Management of Geological Information in Taiwan

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1. Introduction

Natural hazards received much attention in recent years as Taiwan experienced a devastating earthquake in the year of 1999 and the worst-ever flood in Taipei City in the year of 2001. Furthermore, the growth in population forces urban developments to expand to slopelands which are frequently threatened by natural hazards, such as landslides and debris flows. If facts, landslides and debris flows have destroyed many hillside communities and taken many lives in recent years.

It is now the government's intention, as part of national hazard mitigation program, to establish geographic information systems to collect and to manage information related to natural hazards and to compile information loosely kept in the hands of various governmental agencies. As can be noted from Table 1 which lists the major agencies in charge of geological and geotechnical information. Efforts are now being made to enhance geological maps, geological hazard maps and fault maps for the entire island. As the authoritative agency on geology, the Central Geological Survey of Ministry of Economic Affairs is responsible for compiling information on geology and mapping of potential geological hazards, including debris flows, landslides, abandoned mines, erosion of river banks, etc. This work is to

Table 1 GIS Systems for Geological and Geotechnical Information Available in Taiwan

Agency	Contents	Area Covered	Precision	Availability
Central Geological Survey, Ministry of Economic Affairs	Geological Map	Entire Island	1/500,000	By Application
			1/50,000	By Application (on-going)
	Geological Hazard Map	Slopeland on the Entire island	1/5,000	Starting, to be available on Internet
	Fault Map	Entire Island	1/500,000	By Application
			1/5,000 ~ 1/1,000	By Application (on-going)
	Rock Formations and Engineering Properties	Entire Island	1/5,000	Starting., to be available on Internet
Construction and Planning Administration, Ministry of Interior	Geological Hazard Map	Slopeland on the Entire island	1/25,000	Free Download
Information Center, Ministry of Economic Affairs	Borehole Data	Entire island	Coordinates only, not GIS	By Application
Bureau of Mines, Ministry of Economic Affairs	Locations of Mines	Entire Island	1/5,000	By Application
Taipei City Government	Geological Hazard Map	Slopeland in Taipei City	1/25,000	Free Download
			1/5,000	To be completed and available on Internet soon
Taipei County Government	Geological Hazard Map	Slopeland in Taipei County	1/5,000	By Application

be completed in five phases and each phase will take about 1 year to complete. In addition, the Central Geological Survey has conducted extensive studies in the past on geological features which have practical applications, such as groundwater, geothermal and hot spring, volcanoes (all are inactive), mines, etc. However, data are rather piecemeal and are loosely kept as reports and maps. With the rapid advancement in the computer technology, it is now time to digitize all these data and compile them into a unified computer system. All the data collected will be managed by web-GIS systems and application modules will be developed to enable users to retrieve and use these data with ease. Users all over the world will be able to get the access to these data at their finger tips.

2. Management of Geo-Information

Borehole data are jointly managed by the Information Center of Ministry of Economic Affairs and the Central Geological Survey and a centralized databank has been established. Although the law requiring borehole data to be uploaded to the database is still to be passed, some of the governmental agencies in charge of construction projects have already stipulated such requirement in contracts with designers and contractors. There exists data from tens of thousands boreholes, mostly from major public construction projects and mainly in Taipei and Kaohsiung. Authorized users can download information from the databank or upload their own information into the databank. However, there is a lack of consistency in the quality of borehole data and some of information could be misleading. It is anticipated that the passing of the Geology Law, which requires borehole data to be certified by qualified professionals, will eventually lead to the improvement of quality of the data and establishment of the credibility of the databank. However, it may be a long way to go before this law is legislated.

Other than the Central Geological Survey, there are many government bodies and institutes involving in the management of geological information. For example, the Taiwan Power Company and Chinese Petroleum Corporation are the two institutes with most geological information. Unfortunately, their information has not been systematically documented nor is it available to general public. The Water and Soil Conservation Bureau of Council of Agriculture also has a good collection of geological information on slopelands. However, their information is limited to areas with frequent slides and/or debris flows. Many universities have established research institutes for hazard prevention and mitigation and these institutes have been engaged by various government agencies to conduct research studies. Again, the data collected by these institutes are piecemeal and scattered.

3. GIS for Geo-Information

As mentioned above, the Central Geological Survey is undertaking the task of compiling geological data and mapping of potential geological hazards and the work is to be completed in 5 phases. Figure 1 shows the areas to be mapped and it can be noted that the areas covered account for about one-third of the island. The natural geological and geographic features considered include: falling rocks, land slides, unstable slopes, natural cavities, mines, erosion, dumping sites, and large excavations. The work starts with the establishment of digital terrain maps (DTM) with a scale of 1/5,000 using aerial photos. Color satellite images and aerial photos are then studied to identify geological features which are related to geological hazards. These geological features are marked on the digital terrain maps and are then confirmed by field reconnaissance.

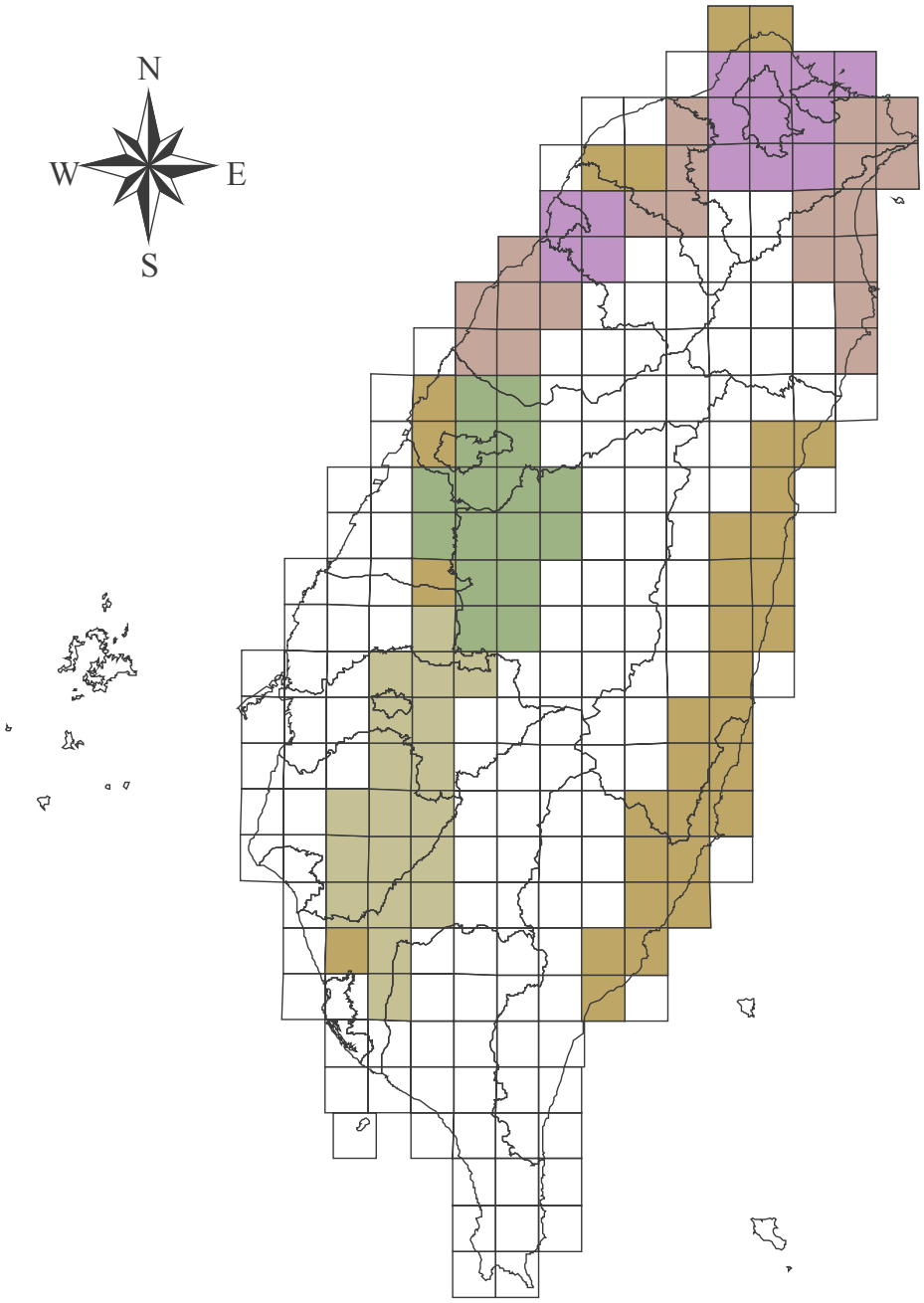

Fig. 1 Area covered in the study for potential natural hazards

Field staff are equipped with GPS for positioning and tracking and PDA for recording observations made at sites. This enables large areas to be covered efficiently and speedily. Different types of information are stored in individual layers in the GIS system to facilitate interpretation and statistical analyses for quantifying the potential of hazards.

Some of the potential hazards can readily be identified from aerial photos but not all. One of the reasons is that most of slopelands are covered by vegetation. Most of the areas marked as potential hazardous were determined by analyzing geographic features of which slope is a dominant factor. However, although slope is a convenient and useful index, but steep slope does not always mean high potential of risk. Therefore, the results require further

refinement. Parallel to this program is another program, also undertaken by the Central Geological Survey, to determine the characteristics of mother rocks. The results of this program can be studied together with the results obtained in the former program so the potential of hazards can be better defined.

4. Applications of Geo-Information

Realizing the importance of information technology, the central government launched an ambitious drive in 1985 to digitize all sorts of information and compile the results by using MIS and/or GIS systems. The task is undertaken by the Information Center of Ministry of Interior and a national GIS (NGIS) Program was set up with the aim of facilitating information sharing among various governmental bodies. Geological information is one of the subdivisions in the Natural Environmental Division of the NGIS Program. It can be used together with information provided by other divisions, such as Resource and Ecology, Transportation, Urban Planning, etc. for engineering applications. For example, the Public Construction Commission is now conducting a research program on establishing a platform for various parties to use the information available in the NGIS Program on planning and design of infrastructure for the purpose of mitigating potential natural hazards and not only geological and geographic data are included but also information on typhoon, transportation network, social and economy, and ecology, etc. Constructions of infrastructures account for a giant share in government's annual spending and proper planning of infrastructures definitely will result in substantial cost savings. Furthermore, natural hazards frequently caused severe damages and loss of lives to infrastructures and it is thus very important in the planning stage of infrastructures to pay sufficient attentions to natural hazards so losses can be minimized.

Other than applications on constructions, geo-information is the basic information for many national hazard mitigation programs. For example, Haz-Taiwan is a program for mitigation of earthquake hazards and requires extensive geological information. Debris flow is a constant threat in typhoon seasons and took a few lives each year. With the geological hazard maps, preventive and contingency measures can be worked out against debris flows. Taipei City Government and Taipei County Government have also established their own GIS systems on natural hazards and are using these systems for mitigating potential hazards on the old developments and regulating new developments to be constructed on slopelands. These systems are also used as a major tool dealing with emergency situations in typhoon seasons.

5. Future Developments

Basically, all the information will be managed by using web-GIS systems. However, various types of GIS systems are being used by the agencies in charge of information and it is not proper, in fact it is impossible, to adopt a single GIS system for all the purposes. Fortunately, with modern GIS software, there are no problems in converting the data from one system to another. As mentioned above, the Public Construction Commission is establishing a platform for users to obtain information from all sources via internet with ease. However, this one-way communication does not take the full advantages of internet. Ideally, users shall also be able to contribute to the growth of databank by feeding the databank with their own information such as borehole data, terrain, locations of permanent structures, etc. This requires legislation to demand users to do so upon the completion of projects. With the consensus, it will not be too long for this to occur. However, it will not be an easy job to

compile information from different sources and with different degrees of reliability. Studies are being conducted to see if an organization can be established, either wholly or partly sponsored by government or supported by its own revenue, to manage all types of information.

6. Conclusions

The rapid development in computer technology has caused the second industrial revolution and engineers are now facing new challenges. While the market for construction industry in developed countries is shrinking, e-business offers engineers a new horizon. With information technology, engineering is no longer the same as before and so is geotechnique. While the work is continuing and will continue for a long time to come, management of geo-information has gained much headway in Taiwan and many web-GIS databases have been established. The information collected can be readily used for mitigation of natural hazards and policy-making regarding the use of slopelands.