Seismic Hazard Warning Service for Asia Pacific Region
- Toward an Established Global Standard -

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Abstract

Development of a prompt information service system is reported. This system monitors the seismic activity in Asia Pacific region and, when a large earthquake occurs, it triggers its analyzing scheme: it collects relevant seismic waveform data across the world, calculates the seismic source process and estimates the strong motion. The system is substantiated on the Web and can deliver the result immediately to a variety of users. The result is updated every time significant new data arrives. The constituents of the system are an analyzer and a database that are well automated and intelligent. The model has been drawing a lot of accesses from all over the world.

Key Words: *intelligent database, real time seismic source analysis, prompt warning, impact assessment*

1 Background and Objective of Research in Stage I

In the HP(homepage) of ERI-EQTAP are summarized our objectives as follows:

①implementation of real time seismic source analyzer,

②design of intelligent dynamic database that supports the analyzer,

③deployment of broadband seismographs and GPS receivers in Chinese continent, and

④development of socio-economical framework to assess the impact of introduction of real time technology into Asian region.

Prompt warning system of large earthquakes supported by an intelligent database has a large potential applicability to seismic hazard mitigation activity in Asia Pacific region, and we have been developing an almost real time information system that releases accurate and detailed information about the seismic source process of occurred large earthquakes. This is a trial of implementation of modern information technology in multilateral collaborative activity for earthquake and tsunami disaster mitigation in APEC region and is fully consistent with the current promotion of the national government of Japan.

2 Methodology

In the construction of the database, we have paid much attention to the serviceability of the system. Our system consists of a daily monitoring that immediately detects large earthquakes and of a prompt analysis system that estimates the spatio-temporal rupture process at the seismogenic fault of the detected earthquake. The daily monitoring system was realized by means of the CMT solution. Currently, *Harvard University* and our Institute are publishing the CMT solution very quickly after each event. The major effort of our team was thus submitted to the improvement of the source process analysis and *Earthquake Information Center* of our Institute had prepared a prototype model of analyzer. We also developed a delivery system on the Web in accordance with the agreement in EQTAP. The structure of our system is shown in Fig.1.

If once accurate information about the source process is available, we can estimate the strong ground motion. The strong motion itself is, however, keenly dependent on the local conditions like sedimentary soft soil or topography and it is open for further discussion whether the strong motion estimation is a good material for the prompt information.

The quality of the system is primarily governed by that of original data. Currently, our activity of

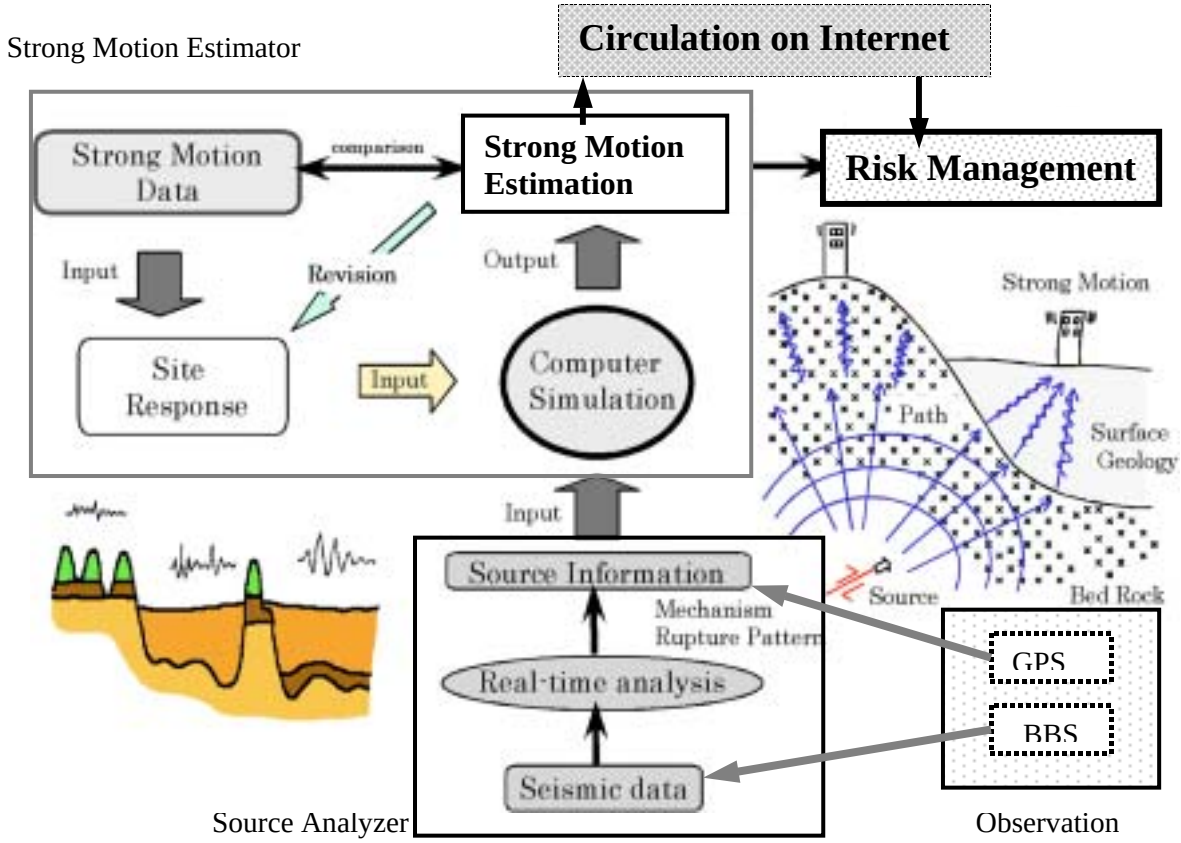

Fig.1 Flow of Analysis

daily monitoring of earthquakes and subsequent source process analysis basically depend on the *IRIS* network of seismographs that has been offered by the USA. More precise estimation of strong motion requires a denser network. But new observation was impossible in EQTAP. As to data acquisition, therefore, we added links with two Japanese seismological data: the nation-wide basic observation network and *Ocean Hemisphere Center* of our Institute. This means that we monitor the Asia Pacific region from the Japan Islands and the Pacific Islands. It is therefore evident that this aperture has one serious limitation; i.e., it does not cover the Asian continent. Recent geoscience has revealed the important contribution to the seismicity of eastern Asia of the continental tectonical movement including the collision of the Indian continent to the Eurasian one. And yet little scientific information is available. This is why we exceptionally conducted the observation in Chinese continent in EQTAP program.

3 Outline of Accomplishment in Phase I

Our goal in Phase I is to make and implement an advanced version of seismic source analyzer and supporting database. We decided to implement the database and the analyzer on our Web site. As to the estimation of strong motion, we commenced to build a new system that determines the strong motion in the near field. Bilateral collaboration of observation of broadband seismographs and GPS was also carried out in China and Mexico.

In Chinese continent, we collaborated with Chinese scientists and engineers and deployed a moderate sized network of broadband seismographs and GPS receivers. Prof. Zheng is reporting in this workshop about some of our achievements. Tight partnership among scientists and engineers of Japan and China will serve establishing a global monitoring system that covers eastern Asia. We also have practiced the collaborative research with Mexican researchers. *UNAM Institute of Geophysics* lead by Prof. Singh has been carrying out an array observation of strong motions in

Guerrero region by the Pacific Ocean and we joined a research on the early warning of tsunamis and strong motion.

USGS of the USA releases its QED after every earthquake of more than M5.5 and this is functioning as a kind of daily monitoring. When the magnitude is not less than 7.5, our HP automatically generates a page, draws broadband waveform data from worldwide *IRIS* network and starts an analysis. Our HP ordinarily shows (1)basic source parameters, (2)mechanism and detailed fault slip derived as a solution of our analysis, (3)historical earthquakes and faults in the source area, (4)tectonic implication of the occurred earthquake, and (5)aftershock distribution and so on. Our HP can add useful information such as asperity map of the earthquake, maps showing relevant tectonical information like underground structures, etc.

Currently, the acquisition of QED takes from one to a few hours. This is too slow for emergency information and this is the center of concern of our system. (New generation of real time circulation of broadband seismograms on the Internet that is under construction will enable more quick release of our information.) In our latest HP, following earthquakes are reported: in 1999, Chi Chi, Taiwan of September 21 (Ms 7.6), Oaxaca, Mexico of September 30 (Mw 7.3), Hector Mine, California, USA of October 16 (Ms 7.3) and Western Turkey of November 12 (Ms 7.3). In 2000, Volcano Island of March 28 (Mw 7.7), Sumatera, Indonesia of June 4 (Ms 7.9), Western Tottori, Japan of October 6 (Mj 7.3) and New Ireland, Papua New Guinea of November 16 (Ms 8.0). In 2001, Off Coast of El Salvador January 13 (Mw 7.6), Western India of January 26 (Ms 7.9), Washington, USA of February 28 (Ms 7.1), Geiyo, Japan of March 24 (Mj 6.4) and Peru of June 4 (Ms 7.9). These detailed and comprehensive information are stored in a form of database and are easy to access and refer to.

More than 30,000 accesses were to the page of Turkey earthquake, 60,000 to ChiChi, 10,000 to Western India from all over the world. We are pursuing to establish the system as more advanced one of the global standards.

4 Research output of Phase I

We show here, for an example, some from the page about New Ireland, Papua New Guinea Earthquake of November 16, 2000. The result of daily monitoring is summarized in the form of CMT map as Fig.2.

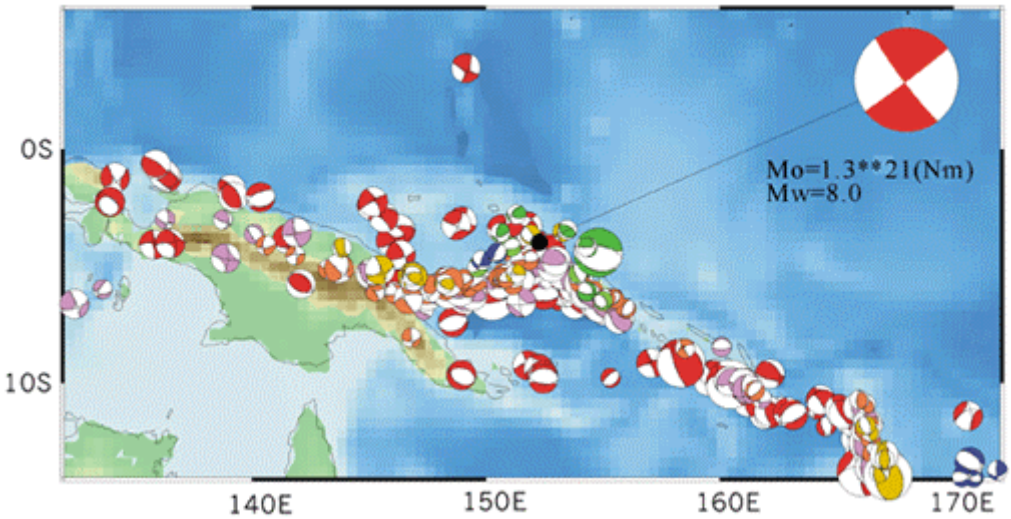

Fig.2 CMT map of New Ireland, Papua New Guinea Earthquake

Inversion was made using teleseismic data provided by *IRIS*. We retrieved teleseismic body wave data via Internet. Data from fourteen stations were used in the waveform inversion. We estimated the reference fault geometry:(strike, dip, rake) = (143, 83, 2) and calculated fundamental parameters as follows: seismic moment Mo = $1.6 \cdot 10^{21}$ Nm (Mw 8.1); source duration T = 70 s;

fault mechanism: (Strike, Dip, Slip)=(145, 84, -5); hypocenter: (latitude= 3.97S, longitude= 152.32E, depth= 35 km) .

The source process is characterized by unilateral rupture propagation as in Fig.3. The maximum slip amounts to 10 m at about 130 km Southeast from the hypocenter. The dynamic rupture process is given in an animation, too, in the HP.

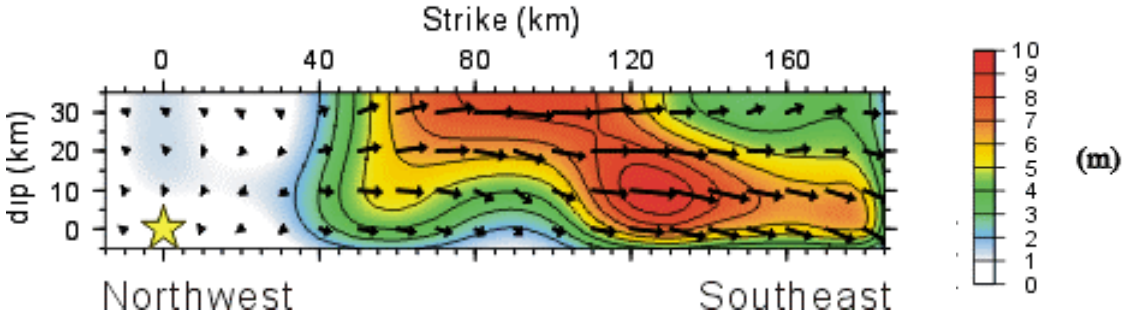

Fig.3 Slip distribution along the seismogenic fault

5 Implication of Introduction of Real Time Information Technology

In order to design the information system, we must consider factors like technical limitations, cost limitations, etc. Especially important is the inquiry into the nature of impact of the introduction of such an advanced technology because modern information technologies are so powerful as to strongly strain the social structure. Above all, adverse effects are to be identified and assessed in advance. The problem of digital divide can bias the balance. This arises a tough question about the eventual destination of benefit or damage.

On the other hand, the application of real time information technology yields great opportunities. Global delivery of our system's early warning about large earthquakes has come true through Internet. Like any political process, disaster mitigation is essentially one adaptive process that is theoretically understandable in terms of control concept. In this context, the most crucial factor of counter emergency measures is the speed, and real time information offers a great opportunity to hedge the negative effects of the disaster. This actualizes the potential capability of community-based activity or other variety of users including NGO's transnational activity, too. This study about the light and shadow of our technology, having initiated on the way of Phase I, is still open for further study. Important thing is that we will face the same question in the study of masterplan.

6 Applicability of PDCA cycle to Asian Disaster Mitigation

The concept of PDCA cycle was adopted in EQTAP. On the other hand, it was difficult to find where to locate our above theme in the PDCA cycle. We therefore addressed a discussion in Manila so as to find our way of approach to implementation.

(1) Three-layered PDCA framework

In Manila workshop, we presented a modification of the PDCA framework that we called a three-layered structure. This idea is shown in Fig.4, in which the original PDCA cycle is sandwiched by a sheet of *databases* and one of *Weltanschauung*. The PDCA cycle does not recognize explicitly the contribution of particular technology or information, while EQTAP itself must do that. This is the meaning of the added databases sheet.

The German word was used as an expression of political issues in a most wide sense that are believed to be prevailing in Asia. Obviously, the political system of many Asian countries does not appear well matured from the western perspective. The society appears often prone to destabilize. It is still true, however, the current poor stability can be suggesting the dynamism or flexibility of the society. Our masterplan thus cannot be silent about what kind of sustainability it is imaging. It must not forget the blame that IMF received from the countries concerned after the recent Asian economic crisis. Apparently, Asian countries are going to define their own sustainable growth.

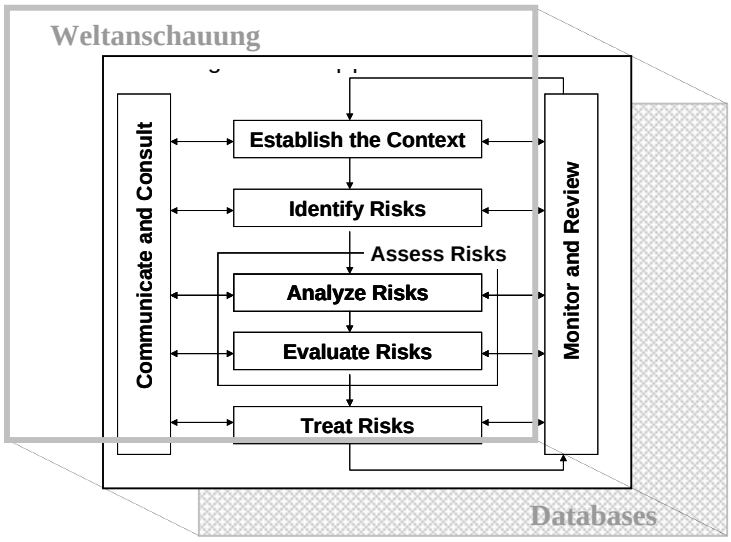

Fig.4 Hypothetical three-layered structure

Only a few months ago, we were liable to assume the globalization to be universal and unavoidable on Earth. But now we are not so naïve, and aware of the intrinsic complexity of the problem that involves living human beings. While the Asian economies would have to accept the main stream of the development of free market system, it is still true that we must invent some way that assures people to defend them from adverse effects of this mechanism. The question is concerning the whole entity of human life including religion, culture or ethics. This issue appears hard to handle by means of the conventional global standard.

According to an international survey, vulnerability of nations to natural disasters has been bipolarizing; it is accelerating in not industrialized countries. This fact is clearly indicating that the vulnerability is strongly dependent on the level of wealth of nations and we may say that some threshold exists about escapability from poverty. Logically speaking, escape from poverty is included in sustainable growth. But it seems necessary to treat this problem explicitly and separately. All the worse, in many poor countries, governmental institution is not mature and liable to instability, while political stability is indispensable for the economy to grow.

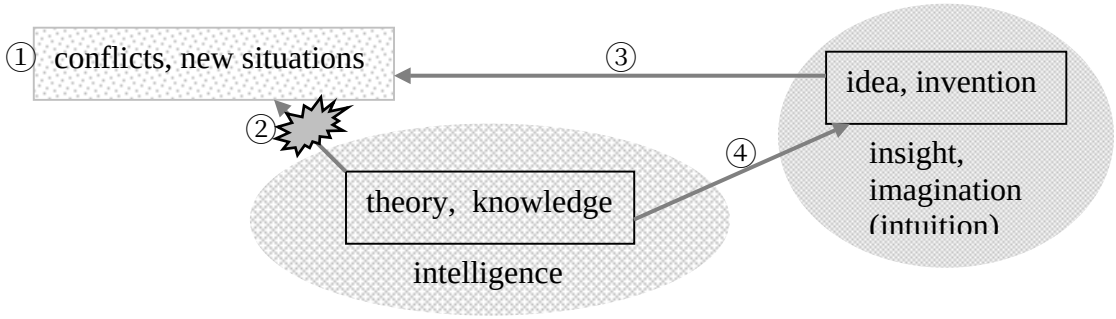

Fig.5 Theory and Practice

We also added some comments about the nature of the masterplan. Although its feature is not yet completely clear, one thing is clear that the masterplan has to well serve practitioners. We used Fig.5 for this discussion saying:

① When some new undesirable situations or conflicts occur,

② we may try to apply some theory or knowledge, but it is doomed to fail. This is because the real situation consists of countless factors that any preformed theory can never cover.
③Truly reliable is creation of ideas or any kind of invention that the persons concerned creates. This ability belongs to the world of insight and imagination, which is deeply rooted to intuition.
④Consequently, the masterplan, being inevitably a system of knowledge, must be so designed as to encourage and help mobilize intuition.

We also mentioned about the necessity of considering from the very beginning of research multi-lateral pre- and post-disaster cooperation.

(2) Towards Establishment of the Context

1) A new trend of engineering research in Japan

In recent Japan, "overlooking" engineering has got growing academic concern. For example, the national plan of atomic power plants has seriously delayed. This is because of the public distrust about the safety of the conventional system and traditional approach of engineering appears no more valid. Overlooking sounds to imply the whole coverage of relevant knowledge, and a consensus appears emerging among people that the protection of public safety requires overlooking wisdom; "intelligence overstepping the border" is also commonly emphasized.

Coincidently, in Tokyo University, a new trans-disciplinary program called a "socio-technology" was set up and, as its first project, multi-disciplinary collaborative research about the safety of the society started. It is noteworthy here that the essence of overlooking is just the same as the establishment of the context in our PDCA cycle or, according to Prof. Kameda, the implementation technology of EQTAP. It is really interesting that substantially same ideas appear simultaneously at different places.

Currently in Japan, decentralization of public administration is in progress. Local governments have been set free from being an enforced and completely controlled agent of the national government. Many competences like urban planning have been transferred. Consequently, the local governments will be much more responsible to the safety of inhabitants, *e.g.*, against seismic hazard. At the same time, Japan has driven forward the disclosure policy of administrative information. A famous professor of public administrative law called it "a genuine revolution since 130 years ago". This system has already introduced remarkable transparency into local administrations. It is also stimulating the NGO activity. After all, extensive decentralization and re-centralization will greatly change our society's style of civil defense.

2) Stakeholders

Identification of stakeholders and their involvement has been emphasized in the TF documents. Consensus about safety is crucial but involvement of all stakeholders does not assure the solution. For example, among many necessary conditions, the crucial point of emergency management is the existence of leadership; no masterplan without fostering program of leaders will succeed. Leadership must be institutionalized. Apart from the dictator of ancient Rome, our leaders must prepare in peacetime; they must identify and clarify the threat, propose countermeasures and get popular support. Leadership must thus contain continuing efforts to establish the context. For this purpose, however, motivation of the potential leaders is of primary importance.

3) One Asian Representative Model

The EQTAP case study of Metro Manila is exhibiting an interesting progress. The well-known scenario inventory approach of risk identification consisting of seismic source identification, strong motion estimation, emergent short-term operations and study of existing scenarios appears successful and promising. Another implication of this case study is that the combination of two conditions, soft ground layer and near active faults, is universal for major Asian mega cities: Beijing, Hanoi, Manila, Osaka, etc. It is therefore desirable to initiate a comparative study of this category in a collaborative manner.