EARTHQUAKE RISK MANAGEMENT AND EMERGENCY RESPONSE SCENARIO SIMULATOR

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SUMMARY

Recent big earthquake disaster, the 1995 Hyogo-Ken Nanbu (Kobe) Earthquake in Japan and 1994 the Northridge Earthquake in USA California, caused immense damage and revealed the vulnerabilities of highly concentrated modern metropolises to major disasters. There were many lessons learned from these earthquake disaster. It was recognized that during emergencies at the time of a disaster, one of the most important factors is proper judgment and decision-making. We are developing a system that simulates emergency response scenarios. It utilizes a visual imaging database to provide support for making judgments and decisions during the state of emergency after an earthquake disaster. The suspected experience based on the lessons from recent big disasters improve risk management ability. Emergency response scenario construction process is very important to search issues on risk management.

INTRODUCTION

The 1995 Hanshin-Awaji (Kobe) Earthquake Disaster in Japan, 1994 Northridge Earthquake in USA and other major earthquakes that have recently struck large metropolises have made us realize the many vulnerabilities of highly concentrated modern cities which have evolved as the result of advanced technologies, growth of societies and the functions required to support them. It is important for us to take the valuable experience learned from the Hanshin-Awaji Earthquake, analyze the problems that were had and put the information to practical use to reduce the level of disaster in similar situations in the future.

Due to the infrequency of major earthquakes, it is not easy for one to conceive the amount of devastation that can occur, and it is therefore also difficult to develop a positive attitude toward emergency response support. One of the reasons is the difficulty in spotting the invisible vulnerabilities caused by the different environment at the time an earthquake strikes. Numerous virtual experiments are inevitable to gain a better understanding of the risks and dangers of such situations. In view of the aforementioned, we strongly recommend the construction of a scenario system capable of simulating varying levels of disaster and calculating the degree of danger and emergency for each situation. This paper discusses the outline of such a system; the Earthquake Emergency Response Scenario Simulator.

EARTHQUAKE EMERGENCY RESPONSE PROBLEMS

We discuss here the emergency response problems that came to light as a result of the Hanshin-Awaji Earthquake.

Analysis and Determination of Level of Safety within a City

Many victims of the Hanshin-Awaji Earthquake resulted from the collapse of or damage to structures. Although many structures were classified as being earthquake-resistant, their construction was not able to withstand the

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massive tremors. For those buildings and structures that did withstand the tremors, there was internal damage and the total malfunctioning of facilities and machinery, thus preventing efficient office operations. With damage to the lifeline system and destruction of various facilities, it was often impossible for policemen, firemen and doctors to reach their rescue destinations during the state of emergency.

One must be aware of the dangers involved not only in the home but other surroundings like the workplace as well, and be prepared to make an immediate response. Even if a building and its interior facilities suffer no apparent damage, the infrastructures that support society have likely been damaged, and will no doubt have an affect on building operations; often making normal functions impossible. We therefore believe that it is important to insist that proper response cannot be conducted on an individual basis. Emergency response support should cover vast areas if not entire cities.

Improving Emergency Response: Regions, Individuals, Organizations (Companies, Governments, Etc.)

In order to evade damage when the force of an earthquake is more severe than previously assumed, the accuracy of how individuals and organizations respond is very important. In addition to the earthquake-resistant and disaster technologies for preventing damage, to simultaneously minimize post-earthquake disaster, it is important to improve the response of the core members of organizations and crisis control teams. In terms of the disaster area, the way the core members respond has a very large impact on the consequences of the victims.

Immediately following an earthquake, the core members of organizations and crisis control teams must judge the circumstances and make policy decisions for proprietary emergency actions, not only in support of the disaster area but also the perimeter regions and isolated areas. These initial decisions have a large influence and will indicate how the outcome evolves. It is also important to consider previous countermeasures when deciding crisis management.

A disaster plan that supports a spreading disaster area must also incorporate judgments for damage to emergency organizations in the area, as these organizations will not be able to operate normally due to the deteriorated conditions. It is therefore important for residents and companies to prepare for responding to disasters as well.

Regarding the transmission of information on circumstances in the disaster area, it is difficult to receive information even from outlying areas. Using the limited information available, accurate circumstances must be deciphered and proprietary emergency responses decided. The clarification of such circumstances results in a large influence on the final outcome.

The actions of the key person(s) leading an organization's response to a crisis are of great importance. There are many decisions that must be made at the time of an emergency. Immediate action must implemented. A survey to learn the actions of government officials, executives and top management of major corporations immediately following the Hanshin-Awaji Earthquake was taken. It was found that there was a tremendous increase in the amount of time for traveling from home to the place of work regardless of the type of transportation used. Those people who left home immediately and went to their offices using a personal form of transportation, arrived at their destinations much faster than those who used their normal forms of transportation (e.g., driver pools). These people ended up caught in traffic jams or stopped on roads due to debris blocking the street. In view of this fact, it is vital that main executives and core members leading the disaster response activities of organizations take action at once.

OBJECTIVE AND POSITIONING OF EARTHQUAKE DISASTER RESPONSE & SCENARIO SIMULATION

The first objective of this system is to improve the response capabilities of the main executives and leaders in command at the time of an emergency.

The ability to respond and provide support in an emergency situation, such as judgments on related circumstances, decisions and judgments on policies or the evaluation of initial information received from a disaster-stricken area, depends on a knowledge of daily crisis control, recognition and experience in responding to various crises, and an understanding of actual disaster situations. In particular, it is very advantageous to have experience in responding to similar disasters. Therefore, the main objective of this system is to train organizational executives in precise crisis recognition for the purpose of improving the implementation of proper disaster prevention measures.

Although risk is evaluated as a product of the probability of occurrence and loss, even if the probability of a large-scale earthquake is small, the risk is great because the loss caused by damage is immense. However, when considering the matter from the point of low-frequency disaster loss, the importance of investment in disaster prevention receives little attention. In order to promote proper investment in disaster prevention, it is important to clarify the cause and effect relationship of actual earthquake risk to the management of organizations. The focus is not always the individual(s) in charge of emergency response, but the key person(s) with a major role in command.

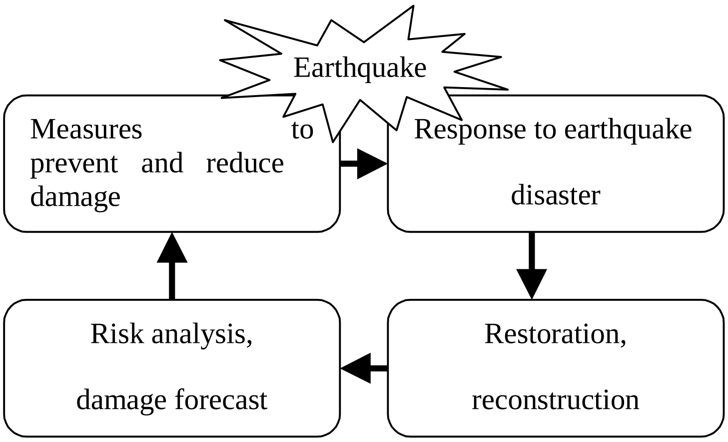

Fig. 1 Earthquake risk management cycle.

The key person(s) must have the ability to make circumstantial judgments, presume the scale of disasters, accurately forecast transitional developments, make rapid policy decisions and be capable of coordinating activities. It has been indicated that the role largely requires experience and knowledge of disasters (e.g., actual experiences, causes and results, regional characteristics, actual conditions within the organization, etc.), thus enabling circumstantial judgments and the estimation of developments. Key persons are expected to show leadership not only during times of emergency but in all phases of disaster prevention measures (Fig. 1).

THE SYSTEM: BASIC FEATURES, CONSTRUCTION AND USE

The purpose of this system is to enable the individual(s) in charge of disaster prevention in a company/government to understand the actual situations involved during an earthquake disaster, thereby providing the knowledge required for improving the ability to respond to emergencies. Therefore, it is important for the system to have the performance characteristics listed below.

System Features

The core of the system is logically developed earthquake disaster scenarios and related circumstances designed for effective persuasion. In addition to the need to reflect related research in earthquake studies such as seismology and earthquake-resistant technologies, a damage occurrence mechanism and secondary developments process are required as a basis to provide a system capable of rational damage estimation and persuasive scenarios. The system now includes a systemized database of various data regarding earthquake disasters.

In order to ensure rational damage estimation, it is important to understand the characteristics of the region where the organization is located, the disaster prevention policies of the organization and the individual(s) in charge. To obtain this information, the surrounding environment of the actual area is studied, and questionnaires or interviews are conducted to learn the characteristics of the organization and the individual(s) in charge of disaster prevention. The data collected is then analyzed.

To give organization/individual in charge of disaster response the actual feeling of experiencing a disaster, a life-like experience has been created by incorporating a multimedia function, which utilizes example images of disasters (motion-picture clips and still photographs) to show the estimated damage, into the scenario simulation system.

System Construction

The system is comprised of several integrated subsystems:
1) The main system in which the actual scenario simulation is conducted; linked by network with outside control.
2) Database system for simulation support; examples of damage (structures ,fires, etc.) and response actions (evacuation, gathering at safety zones, rescue, etc.).
3) Subsystems such as risk analysis for supporting scenario development and damage estimation system.

4) Technology information database for subjects that have been clarified through simulation results.

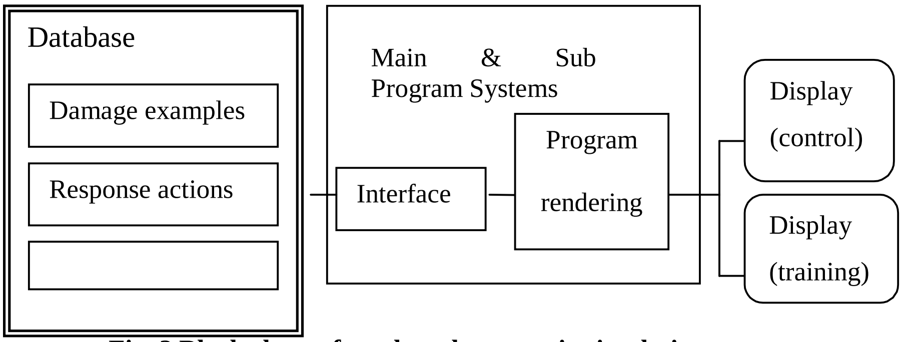

Fig. 2 Block chart of earthquake scenario simulation system.

Distinctive Features of Prototype System

The prototype earthquake emergency response support system has the following distinct features:
- An integrated earthquake disaster crisis control system with a field of vision that covers everything from earthquake disaster risk analysis and previous countermeasures to emergency response and restoration plans.
- Presented as system with human-machine interface combined with participation of remote terminal (control). The menu-type display operates so as to offer a minimum of responses by selection of ideas, and attempts to provide as little foresight as possible while maintaining communication with the person conducting the simulation. For screen control, the instructor requires high skill in the field (disaster knowledge, story coordination, etc.).
- Estimation of damage circumstances provided with examples similar to the characteristics (knowledge of disaster prevention, crisis management system, etc.) of the organization and individual in training. Consideration is given to lifestyle and work environment as well.
- Multimedia function improves the level of life-like experience. For example, the addition of artificial voice enables the reception of instructions by telephone and scenes with radio news. Difficulty in communicating by telephone is also experienced.
- The functions of each subsystem can be used separately for damage estimation, disaster prevention education and training, or support for preparing a disaster prevention plan.
- Any step of a disaster prevention plan can be rearranged, and its effects checked.
- Disaster prevention standards of any company can be experienced through the simulated scenarios.
- Easy to find problems in disaster prevention plans using the simulated scenarios.

Operation Procedures

The procedures for operation of the simulation are listed below.

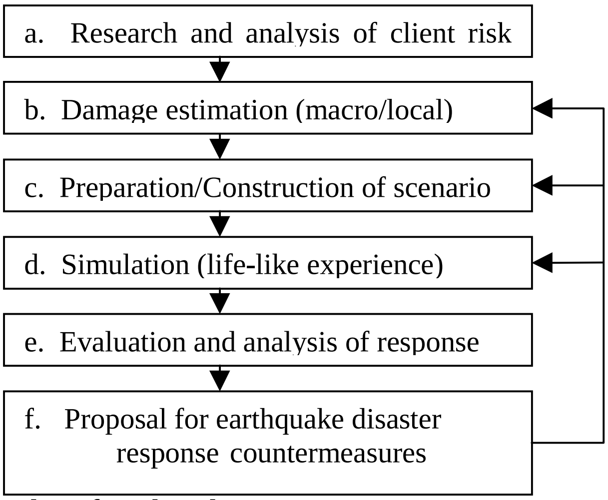

Fig. 3 Flow of earthquake emergency response management training.

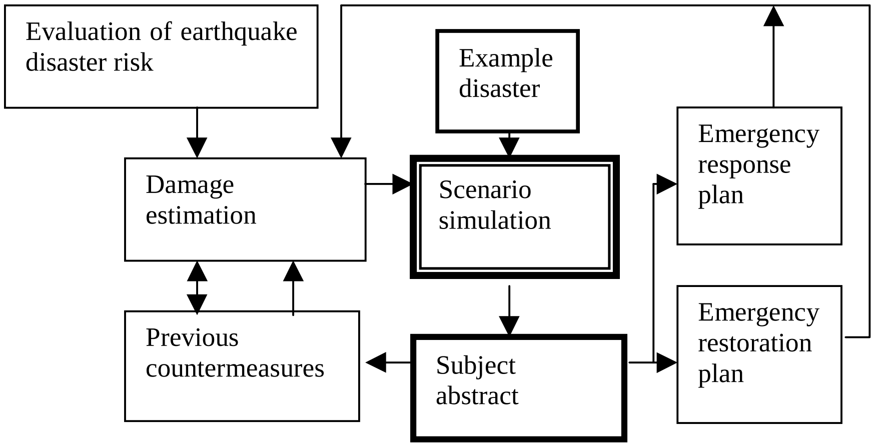

Fig. 4 Flow of earthquake scenario simulation.

Survey of disaster prevention characteristics and crisis management system of targeted companies and businesses

Using site surveys and interviews, we analyze and evaluate such items as site conditions (degree of earthquake activity, distribution of active faults in the region, geography, geological features, etc.), anti-seismic performance of the building, condition of fire prevention measures and equipment, disaster prevention plans, preparation of manuals, etc.

Damage estimation for residences and companies in the surrounding area and for the region

Using the damage estimation results of the developing GIS platform earthquake risk analysis system or the damage estimation information of the government, an estimations of overall general damage and damage to individual facilities are prepared. The estimations include not only damage to structures but also considerations for obstacles to the functions of facilities due to related confusion and equipment damage. If necessary, a response analysis, numerical simulation will be performed.

Establishment of a scenario framework for companies and businesses

The required parameters (time earthquake strikes, season, meteorological conditions, etc.) for the scenario are predetermined. Based on the results of damage estimation of homes, places of work, and the surrounding area, evacuation routes are determined. A macro damage estimation for the assumed earthquake is prepared, and the structural characteristics of homes, places of work and the surrounding environment are taken into consideration to make an evaluation of the initial damage.

Evaluation of simulation operator's characteristics

An individual's disposition is a factor that weighs heavily on crisis response. Each simulation operator is interviewed before beginning a scenario, and his/her crisis management consciousness and experience with and knowledge of disasters are evaluated and analyzed. The interview with the individual is educational in nature. But at the same time, it must be conducted carefully so as to not provide any foresight to the simulation itself, as this might affect the individual's reactions to the simulation and not reflect the actual situation.

Conducting the simulation

Using information from the estimated damage conditions, a similar scene is presented to the individual, who must then judge the situation and chose the actions for response. The simulation is controlled by a remote operator rather than letting the individual chose from a menu. The individual in training and the instructor watch the progress of the simulation on different displays installed in distant locations.

Simulation evaluation

Each individual is shown a variety of disaster scenarios, and an evaluation is given for the adequacy of how situations were judged and the response actions chosen. Based on the results of the evaluation, an educational curriculum for training and countermeasures for improving anti-seismic performance and fire prevention are offered.

Simulation incorporating new conditions

After suggestions for improvement have been implemented or there has been a change in the environmental conditions involved at the time an earthquake strikes, damage estimation and simulation are repeated to confirm improvements in the case of the former, or to evaluate the individual from a different perspective under new conditions in the case of the latter.

BASIC TEST MODEL SCENARIO

A model scenario based on the 1995 Hanshin-Awaji Earthquake was constructed, and the prototype system tested for functionality and efficiency. Information on damage to structures, damage and reduced functionality of commuter facilities, and damage caused by fire was compiled by written survey and formed into a database of damage circumstances. Regarding isolated support to the disaster-stricken region (Kobe) and outlying area (Osaka) by Tokyo business activities and response actions, information (publicity, instructions) exchange (details, resources, media) materials, etc. were gathered by various means of research (e.g., questionnaires, referencing recorded documents, and so on) and interviews with related parties.

Based on the information collected, events were systematically scheduled over a timeframe, and a streaming system was enabled through the inclusion of related events. The development of a timing system to track the term of emergency response completed construction of the model scenario. A team examined possible example responses at various major points and added plural scenario development plots. On constructing a scenario, it was found that many types of judgments, response actions and choices were required.

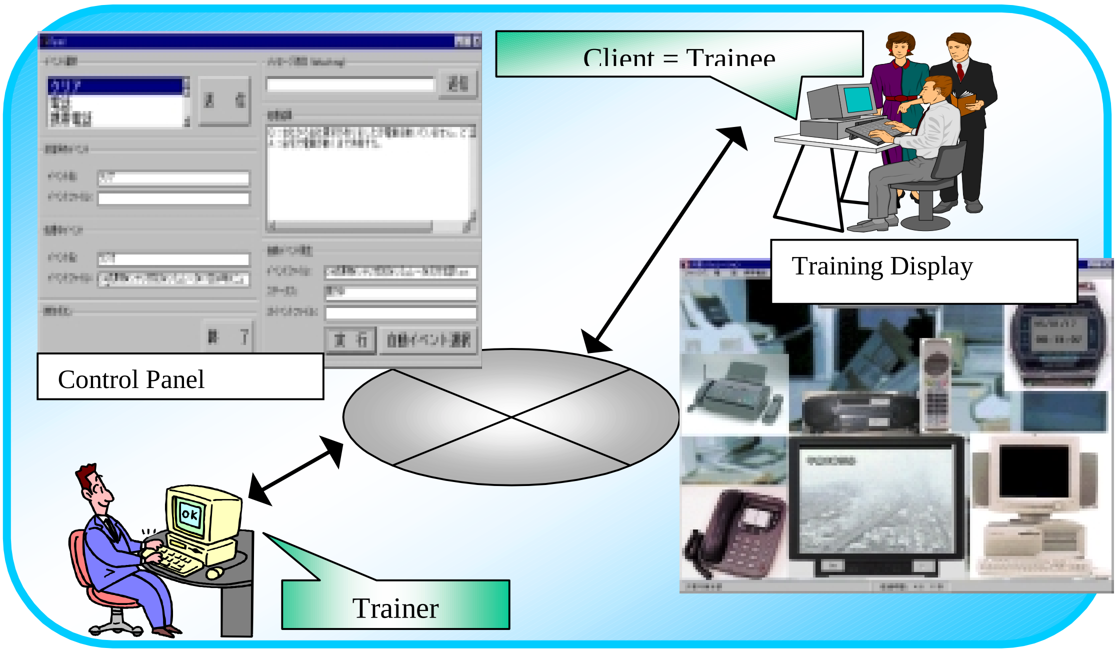

Fig. 5 Scenario simulation concept

CONCLUSION

An emergency response support system, with scenario simulation based on examples of earthquake disasters as its core, has been developed. Although the aim of this system is to improve emergency response, it is recognized that earthquake disaster prevention technologies such as risk evaluation, damage estimation and response forecasting must be synthesized. Plans are to promote the practical application of the system through the accumulation of more disaster examples and introducing greater diversification in scenario development.
Suspected experience through the scenario simulation system improve emergency response ability. Emergency response scenario construction process is effective to search risk management issues.

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