DEVELOPING EARTHQUAKE DAMAGE DETECTION AND INFORMATION SHARING TOOLS FOR ROAD ADMINISTRATORS

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***ABSTRACT*:** After a large scale earthquake, evaluation of damage of road facilities such as bridge has great importance to assure the emergency route for rescue and transport of urgent supplies. Current damage detection is basically conducted by means of visual inspection, but generally it takes so long time to collect whole damage information in the affected area. This paper shows that an advanced IT technology and traditional technology can be utilized to improve quickness and efficiency of damage detection and information sharing, and introduce some researches and implementations.

KEYWORDS: earthquake, damage detection, information sharing

1. INTRODUCTION

After a large scale earthquake, evaluation of damage of road facilities such as bridge has great importance to assure the emergency route for rescue and transport of urgent supplies. The damage evaluation is basically conducted by means of visual inspection by bridge experts, but generally it takes so long time to collect whole damage information in the affected area.

To improve this situation, there should be several methods of damage detection, such as Seismographs, CCTV cameras, Damage Detection Sensor, and Remote Sensing Technology. The combination of these tools can enable us to detect damage of road facilities to make proper decision.

It is also important to share the information within disaster reacting organizations. The Disaster Information Sharing Platform has been developed to solve various problems of traditional information dealings.

This paper introduces some research and implementations of tools for damage detection and information sharing for road administrators. Advanced IT technology and traditional technology can be utilized to improve quickness and efficiency of damage detection and information sharing.

2. CURRENT STATUS AND PROBLEMS OF DAMAGE DETECTION

Post-earthquake damage assessment for nationally administrated roads are basically conducted by visual inspection tours. Recently helicopters have been deployed to regional development bureaus to grasp overall damage state immediately after an

Table.1 Transition of Damage Understanding State(1995 Kobe EQ)

Elapsed Time from EQ	Immediately after EQ	3 hrs	5 hrs	6 hrs	12 hrs	24 hrs
Damage Understanding for Nationally Administrated Roads	—	△	○	◎	◎	●

— Little Information
△ Fragmentary Information
○ Partial Understanding
◎ Schematic Understanding for more than half damage
● Schematic Understanding for most damage

Fig.1 Heli-Tele System

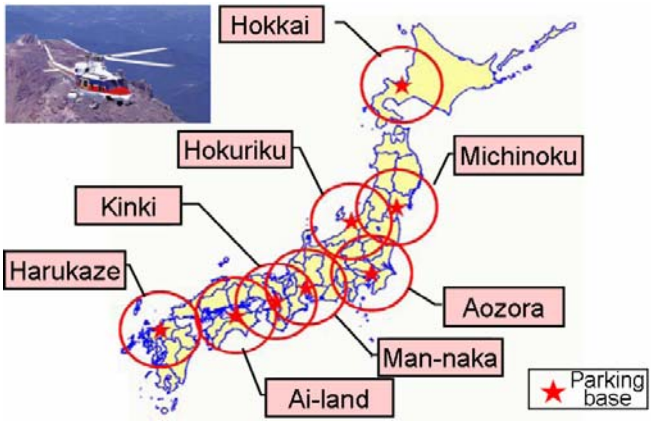

Fig.2 Deployment of Heli-Tele

earthquake. Followings are the current status of damage detection and problems.

2.1 Visual Inspection Tour

When an earthquake occurs, if the intensity of the earthquake is more than the predetermined intensity, the road managers carry out a Visual Inspection Tour, to get information on damage of facilities for decision makers.

However, in many cases there is a delay in the inspection due to disrupted road facilities, traffic congestions and so on. In the case of the Kobe earthquake, it took 6 hours to figure out half of the total damage (**Table.1**).

2.2 Helicopter

HELITELE system (**Fig.1**), helicopter with video transmission system, are deployed to the 8 Regional Development Bureaus to send and receive video through the digital microwave network and the Disaster Prevention Center (**Fig.2**).

Base stations receiving, HELITELE information has deployed 34 mobile receiver units, are covered nationwide.

In North Iwate Earthquake in 2008, the helicopters could not start flights 8 hours after the earthquake occurs, because of being night and the weather was bad. This shows the weakness of the helicopter.

2.3 Importance of Integrated Damage Detection

After an earthquake, information about earthquake damage can be gathered accurately and precisely over time. Various tools for damage detection should be prepared, and after the quake appropriate tools should be chosen or combined to gather information about damage. This is the concept of “Integrated Damage Detection”, which consists of damage detection tools and disaster information sharing system (**Fig.3**).

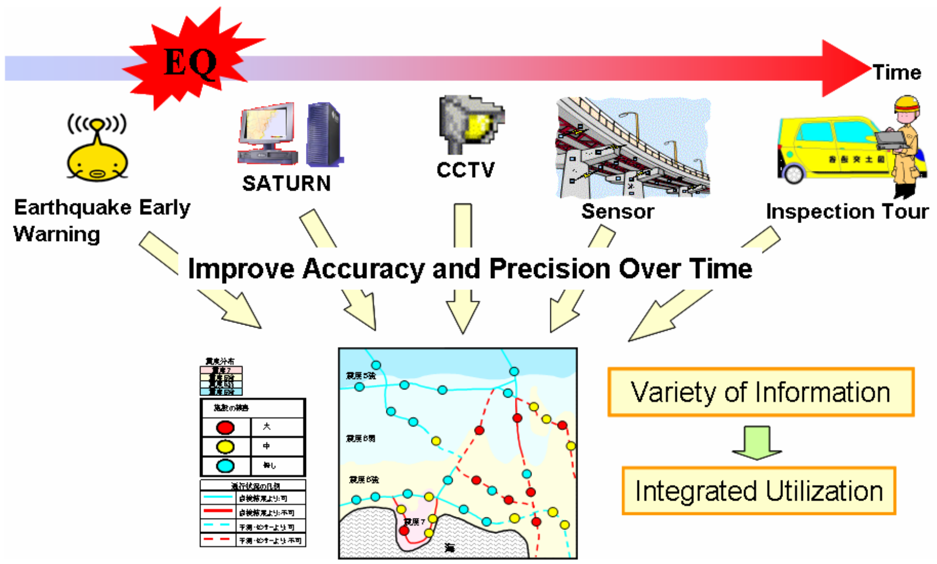

Fig.3 Damage Detection Tools Over Time

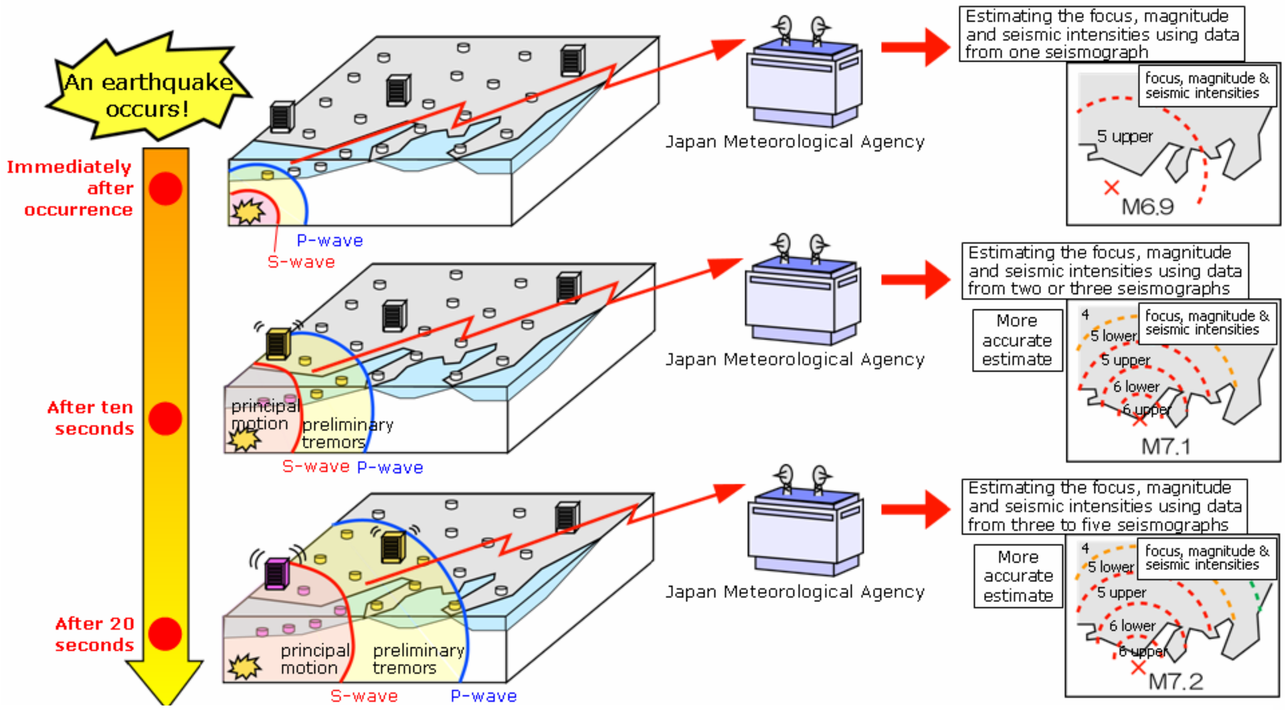

Fig.4 Earthquake Early Warning

3. DAMAGE PREDICTION TOOLS

To grasp the overall damage status immediately after an earthquake, it is important to utilize the prediction information.

3.1 Earthquake Early Warning (JMA)

JMA (Japan Meteorological Agency) has developed and implemented the Earthquake Early Warning system (**Fig.4**). It provides advance announcement of the estimated seismic intensities and expected arrival time of principal motion. These estimations are based on prompt analysis of the focus and magnitude of the earthquake using wave form data observed by seismographs near the epicenter.

The Earthquake Early Warning is aimed at mitigating earthquake-related damage by allowing countermeasures such as promptly slowing down trains, controlling elevators to avoid danger and enabling people to quickly protect themselves in various environments such as factories, offices, houses and near cliffs.

3.2 SATURN

SATURN (Seismic Assessment Tool for Urgent Response and Notification) is a tool which gives

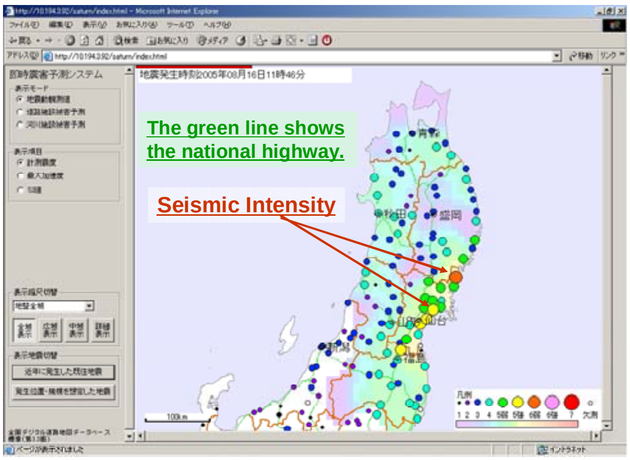

Fig.5 Seismic Intensity by SATURN

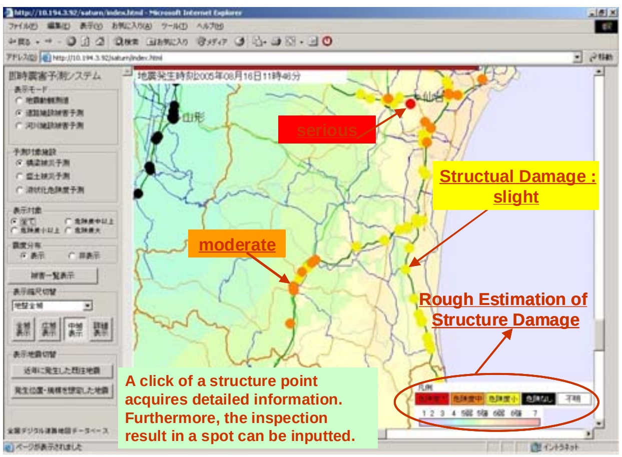

Fig.6 Damage Estimation by SATURN

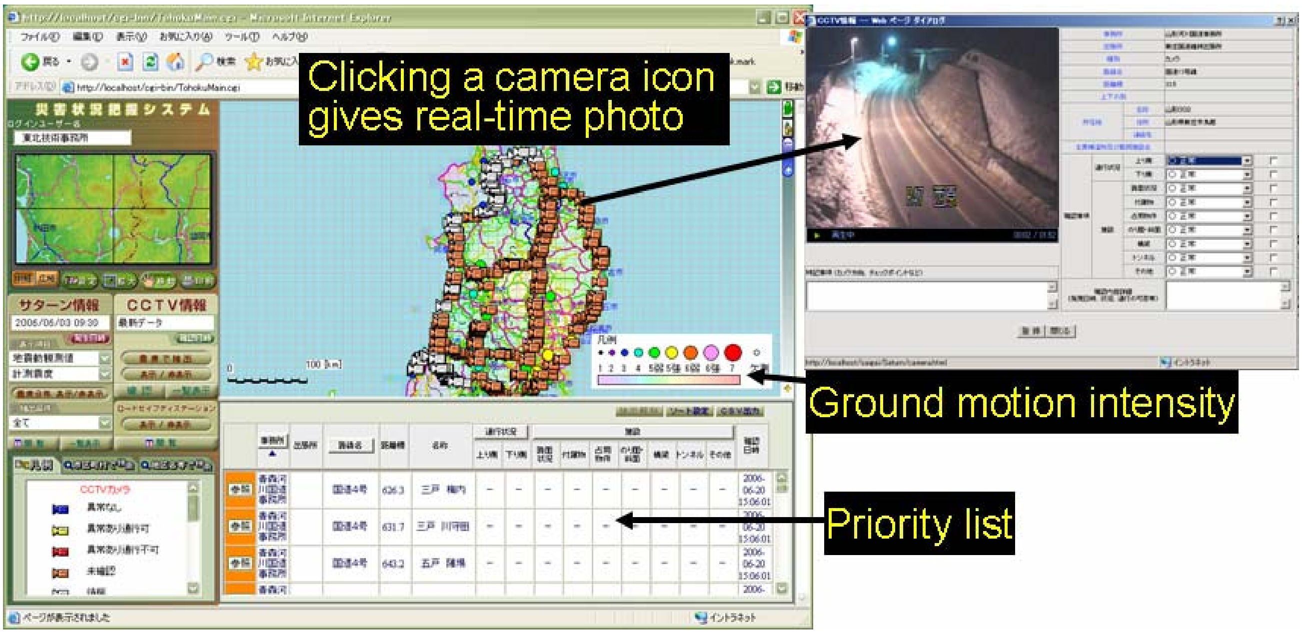

Fig.7 CCTV Damage Detection System

urgent information to the sectors who are in charge of managing public infrastructures and supports their decision making immediately after an earthquake. This system provides rough estimation of damage on public infrastructures in the early stage when the sectors have insufficient information. This system is already being used in some regional development bureaus of MLIT (Ministry of Land Infrastructure and Transport).

SATURN provides ground motion distribution monitored at some 100 sites of each regional development bureau in a short time (**Fig.5**). SATURN also provides rough estimation of liquefaction risk and damage on river embankments as well as highway bridges in about 15 minutes (**Fig.6**). System functions of SATURN are display of the earthquake information and simulation of contingent earthquake.

4. IMMEDIATE DAMAGE DETECTION TOOLS

4.1 CCTV Damage Detection System

In the case of a serious disaster, staffs should check many CCTVs to confirm earthquake damage. There is, however, no method to prioritize the order to check cameras. A system that combines CCTV and Seismographs Network is developed to check cameras in suitable order (**Fig.7**). Road damage states can be visually assessed remotely with Closed Circuit Televisions (CCTV). Shaking map gives priority to road sections to be checked with CCTV.

4.2 Damage Evaluation System based on Natural Period Change

A new damage evaluation system using advanced sensors are developed (**Fig.8**). It can detect the damage level of structures more correctly and quickly just after the earthquake.

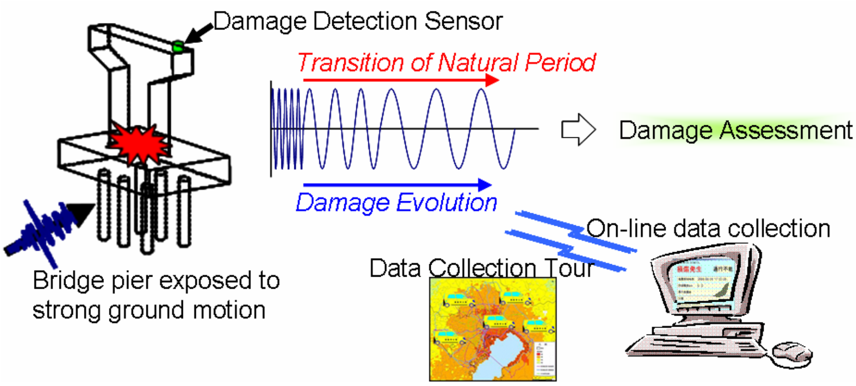

Fig.8 Damage Evaluation based on Natural Period Change

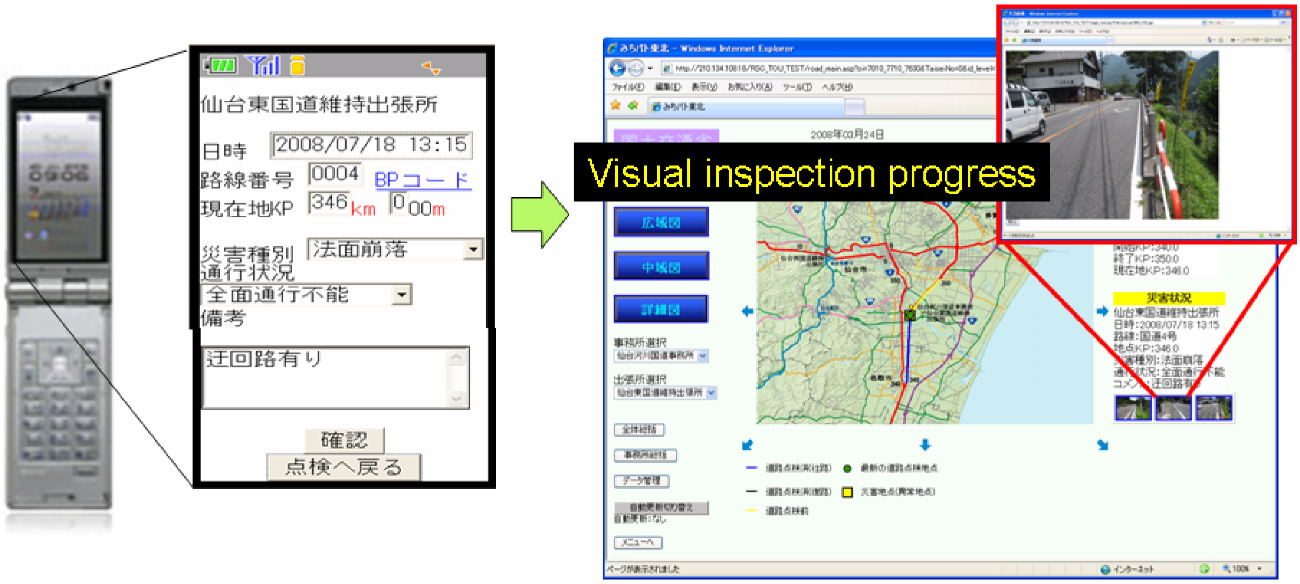

Fig.9 Road Patrol System

When a pier is damaged by the earthquake, the natural period will be longer and vibrate slowly. Advanced sensors can detect the damage of structures by monitoring natural period change.

The relation between the ductility factor and elongation of the natural period is simply obtained and the effectiveness was demonstrated through the shaking table tests for a reinforced concrete column by PWRI.

4.3 Road Patrol System for Post-Earthquake Damage Inspection

Road Patrol System has been developed to monitor the road damage states and inspection progress are shared by using mobile phone (**Fig.9**). Inspection patrollers transmit damage information and photos with mobile phones.

5. REMOTE SENSING TECHNOLOGY

Satellite remote sensing and aerial photography have been used to capture overall status of disaster suffered area (**Fig.10**). However, it is still under development to utilize as a method to detect the

Fig.10 Image of Damage Detection using Remote Sensing Technology

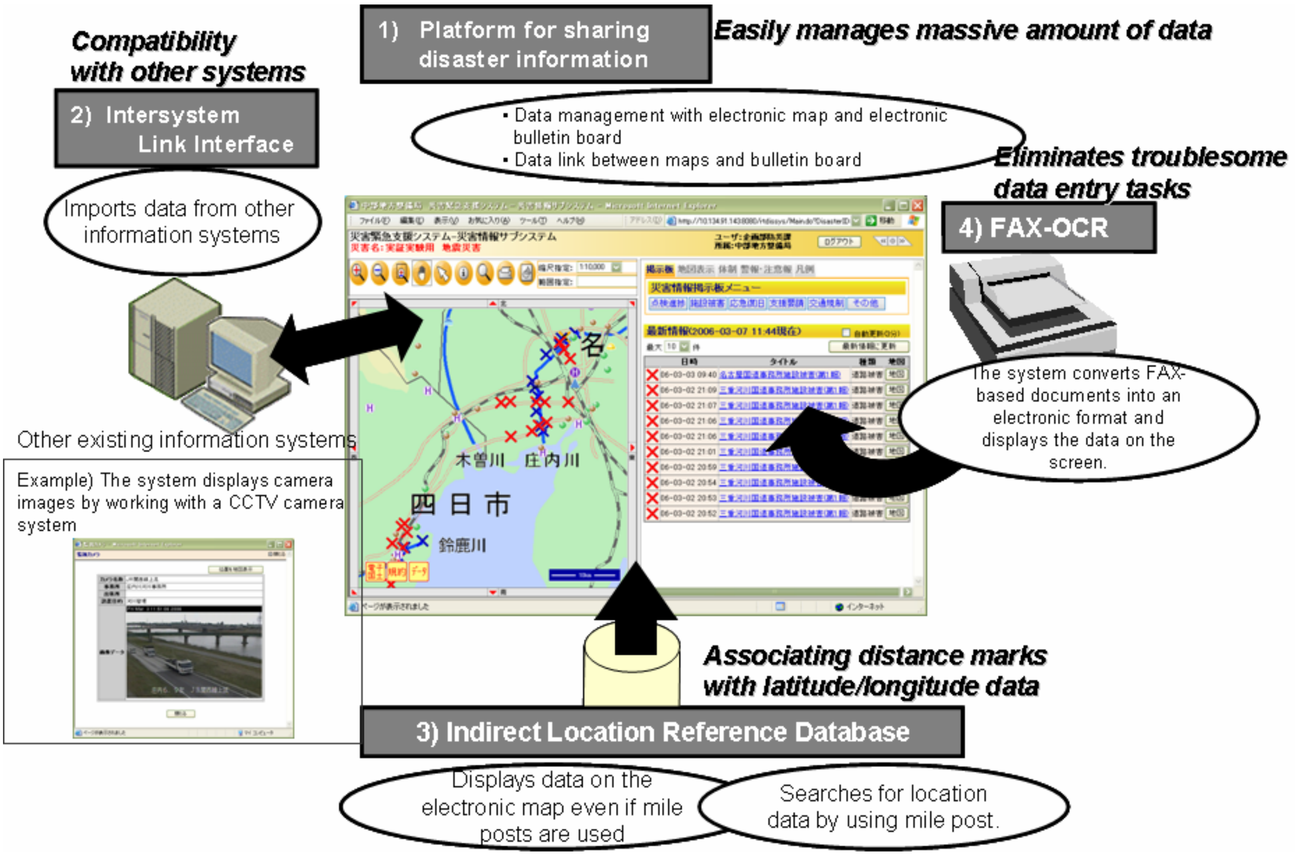

Fig.11 Main Features of Disaster Information Sharing Platform

damage of facilities immediately after the earthquake. The most severe hurdles are, the time to obtain the image after the quake, and the resolution to recognize the damage of road facilities.

6. DISASTER INFORMATION SHARING SYSTEM

It is important to share the information within disaster reacting organizations. Some Disaster Information Systems work less effectively than expected. Therefore, based on a business model analysis, reviews of disaster response activities at recent serious earthquakes and lessons acquired from previous cases that disaster information systems were applied, new information system is developed (**Fig.11**).

7. CONCLUSIONS

In this paper the outline of various damage detection tools which are the elements of the concept of "Integrated Damage Detection", were introduced. The concept is immature and at a starting point. It is necessary to investigate applicability and combination of damage detection tools to realize practical application.

REFERENCES

Nagaya K., Shoji Y. and Sanada A.: Development of a System for Early Detection of Earthquake Damage by CCTV Camera Network, *Civil Engineering Journal*, Vol.50, No.3, 2008

Sanada A., Kusakabe T.: Development of Disaster Information System Based on a Present Business Model Analysis, *Journal of Applied Computing in Civil Engineering*, Vol.15, 2006