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EARTHQUAKE DISASTER PREVENTION INFORMATION SYSTEM BASED ON RISK ADAPTIVE REGIONAL MANAGEMENT INFORMATION SYSTEM CONCEPT

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SUMMARY

The disaster prevention information system which functions surely enables damage reduction of the earthquake disaster. In this study, decentralized independence type disaster prevention information system was proposed. Based on the concept of RARMIS (Risk Adaptive Regional Management Information System), this system consists of “municipality information system” for disaster information processing as a seamless extension of the daily work at local government and “the disaster prevention information center system” for the disaster responses exclusive processing. Disaster prevention information center pilot system which realized a series of function based on this concept was developed.

INTRODUCTION

In the Hanshin Awaji (Kobe) Earthquake in January 1995, the blank of information was caused because neither the information collection nor sharing functioned adequately. From this experience, the disaster prevention system to support the disaster responses was introduced and examination of information sharing is advanced in the country and the local government. A lot of systems have been developed to overcome the information problem at the time of earthquake since the Hanshin Awaji (Kobe) Earthquake, and they have introduced into the country and the local governments. The existing systems which designed on the presupposition of information sharing were few, because they were individually developed in country and each local government.

Many of existing disaster prevention information systems adopted introduce Geographic Information System (GIS). Almost of the GIS data base structures are closed model. In the information sharing in the country and the local governments, the data sharing through XML(Extensible Markup Language) is a method of the effective for the regular update data. However it doesn't become a real solution when dealing with transition of the time of information changing every second like disaster information. It is not have a function to update area information always, because of the problems that the function of updating of spatial data and the cost of updating data base, so that it is exclusive data only for a disaster

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prevention system. Therefore, there are a lot of systems that data dose not update several years have passed since the system was introduced.

It is apparent that the disaster prevention system based on the old data is not effective from the point that not only disaster information but also regional management information immediately before suffered disaster is necessary for the disaster activity of municipality. In addition, there is economical issue that the municipality which keeps the system is limited to the municipality of relatively big economical scale, because of the cost of introduction and maintenance of disaster information system which include establishment of backup of system, construction of seismic isolation building, and installation and maintenance of monitoring system for improvement of earthquake protection securing of system are expensive.

Experience of an earthquake disaster is not made use of by the next earthquake disaster, on account of the probability of the great earthquake occurrence is low in man's life span years and the life span of the structure. To solve this problem, it is important to construct a practicable system which applies the technology, natural science and social science to the disaster prevention practices. Also it is necessary to maintenance of unification data base such as nature, use of land, social infrastructure, and statistical data, and to have a function of spatial temporal management to control changing information at normal and disaster time. In this study, the disaster prevention information system is developed that achieves decentralized independence system and concept of RARMIS (Risk Adaptive Regional Management Information System)(Kameda[1]) which achieved seamless cooperation in ordinary circumstances and emergency, time management of spatial information, mutual reference and sharing.

One of the authors has advanced the examination of what should be of the earthquake disaster prevention information system from the experience of the Hanshin Awaji Earthquake. The system which functions surely in the municipality at the time of disaster is a system using in daily work at ordinary circumstances. It is important to design the system that the system of ordinary circumstance is able to correspond in emergency, and it is shown to be able to construct the system satisfy the concept of RARMIS by placing the information processing, which is not used at ordinary business, to professional institution outside of municipality. As concrete research based on the concept of RARMIS are “Research and Development on Seismic Emergency Information System” (Ebisawa[2]) and “Development of Spatial Temporal Information System using under the Disaster" (Hatayama[3]) , etc. which has been applied to the disaster drill of the municipality.

In this study, disaster prevention information center pilot system intended for the nationwide was constructed to solve the problem of the current research based on the concept of RARMIS and the specification of the effective information system was clarified. Disaster prevention information center pilot system provided seamless spatial basic data of the nationwide, constructed the frame to achieve the introduction of the system base intended for the nationwide and low-cost, and showed the problem solving method to make surely established to the municipality. In this report, specification of decentralized independence type disaster prevention information system which proposed as a resolution approach of conventional systems and evaluation by pilot system directionality of development in the future was described.

SUBJECT IN THE PAST STUDY

In the concept of RARMIS, the management of regional information in the municipality, differs from the regional information management based on address, manage the region on the map by GIS. In other words, the data which belongs to a spatial position in a basic map data is managed spatial temporal.

Moreover, house data, lifeline data and resident data on the basic map are mutually referred at need, and the phenomenon in the event and the regional management data both in ordinary circumstances and disaster are managed based on the position coordinate and the time history. As a use example of ordinary circumstances data to disaster is to use the resident data of ordinary circumstances for victim's safety confirmation and safety secure at the earthquake. Similarly, the fixed assets data of ordinary circumstances can be used for the disaster waste management at the earthquake disaster, the lifeline data of ordinary circumstances can be used to recover the living environment at the earthquake disaster, regional planning in ordinary circumstances can use revival of the city of the earthquake. The phase of the crisis management at the earthquake disaster can be classified into the following five by showing details at time from ordinary circumstances to the disaster.

(1) Real time = correspondence in a second unit from earthquake occurrence (warning and automatic interception, etc.)
(2) Semi real time = correspondence in a few minutes to several hours (disaster and damage information collection, and damage estimation and grasp at early stage, etc.)
(3) Emergency response = correspondence in several hours to several days (emergency, lifesaving, and urgent transportation, etc.)
(4) Restoration and revival = correspondence in several days to several months (recovery of municipality service and disaster waste management, etc.)
(5) Ordinary correspondence = correspondence to the next earthquake from several months (recovery of urban function, urban diagnosis, and provision for the next earthquake, etc.)

Many of disaster prevention information systems that have been developed make a point of nature of real time functioning in the phase of (1)-(2). On the other hand, the study in the concept of RARMIS intended for the function in the phase of (3)-(5). For the construction of the system that the ordinary circumstances and disaster continue seamlessly, it is necessary to construct the system that functions from phase (1) to phase (5) continuously. In other words, the construction of the system that the ordinary circumstances from immediately after the disaster to just before the next disaster connected seamlessly is required. Disaster prevention information system which introduced in municipality requires system operation by expert staff. In this case, it is possible to obstruct the system operation when expert staffs were suffered, because the disaster prevention expert staffs are small number in municipality.

Moreover, in this system, it is designed in assumption of that the resident data, house data, and the lifeline data, etc. which the municipality has can be used for the disaster. However, in Hanshin-Awaji (Kobe) Earthquake, the public office building of the local government was destroyed and the municipality data was not able to be used. Information processing required at the time of disaster is to command the disaster condition accurately from various and huge fragmentary information and to have a function that support the decision making by planning effective disaster counter measure and evaluating effectiveness of it when corresponding to disaster. The disaster management method based on the experience of the latest knowledge related to the disaster and a past earthquake is necessary to support the decision making. More important thing is that the local government staffs who doesn’t have experience and expertise can process swiftly and adequately.

For the disaster prevention information system which functions surely and enables to achieve the information processing at the disaster, it is necessary to satisfy the following points;

i) It is possible to extend and develop many and unspecified local governments.
ii) API(Application Program Interface) , etc. should be opened to the public, and it is possible to be free plug-in to a basic system, and to expand the system.

iii) It functions in the local government that does not have an original seismograph network and the monitoring system.
iv) It is possible to incorporate a regional management data which is updated every day.
v) Introduction cost and support costs of the system are cheap.

SPECIFICATION OF DECENTRALIZED INDEPENDENCE TYPE DISASTER PREVENTION INFORMATION SYSTEM

Concept of development system

To construct certainly useful disaster prevention information system for the earthquake disaster, it is necessary to construct the system which functions surely when local government facilities receive the extensive damage. In addition, it is necessary to have a good economical efficiency without a advanced system, which require expense for secure earthquake-proof and backup system, of local government it self. Then, as shows in **Fig.1**, the decentralized independence type disaster prevention information system that consists of "disaster prevention information center system" that does special information processing for disaster for which use frequency in individual municipality is low and introduction of innovative technique and expertise is necessary, and "municipality information system" that processes regional information of disaster as seamless extension from daily work is constructed. The information processing in the time of disaster, it is possible to classify into the information processing of continuation of daily process in local government and information processing only at the time of disaster. The information processing only at the time of disaster is supported by the disaster prevention information center outside the disaster area.

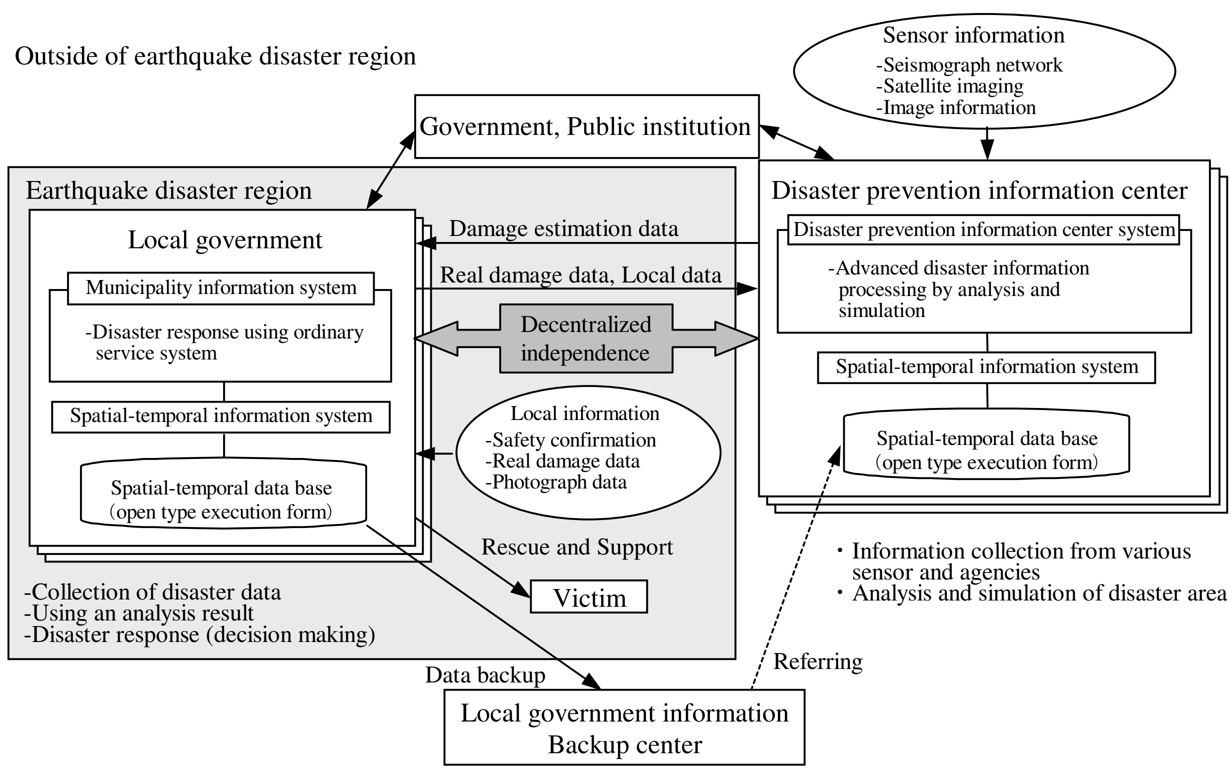

Fig. 1 Decentralized independence type disaster prevention information system

The municipality information system is composed of plural portable PC and functions as a decentralized independence type operation terminal of each department in normal circumstances. Each terminal carries out the function as the information terminal for disaster response at the disaster. As a result, if one PC is working, securing the information processing function for the disaster of the municipality becomes possible even when the municipality facilities receive damage. Moreover, municipality information can prevent lost data at disaster by setting up the backup center of municipality information in the remote place, and backing up municipality information regularly. Similarly, it is possible to decrease the risk of the function loss of the system by prevention information center system outside the disaster area also has the backup site.

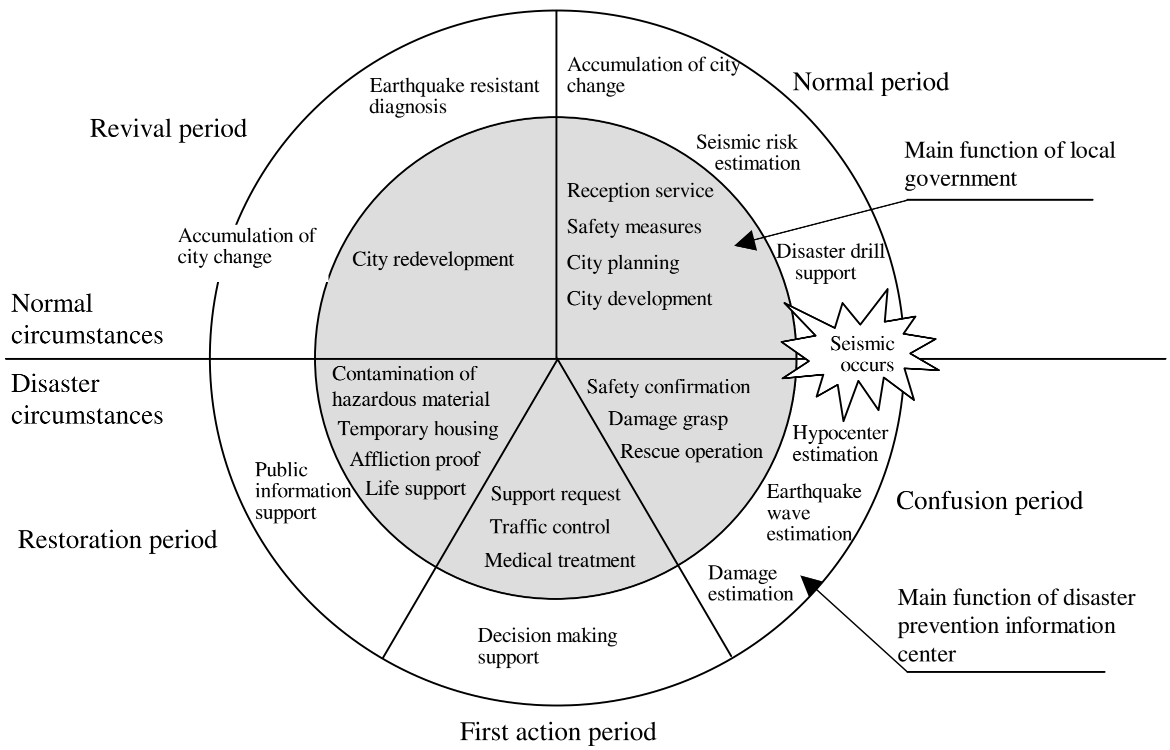

Fig. 2 Classification of decentralized processing and cooperation at consecutive normal circumstances and the disaster

In addition, as shown in **Fig. 2**, from normal period before the disaster to confusion period after earthquake, restoration period, revival period through to the ordinary period to prepare for the next earthquake disaster, information and the result of analysis accumulated by the mutual information transmission of the disaster prevention information center and the municipality can be effectively used in disaster prevention. The municipality information system does not require special knowledge at the disaster, operate the system by the same machine as parts of daily work, collecting and arranging the disaster data of disaster area, and achieves disaster response utilizing damage estimation data and the result of analysis by disaster prevention information center.

At the time of the disaster, the disaster prevention information center system does the information collection, the damage estimation, and the analysis, and transmits the result to the municipality system at the disaster. In addition, information of the disaster area that changes hourly can be processed by doing the reanalysis and repeat estimation based on real damage information from the municipality, and doing the information transport of interactive transmits the result to the municipality system. As for the composition and the management form of the disaster prevention information center, the method of joint management in country and two or more municipalities and management by contract between municipality and private company, etc. are devised.

The construction of the decentralized independence type disaster prevention information system corrects the difference of the disaster prevention information system possession by the budget scale of the municipality, and achieves sharing and the integration of efficient disaster information. The disaster prevention information center system realize the information support from outside of disaster area, as the example of earthquake, it is considerable to function effectively by establishing in consideration of consideration of the struck scale of the intraplate earthquake, the large-scale plate boundary earthquake such as Tokai and the southeast sea earthquakes.

Spatial temporal information processing foundation system

Sharing information is important to decrease the information blank and confusion at the disaster as much as possible. It is difficult to rapidly sharing the information when the system of the organization or the municipality is plural and has an original data base and it is not compatible. In a large-scale earthquake, It was feared that facilities suffering and deterioration of the communication environment. It functions effectively that not the client-server type but decentralized independence type system that cross-reference if it is necessary (Kakumoto[4]).

To achieve information processing that manages presumption and forecast data with simulator and management of regional information that changes hourly at earthquake disaster, the information processing system that can manage time is requested. In the disaster information management, the data of a social condition and the natural condition, etc. is registered in GIS, and the system that integrates and uses the spatial information on a digital map is effective. Most existing GIS manages only the spatial information system, and which system cannot be describe a momentarily change. The integration of different data and cooperation with other information systems is difficult, because the data structure each GIS has an inherent of nondisclosure structure.

In the processing of information on disaster prevention, open and public data structure is necessary, because integration of information at different region and time, integration of data systems different in each department and synchronization of two or more information systems are required. The description structure of data can be understood mutually or the same is necessary to cross-refer the information, which is managed independently in normal circumstances, at the time of disaster.

In this study, spatial temporal information processing foundation system based on open type execution form spatial temporal data base and spatial temporal information processing system which used Disaster Management Spatial Information System (DiMSIS) is developed. DiMSIS was developed mainly at Kyoto University Disaster Prevention Research Institute in an opportunity at Hanshin Awaji (Kobe) Earthquake. A basic system becomes the common base of the disaster prevention information center system and the municipality system as shown in **Fig. 1**.

For the open type spatial temporal data structure, KIWI + in which one of the authors was involved for development is improved. Japan Digital Road Map Association also uses various definitions for KIWI + in addition as a guideline. KIWI is adopted as data form of the car navigation system with a lot of domestic products. As for KIWI, the industry-wide standard and the international standardization are advanced. The description structure spatial temporal data is not described statically as data for graphics primitive and the attribute element, related ID information and phase information. When retrieving it, the phase information is dynamically requested by a representative point coordinates of the attribute element and a positional calculation with the graphics element. Therefore, the data integration of the incorporation and the overlay data can be easily achieved. Moreover, because it is time management of an individual graphics elements and the attribute element, e.g. history management from generation to the disappearance, regional management information at the arbitrary time can be reproduced. Spatial temporal Information processing foundation system works on PC. The application such as simulators can be refer to spatial temporal database, read and write based on open type API.

Examination of interactive information transmission approach

The communication environment at the earthquake becomes a very bad situation due to receive damage, crowding, and the power failure, etc. Almost five days were spent on the restoration of public line in the Hanshin Awaji (Kobe) Earthquake. It is a serious subject to secure the interactive information transmission function between the municipality system and the disaster prevention information center system for 72 hours after the earthquake disaster which is said as a important period for disaster response.

As the way of solve this problem, it is realistic to make it possible to do information transmission by using one of the equipment of the data transport such as public line, the leased line, the mobile phone, the satellite phone, the wireless, and the data media. In this case, it is required that the communication apparatus material used by staff of the municipality is using at daily work. Exclusive equipment at the disaster caused the situation that a communication function is not effective by the unknown thing as for use. The staff of the municipality does the information transmission by extending daily work at the disaster becomes possible by the system that daily transmits the data of the site investigation of the property tax of the municipality with the satellite phone and the mobile phone is built into the municipality daily work system.

Function of disaster prevention information center at disaster circumstances

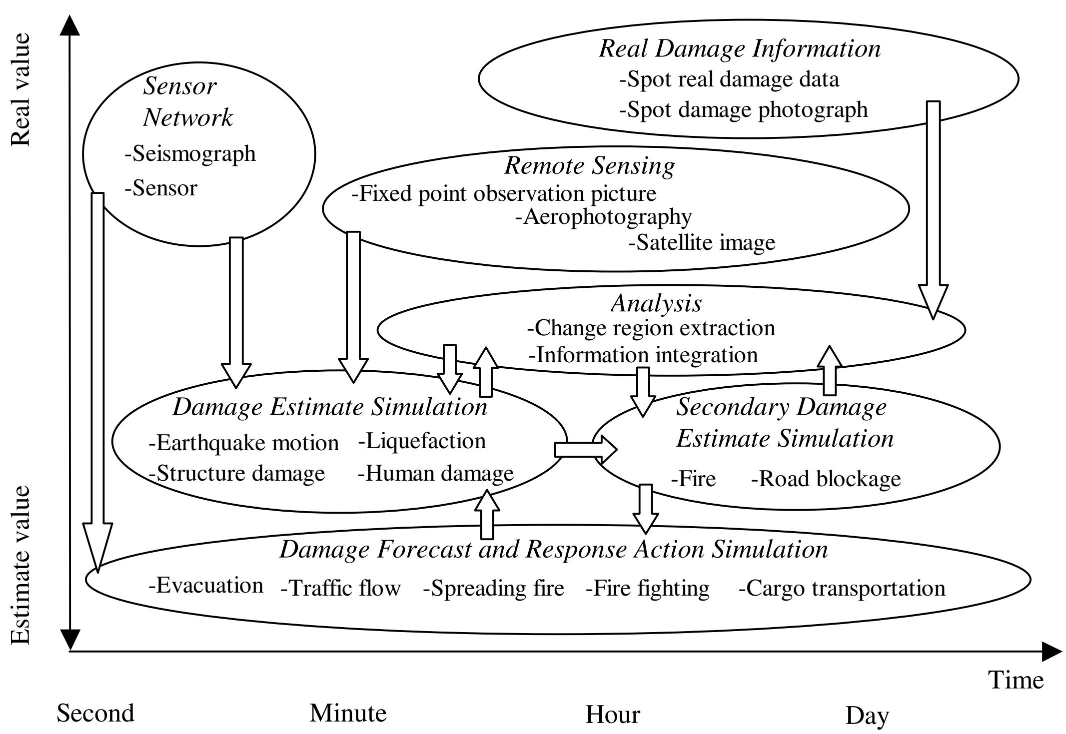

Fig. 3 Information processing of disaster prevention information center at disaster circumstances

The information processing on the disaster prevention information center is to collect real-time earthquake information from the sensor network such as seismographs immediately after the earthquake, and to estimate damages. In the initial response to the disaster, disaster analysis by measured data and remote sensing data and collections of real damage and an offer of decision support information to be appropriate with swiftness are required.

Afterwards, image information of the area of distress by such as the aircraft and the remote sensing data are collected. And damage estimate of change area by comparison with the latest image before earthquake are executed. In addition, real damage information is collected as time passes. And accurate damage estimate is improved by estimate again based on the fact report. At the next stage, secondary damage is estimated based on the damage analysis and the estimated result. In parallel with these, the simulation of damage forecast and response action is executed. (**Fig.3**)

DEVELOPMENT OF DISASTER PREVENTION INFORMATION CENTER PILOT SYSTEM

Purpose of development and system configuration of pilot system

First of all, it is necessary to construct the nationwide seamless spatial temporal data base to solve the problem of an existing system, and to construct the system targeting all over the country. Moreover, it is required to achieve the information support with earthquake quick announcement and earthquake ground motion estimation to the municipality without a real-time seismograph and detailed regional spatial data. And, it is necessary to evaluate the effectiveness of the proposed system by constructing a pilot system and verifying the flow of the information processing.

In addition, it is required that clarifying interface standard with the applications such as analytical systems and simulation systems, and examining the structure of basic system, unification of information and adaptation at the scene of disaster that satisfy the requirement specification of the simulator and the municipality as an end user.

Disaster prevention information center pilot system is composed of the spatial temporal information processing base system and spatial temporal data base using open type execution form that becomes the basis of information processing, the simulator group, the control subsystem, the information integration subsystem, and the information transmission subsystem. The function of the simulator and the entire system is confirmed on pilot system, and speed-up of simulator, reinforcement of communication function, speed-up of the system and mutual cooperation will be advanced in the future.

Spatial temporal information processing system, control subsystem, information integration subsystem

The spatial temporal information processing system adopted DiMSIS that is an archetype of the pilot system that advanced development for this study. The spatial temporal information processing system which is in development succeeds to the API function of DiMSIS and guarantees the operation of the application constructed on pilot system.

The control subsystem consists of the program that controls a whole system, the program that controls the simulator, and the task management program. In the pilot system, a basic protocol and the task management control system of the simulator group were constructed.

The information integration subsystem consists of programs which display results of simulation, display integrated results of plural simulation and estimation and process arithmetically.

Information transmission subsystem

For the disaster prevention information center system, the function to collect the seismic data and the picture data from the sensor groups such as an existing seismograph networks and the image satellites is required as at the earthquake disaster. On an earthquake data, the function to collect the hypocenter data of which required quick announcement and the earthquake ground motion data which is necessary for estimate detailed distribution of earthquake ground motion.

It is necessary to collect hypocenter information in real time to use earthquake information as a trigger of the disaster response. Moreover, the strong motion waveform data of the earthquake disaster area is necessary for detailed damage estimation. A joint experiment with the University of Tokyo that delivers hypocenter information, decided by the real-time earthquake information analysis system with the high sensitivity seismograph network of the National Research Institute for Earth Science and Disaster Prevention (NIED), by the satellite has been conducted since 2003.

In addition, the real time of the data of strong motion observation network (k-net) is scheduled in the future. In disaster prevention information center pilot system, the function to receive data of real-time hypocenter information delivered from the satellite was constructed.

In the decentralized independence type disaster prevention information system, the interactive information transport of the damage estimation data, the municipality latest information, and real damage information are transmitted between the municipality system and the disaster prevention information center system.

In disaster prevention information center pilot system, communicative function by e-mail and FTP(File Transfer Protocol) was constructed as one method of achieving the interactive information transport. The municipality information system constructed the function to access the mail server and the FTP server directly from RAS(Remote Access Service) of the disaster prevention information center by dial-up.

As a result, an enable sample to achieve the transmission of interactive information of damage presumption information and real damage information by accessing to the disaster prevention information center with using possible communication equipments was shown.

Construction of nationwide spatial temporal data base

The improvement of the national spatial data infrastructure is being advanced as a national project now. However, the integration data for nationwide in seamless at present is only private data for the car navigation system. In this research, the spatial temporal data base of the national level of the open type execution form is constructed by unification of geodetic and coordinate transformation using public data which is individually maintained in Transport Geographical Survey Institute Ministry of Land, Infrastructure and Statistics Bureau Ministry of Public Management, Home Affairs, Posts and Telecommunications.

The geomorphology classification data of the digital national land information prepared to estimate the earthquake ground motion distribution is about 1km mesh data. To support for the large city, the data accuracy should be insufficient, so that introduction of the detail data which the municipality possess is required. Similarly, the accuracy of the system improves by using detailed map information on the municipality.

The aims of preparation of the spatial data base are to construct the basis of nationwide common specification integration data base through the unification of existing data of the public which can be used. The cooperation of the local government, the country, and the disaster response organization can be efficiently sharing information in the nationwide spatial temporal data base. For the local governments that do not own the spatial database, it is possible to easily construct the regional management information system by using spatial temporal database constructed with pilot system.

Simulation system

In the disaster prevention information center pilot system, the simulator by the simplified approach was mounted to examine plug-in specification of the simulator and to confirm the synchronization of two or more simulators and the system control functions. The simulator, which estimate the earthquake ground motion distribution, estimate earthquake ground motion on the engineering rock surface by the distance attenuation formula method based on hypocenter information (Annaka[5]) and estimate earthquake ground motion in the ground level according to the surface subsoil amplifying characteristic based on the geomorphology classification data (Onishi[6]). House damage and human damage estimation simulator estimate house damage and human damage based on the relation between the maximum velocity and the damage rate (Hasegawa[7] Japan Association for Fire Science and Engineering[8]). In the future, a detailed data base will be prepared and an advanced simulator will be mounted.

EVALUATION BY PILOT SYSTEM

Information flow at earthquake disaster

To support the initial motion response of the local government in the earthquake, quick announcement of the earthquake occurrence is required. In disaster prevention information center pilot system, the functions were constructed that hypocenter information which is decided immediately by the real-time earthquake information analysis system delivered from the satellite is received, a trigger was judged according to the earthquake ground motion scale in the object local government, and to transmit the quick announcement. It was shown to be able to support the local government which do no t have an original real-time seismograph network by this function. It is also possible to make latest regional management information evacuate to the municipality backup site if the hypocenter is not a just under.

In the disaster prevention information center, the earthquake ground motion distribution is estimated from the geomorphology classification data of the spatial temporal database and hypocenter parameter. In the local government which has detailed ground data, the earthquake ground motion distribution can be independently estimated from the hypocenter parameter received by the quick announcement. The local government with detailed building data can estimate building and human damages by sending estimate value of the earthquake ground motion distribution. For the local government without detailed building data, estimate value of building and human damages which presumed with house data in every address derived from statistical data can be transmitted. Moreover, it is also possible for the disaster prevention information center to arrange the support to the local government by acquiring detailed local government data from the municipality information backup center immediately after earthquake.

Afterwards, estimated accuracy can be improved by re-estimated based on the real data from disaster site collected in the local government. In addition, the aerophotograph and the satellite imaging are collected and real damage is understood in the disaster prevention information center. The profitable offering for the decision making of the local government is achieved by doing the forecast and the response simulation based on obtained information.

The effectiveness of the decentralized independence type disaster prevention information system was evaluated by proving these information flows by disaster prevention information center pilot system. In this study, it is clarified that an ideal method of information processing depending on holding level of regional spatial data of object local government and obtaining level of municipality regional management data in disaster prevention information center at earthquake disaster.

Subject in the future
In this study, the development of the disaster prevention information system that can adjust to various regional scales and the disaster scales is a purposed. It is necessary to develop the municipality information system in close cooperation with the local government which does a joint research in the future, and to guarantee the scalability of the system.

In the construction of the municipality system, the management of spatial temporal information in an efficient is achieved by solving the information problem without changing the method of work for staff of the local government. Because the operation system and flow of the present in local government optimized by spending long time, and it is considered that only the system that can be introduced without changing the method of the work for staff of the local government is succeed the real operation in the municipality.

Moreover, it is considered that there are differences in the effective information processing at the struck level from large-scale damage to the small and medium-sized scale damage. A current history of the earthquake and the knowledge of the social science field are made the best use of for the system development, and useful system development through not only the disaster information support but also daily work is necessary.

It is important to tying to the real operation in the local government, by examining correspondence to other natural hazards, and achieving the frame of the decentralized independence type disaster prevention information system, in the future.

CONCLUSION

In this report, the problem and subject of the disaster prevention information system were arranged, and the directionality of the problem solution was clarified by disaster prevention information center pilot system that achieved the concept of the decentralized independence type disaster prevention information system. In addition, the realization method of the disaster prevention information system that process disaster information in low cost which means did not depend on the scale of the local government, and functioned without fail at the disaster was shown.

As for disaster prevention information center pilot system, it is scheduled to be improved by trial experiment in local government that does a joint research and speed-up of system for practical use of system. It is important to evaluate the economic effect to achieve the practical use of the decentralized independence type disaster prevention information system and to show superiority to an existing system quantitatively. That is to say, it is necessary to achieve cheaper and more superior information service than existing systems.

The decentralized independence type disaster prevention information system is effective from the both sides of the earthquake disaster risk and the introduction cost of the system. In addition, it is effective system from international cooperation point of view, because it is also possible to do information supports in overseas disaster, when define the end user as an overseas country and the region, by that Japan bears the function of the disaster prevention information center and object country's or region possess the regional information system.
A large-scale earthquake such as Tokai earthquakes and the southeast sea earthquakes will be expected to occur in the future. The construction of information environment to make use of conventional earthquake disaster experience and the latest technology in disasters prevention is a matter of great urgency.

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