal is foldable. The foldable pendulum can be carried in a pocket. It is possible to change the height, number, and heaviness of weights freely and attach and remove a magnet sheet that functions as a friction damper. This enables vibration experiments with changes in mass, height of mass, the number of lumped masses, and damping constant. Moreover, it is possible to carry out experiments on soil-structure interaction according to the hardness of the soil by grasping the inverted pendulum tightly or softly.

The other type is a paper building model kit that makes it possible to understand the key points of seismic retrofitting easily. It is made of perforated cardboard. If there is double-sided tape available, even children can make a building in about ten minutes. The kit is greatly effective for seismic retrofitting events and lessons at elementary or junior high school, because event visitors and students can understand the importance of the weight of the roof and the balance of the cross bracing and feel the vibrations of a building while making the model. Manuals for making and using the kit can be downloaded from our homepage.

(a) Folding pendulum (b) Paper two-story building model kit

Figure 10 Vibration models that participants use by hand

These materials are used in a wide range of fields, including the dynamics education at university, disaster prevention education at elementary or junior high school, disaster prevention training, and disaster prevention exhibitions. To promote more effective use of these materials, we have a website called “BURURU Homepage” (http://www.sharaku.nuac.nagoya-u.ac.jp/ bururu). As shown in the next section, the website not only explains the various types of experimental materials described in this paper but also shows videos of experiments using the materials and carries manuals for using the materials.

SIMULATOR THAT USES WEBGIS FOR PROMOTION OF SEISMIC RETROFITTING

Development of residents’ awareness by the use of experimental models has limits in terms of the number of participants, time, and place. To cope with this, we also developed the “Simulator for Improvement of Disaster Prevention Power of Community,” an education tool that makes use of the Internet and has no limit in terms of people, time, and place. This system complements the above-described vibration experimental materials. This online system helps each resident "become aware of" and "learn" the necessity of preparations for an earthquake. It can also be used as a tool necessary for facilitators to carry out disaster prevention activities. The purpose of this system is to encourage residents to carry out disaster prevention activities by providing education materials that make it possible to feel the danger of an earthquake as a familiar problem and understand the reason.

This system uses WebGIS to provide the following: a three-dimensional bird's-eye view system that uses aerial photos to show the history of the ground; simulation of earthquake response analysis by the use of a high-resolution soil model; simulation of collapse of a house by simply inputting characteristics of the house; simulation of falling of indoor furniture; rich image materials for vibration experiment; and a list of related websites. Using them, the system makes residents become aware of the danger to their homes and encourages them to evaluate seismic capacity and retrofit house and fix furniture. In addition, the system provides devices that residents can use when carrying out disaster prevention activities, such as the DIG (Disaster imagination game) function and the hazard mapping function.

Figure 11 shows the procedure of the Simulator for Improvement of Disaster Prevention Power of Community. As shown in the figure, this system provides answers to each resident's anxiety about earthquakes, shows an image of a resident's home damaged by an earthquake, explains the reasons for the damage, and encourages the resident to make preparations. Moreover, this system includes support tools for residents interested in disaster prevention activities.

First, to understand the characteristics of the community and the risk of disaster, a resident learns the risks of vibration and liquefaction and becomes aware of the relation between the risk of disaster and the soil, referring to the result of the administration's earthquake damage prediction. Next, the resident learns about changes in the ground under his or her home through prewar and postwar aerial photos to know why the risks of vibration and liquefaction are high. This is the step to "become aware of" and "learn" seismic risk.

The next step is to "become aware of" and "learn" the safety of the resident's house. The resident inputs information on the house and furniture so that the response simulator can predict how the house will collapse and how the furniture will fall. After that, to encourage the resident to improve the safety of the house, the system explains how to evaluate seismic capacity and retrofit house and fix the furniture.

To satisfy residents who have awareness of the importance of seismic retrofitting and have motivation for learning, we provide various learning tools, such as experiment videos, hands-on education materials, an interactive counseling system, video lecture materials, and a knowledge database.

Moreover, to support residents who are eager to lead community disaster prevention activities, we provide the WebGIS, which provides training on hazard maps and allows them to make a hazard map on the Internet.

Because we assume that this system will be used in the Internet environment, information is provided on the GIS. In addition, we have prepared hands-on education materials, such as simulators for analyses of responses of the ground, buildings, and furniture, various vibration experiment videos that show the effect of improvement of earthquake resistance of house and the effect of prevention of furniture falling, and the above-described vibration experiment materials.

Tools for "becoming aware of" and "learning" the the community and changes in the ground

Community disaster prevention starts with learning about the community. As shown in upper left of Figure 12, a resident selects information he or she wants to know from the menu on the left of the screen, referring to the map. The resident selects the map scale at the bottom of the screen in the center. The resident can freely move around the screen by operating the mouse. For example, if the residents click the place where they live, the screen automatically displays the address and it explains the estimated seismic intensity, the risk of liquefaction, the characteristics of the topography and the ground, the characteristics of the industrial,

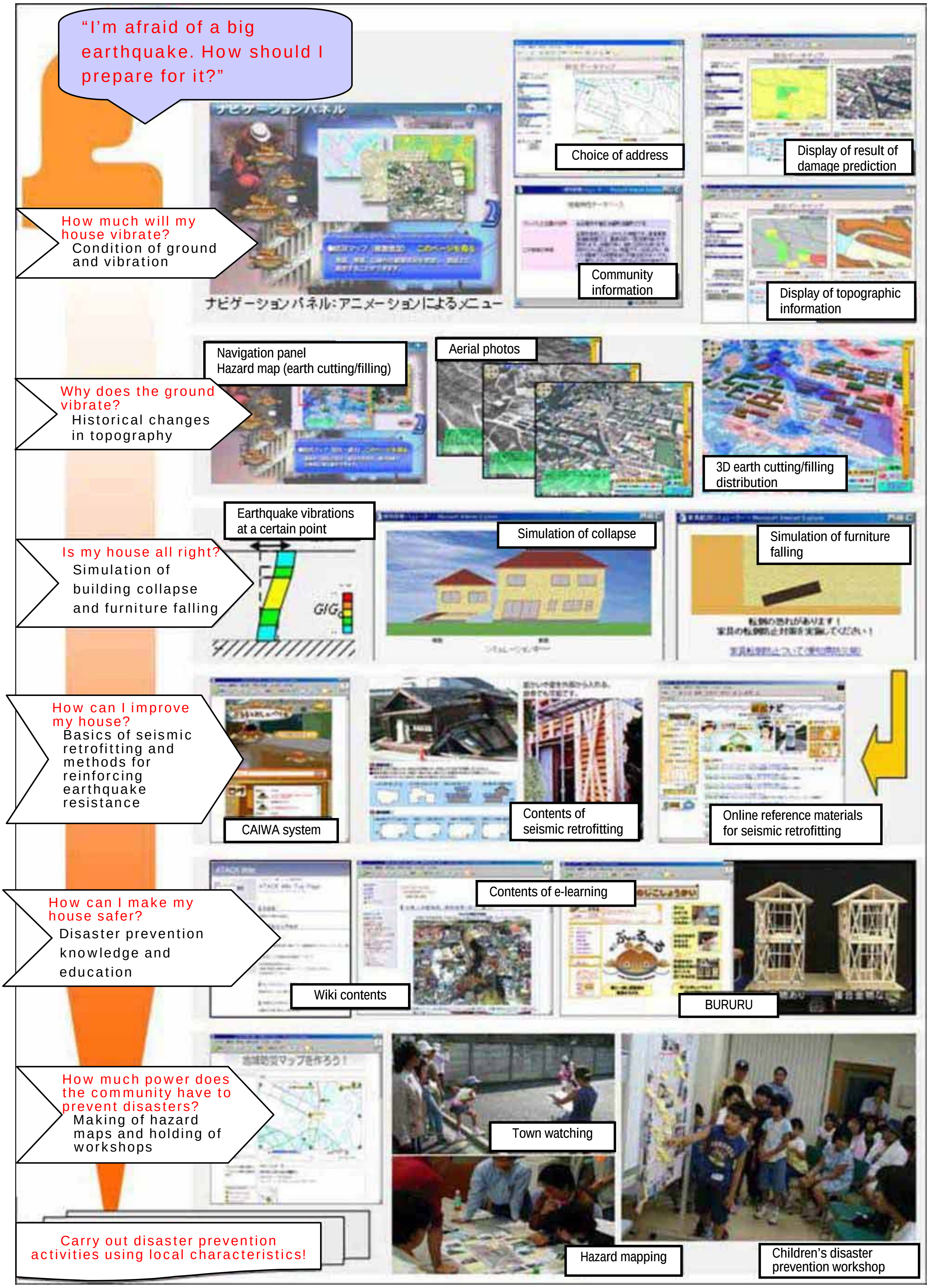


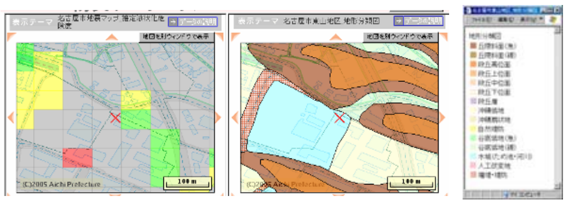
Figure 11: Outline of Simulator for Improvement of Disaster Prevention Power of Community

commercial, and residential areas, the characteristics of the building, and the age distribution of residents. Furthermore, there is a list of websites that provide detailed information.

Figure 12: Acquisition of information on local characteristics through WebGIS

Under this system, residents can also read results of the predictions of earthquake damage. As shown in Figure 13, two maps are displayed simultaneously. Because both maps are connected in terms of movement and magnification/reduction, it is possible to analyze various results of damage predictions, comparing with aerial photos and topographical data. (a) is the result of comparison of the predicted seismic intensity and an aerial photo. (b) is the result of the comparison of the predicted liquefaction and the topographical classification map. (c) is the display of a wider area on a reduced scale. The area is located on a hill where a valley and a ridge cross. Because the soil of the ridge is relatively hard, vibrations will be small. On the other hand, because the soil of the valley is relatively soft, the risk of liquefaction is greater. (a) enables residents to realize the seismic intensity around their homes. (b) and (c) enable them to notice the relation between the risk of vibration or liquefaction and the topography.

(a) 50 meter-mesh prediction of seismic intensity and aerial photo



(b) 50 meter-mesh prediction of liquefaction for the same area and topographical classification map

(c) Same prediction with reduced scale

Figure 13 Comparison of predicted earthquake damage and various data through double-screen GIS

The topographical classification map in Figure 13 shows the former topography restored by reading prewar and postwar aerial photos hypostatically. Moreover, data on sea levels are digitized through conversion of an old aerial photo into an aerial survey map and are superimposed on the aerial photo to produce a three-dimensional bird's-eye view and data on the distribution of earth cutting and filling (land changes). We used these data and MatrixEngine®, which reproduces real-time 3D contents, to experimentally produce a bird's-eye view system that makes it possible to realize topographical changes. As shown in Figure 14, it is possible to change the screen by mouse clicks and make position changes by mouse dragging, including moving, revolving, and zooming in and out on the screen and changing the point of view. It is also possible to go back to the past by dragging the time bar. Because residents can realize changes in the topography around their houses, they can fully understand the relation between seismic intensity and the topography.

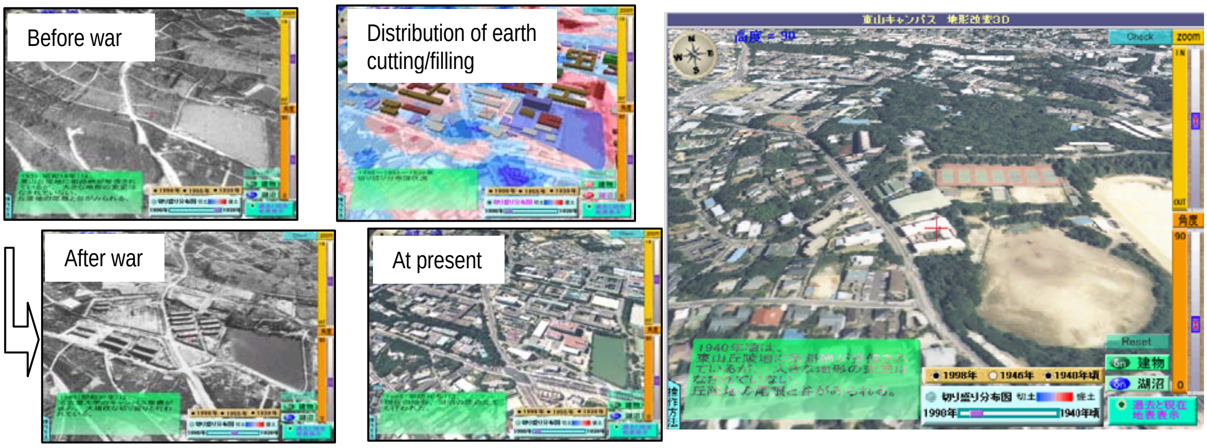


Figure 14 Three-dimensional WebGIS that shows topographical changes

"Awareness" and "learning" tools for checking the safety of houses and encouraging residents to carry out earthquake resistance measures

a. Simulator for seismic ground motion

We developed algorithms for estimating the soil velocity structure shallower than the engineering bedrock and estimated seismic ground motions at the position of the engineering bedrock by the statistical Green's function method. We used these data to estimate the surface soil structure at a certain point and constructed a system for earthquake response simulation. As shown in Figure 15, if a point on GIS is clicked, the system estimates a soil model at the point. Moreover, if the soil response calculation button is pushed, the system displays an animation of soil response simulation as shown in the right figure. This enables residents to see the vibrations of their houses and realize the relation between the hardness of soil and its response.

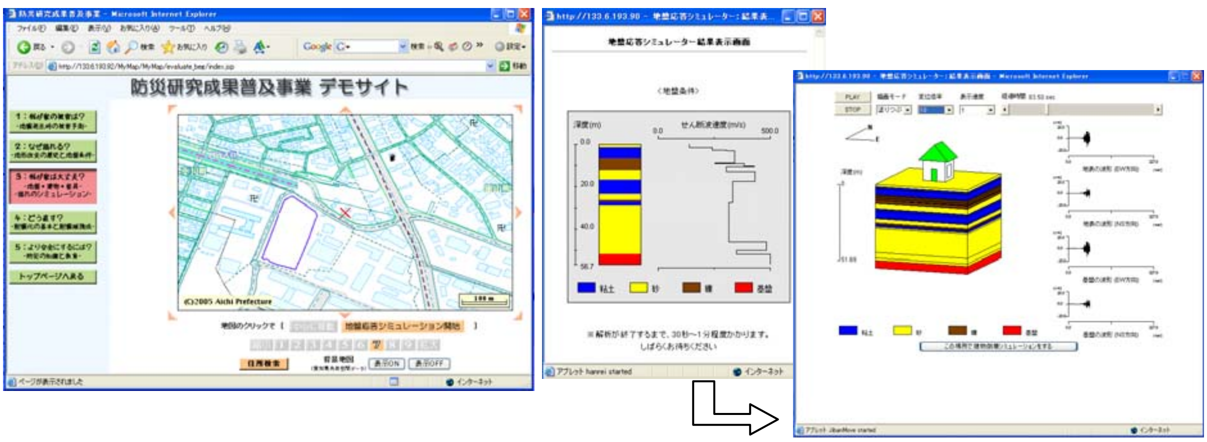
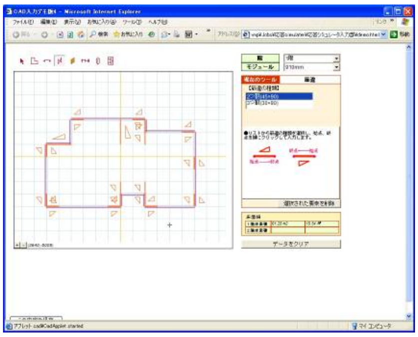


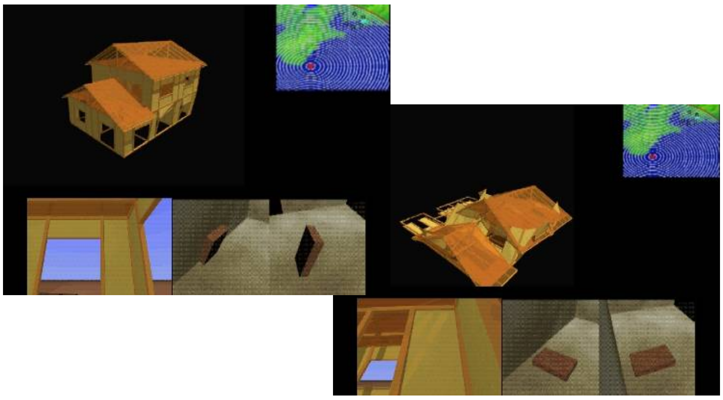
Figure 15 Earthquake response simulation of the surface soil at an arbitrary point

b. Simulators of house collapse and furniture falling and encouragement to evaluate seismic capacity and retrofit house and fix furniture

To check the seismic capacity of houses easily, we have prepared simple tools for simulation of the response and collapse of wooden houses. If the user inputs data into the PC, such as the year of construction and the plan of the house using CAD system, an earthquake response analysis model is produced automatically. If the user inputs surface ground motion calculated as shown in Figure 16, the PC makes an earthquake response analysis and displays a real-time animation of the result. In addition, the user can reproduce the predicted response of the ground surface and the building by using shaking table shown in Figure 9(b). If the house collapses, the tool guides the user to websites concerning seismic capacity evaluation and seismic retrofit so as to encourage the user to carry out the processes from evaluation to retrofit. On the other hand, if the house does not collapse, the furniture falling simulator starts. The user inputs the floor on which the furniture is placed, the size and weight of the furniture, the type of floor furnishing, etc. The furniture's response is analyzed based on the response waveform and displayed as an animation.



(a) Screen for CAD input of wooden house data



(b) Simulator of collapse of wooden house and falling of furniture

Figure 16 Simulator of collapse of two-story wooden house and simulator of falling of furniture

Various learning tools for residents interested in disaster prevention and seismic retrofitting

The next step for residents who have become aware of seismic retrofitting and indoor safety is “learning.” This system includes not only passive learning tools for residents but also positive learning tools for various purposes. There are several learning tools by which residents who have understood the importance of the seismic capacity evaluation and retrofit understand the key points of seismic retrofitting. Figure 17 shows the website of BURURU, the vibration experiment education materials described in the previous section.

For example, the two-story house simulator plainly explains an applied calculation of the two-degree-of-freedom system so that residents can easily understand it. Because it is possible to shake the building on the Internet by moving the mouse as ground motion, residents can understand how much the weight of the roof and the stiffness balance between the first and second floors influence the vibrations of the building.

As shown in the lower left part of Figure 17, we have prepared videos of comparative experiments on the effect of improvement of earthquake resistance by the use of models of two-story wooden houses. Residents can understand the necessity and key points of seismic retrofitting through these simulators and videos. Regarding the result of this collapse experiment, we have prepared PDF data for making cutoff animation.

Moreover, we have prepared a paper model two-story house kit and user’s manual. Residents can easily make a paper model by downloading the kit and printing it on cardboard. The paper model can be used for explaining the importance of roof weight, the effect of cross bracing, and the balance of walls.

In addition, to show the effect of prevention of furniture falling, videos about comparative experiments on shaking tables by various prevention methods can be seen on the Internet. This makes it easy to confirm the effect of prevention of furniture falling. These hands-on education materials are effective for supplementing virtual information systems.

In this section, I showed examples of development of support systems for improving community disaster prevention power by the use of the Internet environment. The basics of community disaster prevention power are seismic retrofitting of weak houses and the promotion of fixing furniture. We developed the systems to encourage each resident to make voluntary efforts for seismic retrofitting and fixing furniture and to support various groups in developing residents’ awareness of seismic retrofitting and fixing furniture.

CONCLUSION

Promotion of seismic retrofitting requires (i) development of residents’ awareness, (ii) establishment of laws and systems, (iii) inexpensive earthquake proof construction methods, and (iv) economic incentives. In this paper, I focused only on (i) development of residents’ awareness and examined it from the viewpoints of training of leaders, creation of programs for development of residents’ awareness, and education materials.

(a) Top page of BURURU

(b) Vibration simulator for two-degree-of-freedom system

(c) Video of model experiment on effect of seismic retrofitting measures for wooden houses

(d) Paper kit of two-story building

(e) Video on effect of prevention of furniture falling by shaking table experiment

Figure 17 Hands-on education materials that supplement simulators

The most important factor for the development of residents' awareness is training of leaders. In this paper, I chiefly showed examples of development of tools for increasing residents' awareness. The tools can be roughly divided into various model vibration experiment materials that plainly show the importance of seismic retrofitting and the e-learning system that supplements the materials and uses the Internet.

The experiment materials can be used according to purpose or target. Each of them consists of a vibration-producing device and various building models. We have developed various vibration-producing devices, ranging from hand-rotating ones to digitally controlled ones that use a PC.

On the other hand, because the e-learning system can be used without limit on the number of persons, time, or place, it can provide information on disaster prevention through WebGIS. Residents can learn about seismic intensity in their community, the seismic capacity of buildings, and indoor safety on the Internet. To encourage residents to carry out concrete disaster prevention activities, we provided a place where they can think about familiar problems with actual feeling.

In the community where I live, seismic retrofitting is steadily progressing through the use of these education materials. This proves that the creation of easy-to-understand education materials is useful for the promotion of seismic retrofitting.

Communities with a high risk of earthquake disaster are expected to make residents enthusiastic about disaster prevention and prepare and disseminate these education materials.