DEVELOPMENT AND USE OF DIGITAL DATA TECHNOLOGY IN SABO

Shigeo HORIUCHI [1],

ABSTRACT

The Sediment-related Disaster Prevention Law, which was promulgated in 2001, has initiated the widespread adoption of non-structural measures, including the survey and designation of sediment-related disaster hazard areas. It has also given impetus to the electronification of data in the erosion control field. Both the central and prefectural governments have started to electronify erosion control information; mainly geographic information, and accumulate it for use in disaster prevention.

The Sabo Frontier Foundation has been involved in preparing procedures and guidelines concerning the electronification and utilization of geographic information in the erosion control field.

This report presents an outline and the features of electronic erosion control information produced in Japan, as well as the systems, records, and future perspectives associated with this information.

I FEATURES AND THE PRESENT STATUS OF ACQUIRED AND ACCUMULATED ELECTRONIC EROSION CONTROL INFORMATION

1. Production of digital maps used for surveys of sediment-related disaster hazard areas

The Sabo Frontier Foundation has prepared guidelines for the production of digital maps and a survey manual for use in surveys related to the Sediment-related Disaster Prevention Law. The guidelines are entitled “Production Guidelines on Digital Maps Used for Surveys Related to the Sediment-related Disaster Prevention Law (Draft)”.

According to the guidelines for digital maps (hereinafter “erosion control base maps”), the cartographer is required to produce digital maps with a precision of 1/2500 by taking and reading aerial photographs, in principle, without using existing maps. To achieve a high level of accuracy fit for the intended use, a variety of technical devices were introduced. Some of them are shown below.

1-1 Representation of water areas (rivers, irrigation channels, etc.)

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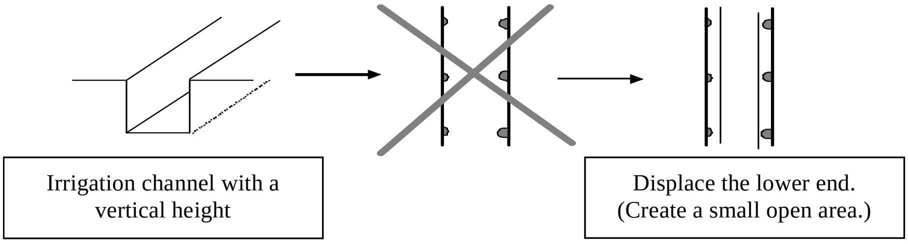
1 Director, Sabo Data Management Center (Sabo D-MaC), Sabo Frontier Research Institute,Sabo Frontier Foundation, Sabo-kaikan, Hirakawa-cho 2-7-4, Chiyoda-ku, Tokyo 102-0093 (Corresponding Author; Tel.: +81-3-; Fax: +81-3; s-h_center@sff.or.jp)

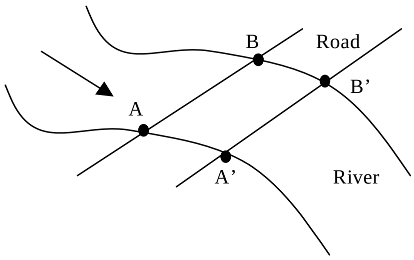
(1) The height of a concave water area, such as an irrigation channel, is the distance between the upper and lower ends of the channel. But, as the terrain model cannot represent a vertical height, the lower end of the channel, which is treated as a terrain model element, is displaced toward the inner side of the channel (with a small open area created). This allows editing with no inconsistency as a terrain model that can represent an approximated concave cross-section.

Fig.1



(2) When 2D and 3D data are used in combination, such as at the intersection of a river and a road (bridge), use A-A’ and B-B’ for the river and delete A-B, A’-B’ for the road in the 3D terrain model. In the case of 2D data, use A-B and A’-B’ for the road and use a hidden line for A-A’ and B-B’ for the river.

Fig.2 Road-river intersection



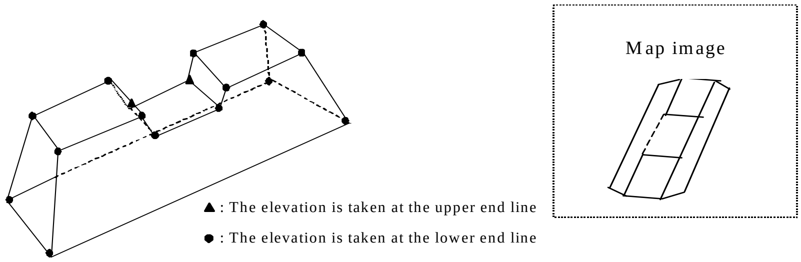
1-2 Representation of water area structures (Bank covers, erosion control dams, waterfalls, weirs, etc.)

(1) A terrain model is not capable of representing the vertical cover of a channel bank. Therefore, if the difference in elevation is more than 1.0 m, displace the planar position of the upper end or the lower end, which is treated as a terrain model element (create a small open area), and edit it as a terrain model that can represent an approximated vertical cross-section.

(2) Obtain the elevation at the data acquisition line of water-area structures.

(3) If the photograph is unclear, conduct a field survey or obtain information from other sources, such as facility location maps or design drawings.

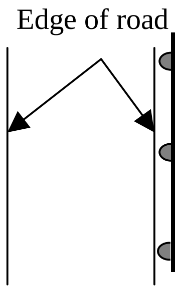
Fig.3 Erosion control dam (including the natural ground)



1-3 Representation of enclosures, etc. (engineered slopes, earth banks, covers)

(1) If contour lines indent into the slope and create unnecessary concaves and convexes on the slope when creating a terrain model using the height information of both the slope and a structure, produce an appropriate terrain model for the slope by selecting the appropriate contour lines as terrain model elements.

(2) Cover: Acquire the data of the cover if its projection is more than 1.0 m. The data of both the upper and lower lines should be acquired by creating a small open area.



The 3D terrain model requires the data of both the upper and lower lines. If the lower line overlaps with a road or a river, apply 1. (2) and delete the data of the lower end of the cover from the data of the digital terrain model.

(3) Circle and dot symbols inside the cover: Circle and dot symbols inside the cover are not used in the digital terrain model. The data should be 2D data.

1-4 Acquisition of contour lines

(1) Do not use a method that automatically creates contour lines using the elevations obtained by automatic elevation extraction during orthoimagery production.

(2) To ensure a faithful reproduction of topographic features, Mapping attributes should be acquired with special care at positions of topographic change on the ridge, valley, etc.

(3) Acquire contour lines carefully in view of the purpose of the work so that the shape of a ridge and a valley as well as the concaves and convexes of a slope and inflections in longitudinal profile of a slope can be identified from contour lines.

1-5 Representation of reference points

(1) If unnecessary concaves and convexes are created on a road surface or flat farmland when a terrain model is created using single points in the road or farmland, select appropriate individual points from the multiple points created and produce an adequate terrain model of the road or farmland.

1-6 Acquisition of break lines

(1) To ensure relative consistency, acquire break lines when it is appropriate to interpolate the heights at positions of topographic change or the height between elements (between features).

(2) Acquire break lines indicating the inflection of a slope (due to original topography or due to artificial structures), ridge, and valley that are not represented by contour lines. Also, acquire break lines that represent micro-topographies (paddy fields, dikes, flooded terraces).

(3) Insertion of break lines
If a feature that is represented by a single line in the 1/2500 digital map has an difference in elevation of more than 1 m, it is desirable to add a break line.

Example：

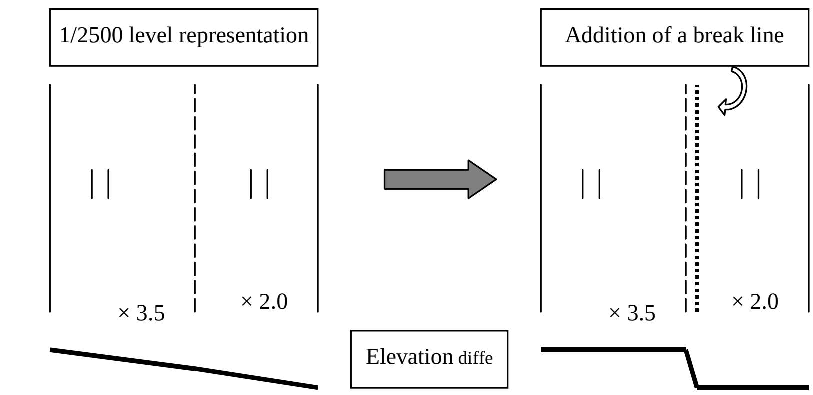


Fig.4 Image of a 3D model (topographic representation using a T.I.N. model)

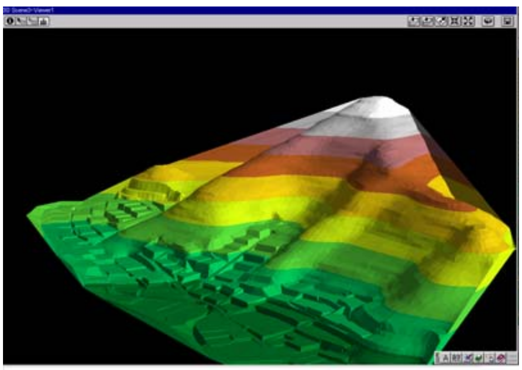


Fig.5 Image of the longitudinal section of a terrain model

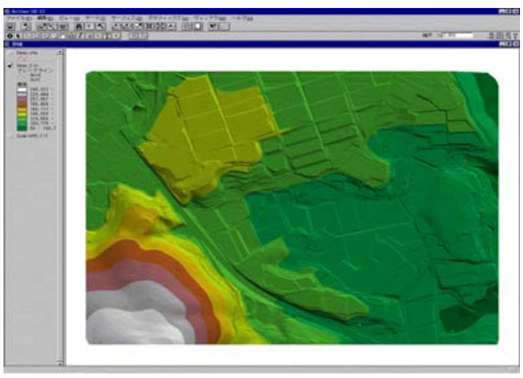
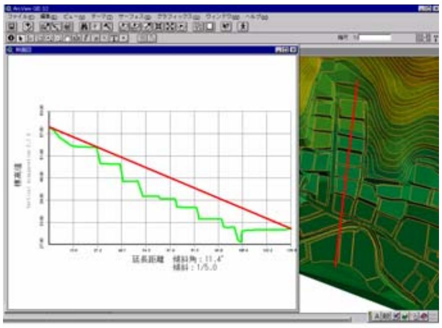
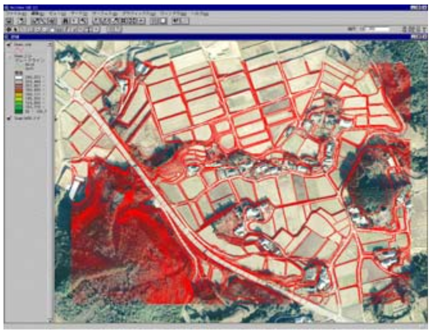


Fig.6 Superimposing an orthoimage and contour lines


標高値
延長距離　傾斜角：11.4°
傾斜：1/5.0



2. Development of a system that supports identification of disaster hazard areas

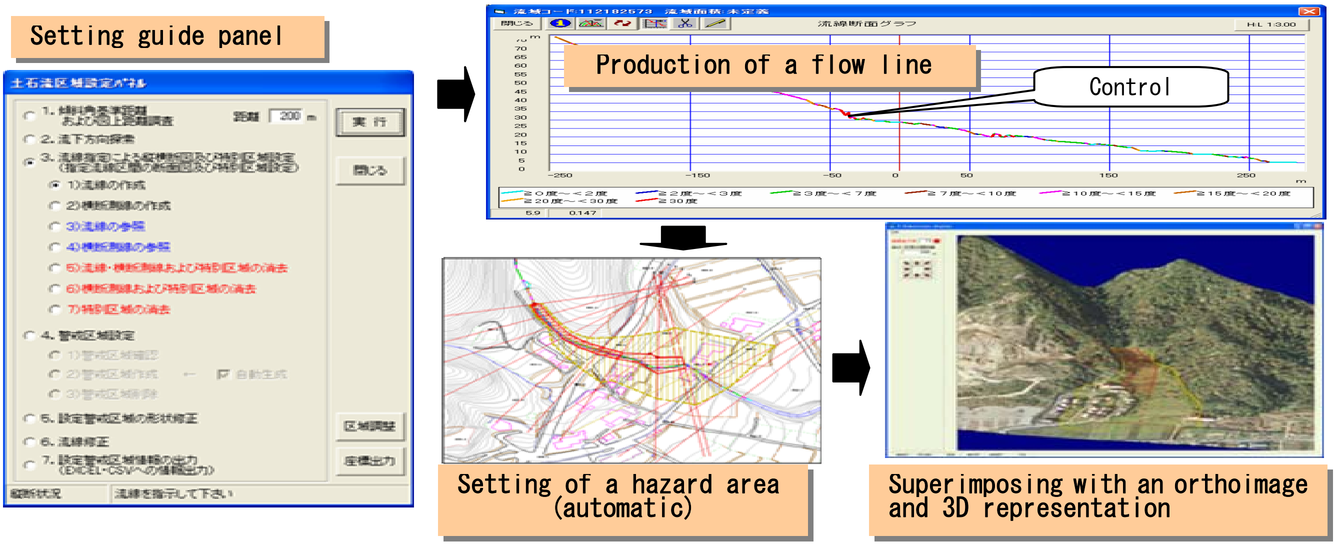
The Sabo Frontier Foundation has developed a computer program that supports the identification of hazard areas for each phenomenon, namely, debris flows, slope failures and landslides. The program can automatically depict a sediment-related disaster-prone area on the computer utilizing the erosion control base map.

The system is used before setting out on a field survey to designate a hazard area.

This system can identify a disaster-prone area automatically based on the topographic conditions represented by a 3D terrain model and parameters such as the sediment volume.

The identified disaster-prone area is then corrected based on the results of the field survey, and established as a sediment-related disaster hazard area.

Currently, this system is used as a standard in most parts of the country.



3. Integrated management system of the entire erosion control base map data produced in Japan

Electronic erosion control data, such as erosion control base maps, are being accumulated in many prefectures in Japan. These prefectures then requested the Foundation to store backups of their data to create a central repository for the valuable data that had been accumulated. In response, the Foundation established a free system to store the backup data by exchanging a memorandum with the prefectural governments. The Foundation currently retains backup data for about 30 of the 47 prefectures of Japan.

4-1. Data management system at prefectural governments

As the production of erosion control base maps and field surveys using them continue, the number of areas designated as sediment-disaster hazard area is increasing. As of October 2009, about 100,000 areas are designated throughout Japan. Most of the data related to these areas is sophisticated GIS data and the volume is growing each year.

Therefore, the erosion control department in each prefecture needs a system that can manage the data easily.
In response to this need, the Foundation developed its sediment-related disaster hazard area management system, for which it was granted a patent in 2009 (Patent No.: 4286900). The system can integrate the management of sediment-related disaster hazard areas, sediment-related disaster-prone locations, erosion control base maps, and ortho-photographs (aerial photograph images), and display superimposed images of the data, all based on GIS technology.

Using this system, the erosion control department of each prefecture is now able to manage erosion control data and other operations with greater efficiency, including the progress management of basic surveys, the identification of sediment-related disaster-prone areas, and the preparation of hazard maps effective for warning and evacuating local people.

The primary functions of this system are as follows:

Progress Management of Basic Surveys
The progress of basic surveys and the designation of hazard areas (not surveyed → being surveyed → designated) are indicated in different colors using the data of conventional sediment-related disaster-prone areas. This is useful in managing the operations systematically.

Management of Sediment-related Disaster Hazard Areas
The information in area reports produced from basic surveys is managed as a database that can be searched according to various criteria. It is possible to browse area reports and public documents and display the map of a given area utilizing this search function.

Management of Erosion Control Designated Areas
The basic information on erosion control designated areas contained in registries is managed as a database. It is possible to browse the registries and display maps using a search function with specified criteria.

Management of Hazard Maps for Sediment-related Disaster Prevention
Hazard maps for sediment-related disaster prevention are easily produced if an area is specified on the map screen. This is useful in making information available to local cities and towns efficiently.

This system has already been introduced in over ten prefectures around Japan, enabling the prefectures to receive web information from the web server of the Foundation.

4-2. Data management system at the local erosion control offices of the Ministry

In recent years, local erosion control offices of the Ministry of Land, Infrastructure, Transport and Tourism (M.L.I.T,) are taking a more active role than the erosion control department of each prefecture in promoting the electronification of erosion control information.

The Sabo Frontier Foundation has developed an Intranet-based integrated erosion control information management system that combines the accumulated systems expertise and the most advanced GIS technology. Each official at the local erosion control office can now browse and utilize the accumulated electronic erosion control information at his or her desk.

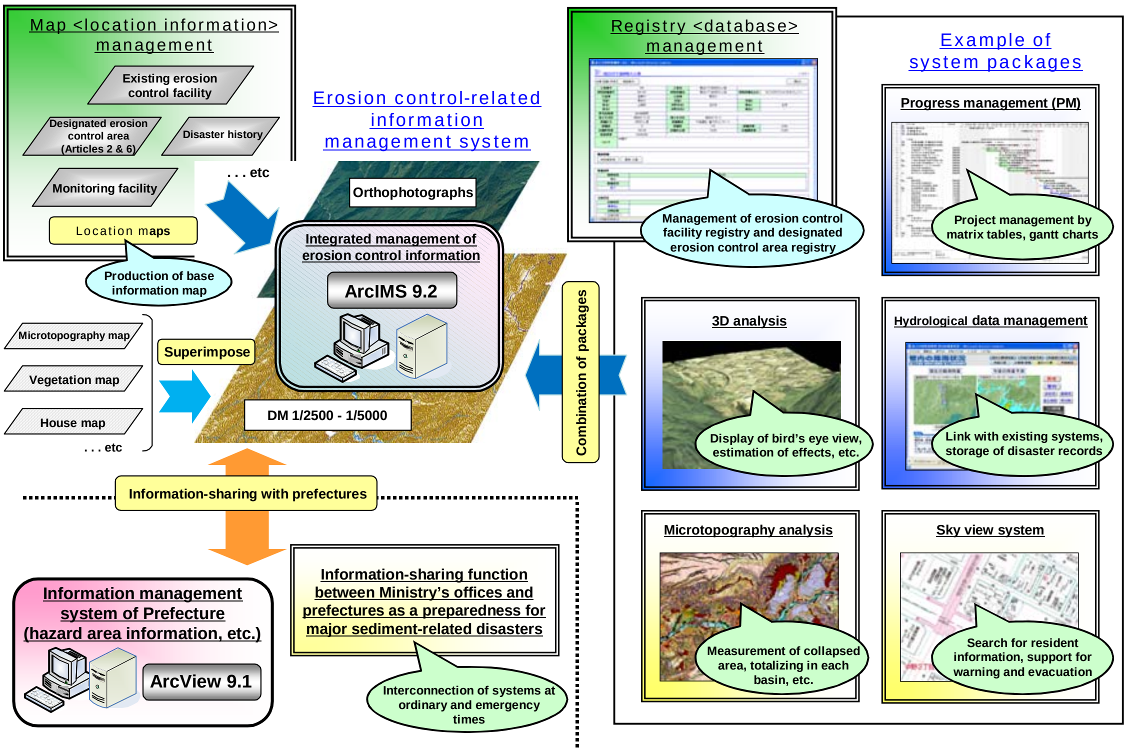
Ordinary data management systems are often constructed by combining the location data on an electronic map with a database containing attributes, such as names and land areas. Actually, however, many other electronic files exist which contain documents, photographs, CAD drawings, etc. If all of these information sources are put into the database, the system configuration and means of updating the data become very complicated. The new system resolves this difficulty by using a configuration that compiles location and attribute information into the database and links it with the folders containing electronic files.

In this way, the system provides a database function for locations and other attributes and an integrated function for managing erosion control information.

Local erosion control offices require various system functions depending on their history, background, and level of data accumulation. To meet these requirements, the system is designed to be scalable. In its basic configuration, it has an integrated function for managing maps, the database and folders. In addition, the following three systems can be added as options: (1) Management system for various observation data (2) Progress management system for projects (3) 3D data analysis system (4) System for linking with prefectural information management systems.

Using the basic system (patent pending) as the base configuration, it is possible to incorporate the above system modules, which were developed by multiple consulting engineering firms. In this way, the system can be configured to meet the needs and level of data accumulation of each office. This system has been adopted and put into operation at a number of local M.L.I.T, erosion control offices since fiscal 2008.

Outline of "D-Mac System" for the local erosion control of the Ministry



5. Preparation of product specifications for an erosion control base map and preparation of specifications for the acquired laser measurement data in the erosion control field

The revision of the Survey Act in April 2008 has made it mandatory to prepare product specifications when performing a public survey, thereby standardizing geographic information throughout the country.

Through a supplementary budget in fiscal 2008, the local M.L.I.T, erosion control offices have started to acquire laser profiler data that is useful for surveys in time of disasters, mainly in the areas under their management.

The Foundation has prepared draft product specifications based on Japan Profile for Geographic Information Standards through consultation with the Geographical Survey Institute and the Sabo (Erosion and Sediment Control) Department of the Ministry of Land, Infrastructure, Transport and Tourism (M.L.I.T,), thereby contributing to the standardizing of electronic data standards and specifications.

II EXAMPLES OF THE USE OF ELECTRONIC EROSION CONTROL INFORMATION DURING MAJOR DISASTERS AND RELATED PROBLEMS

When major natural disasters, such as earthquakes, typhoons or torrential rain occur, various experts from the central government and academic societies as well as volunteers gather at the disaster site to initiate response activities. However, it is difficult to share a wide range of information because the erosion control department responsible is caught up in the confusion of the emergency.

The efforts during the Mid-Niigata Prefecture Earthquake in October 2004 led the Sabo Frontier Foundation to develope a system that has a function to provide on-site information via the Internet. It allows field survey teams to browse, write and download related information through the GIS server that the Foundation manages and operates 24 hours a day, 365 days a year, to enable the relevant parties to obtain and utilize the accumulated electronic erosion control information quickly in the event of a major disaster.

This website is not operated constantly due to constraints, such as data volume, but it was put into operation as an emergency site during the following disasters and it provided information useful for field surveys to various organizations.

July 2 - 12, 2007	Sediment-related disaster due to heavy rain in Kagoshima Prefecture
June 12, 2008	Sediment-related disaster in Kokonoe Town, Kusu-gun, Oita Prefecture
June 14, 2008	Sediment-related disaster due to the Iwate-Miyagi Inland Earthquake

The backup data from to the prefectures and the local M.L.I.T, erosion control offices that the Foundation stores is a database of location information. Users can conduct a search by linking the data with other electronic information. The emergency portal site of the Foundation, which becomes operational in the event of major disasters, is virtually the only service in Japan that provides an emergency information service on sediment-related disasters on this scale, in terms of the volume and level of information and the immediacy with which the information is delivered.

At present, the SABO D-MaC system stores a backup of the erosion control base map data of about 30 prefectures and the electronic erosion control data of about 10 local M.L.I.T, erosion control offices. To improve operation of the delivery system, the Foundation is currently developing a function resembling a message board using map information as a medium. When it is complete, it will become a two-way interaction system that allows users to exchange information and opinions, thereby departing from the conventional role of delivery only.

III FUTURE OUTLOOK AND VISION FOR THE MANAGEMENT AND UTILIZATION OF EROSION CONTROL INFORMATION

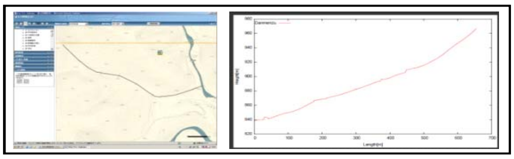
1. Utilization of electronic erosion control information accumulated nationwide

As mentioned earlier, erosion control departments around the country learnt a lesson from the formation of multiple landslide dams in the Iwate-Miyagi Inland Earthquake in 2008, and began to gather detailed topographic information in the sediment-related disaster-prone areas using a laser profiler (LP). If the LP data is made available, it becomes possible to find the details of the collapsed sites by conducting differential analysis using the data before and after the disaster. It is also possible to analyze the possibility of collapse using the data before the disaster and to analyze the disaster level by superimposing aerial photographs (bird’s eye view) of the slope taken from a helicopter after the disaster over the slope data before the disaster. In recognizing this use of LP data, the Foundation has developed a system that can conduct 3D analysis of LP data on the information management system and on the emergency portal site set up to cope with major disasters.

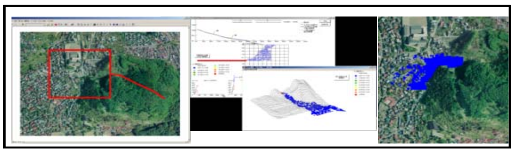
This system can analyze both LP data and 3D terrain model data (triangulated irregular network (TIN) data) in the erosion control base map prepared by each prefecture. This system was developed with attention paid to the following objectives.

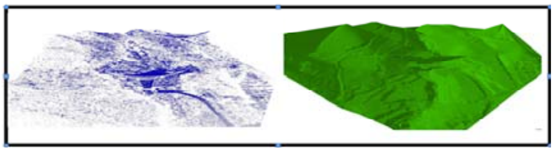
(1) The data processing speed should be improved.
(2) A wide range of data should be handled seamlessly.
(3) The detailed topography of a mountain slope should be represented.
(4) The text data should be handled as is.

To achieve these four objectives, this program was designed to first load the attributes of each file into the database and then process the 3D data, as shown (1) - (4), using the engine of the erosion control information management system.


(1) Cross-section of the survey line specified on GIS


(2) Bird’s eye view of the range specified on GIS


(3) Preparation of data for 2D flooding simulation


(4) 3D processing using LP data

This system was introduced at the convention of the Japan Society of Erosion Control Engineering in 2009. It is being installed in the local M.L.I.T, erosion control offices as one of the modules of the erosion control information management system of the Foundation (patent pending).

2. Public role of third-party institutions regarding the management and utilization of erosion control information and future perspectives

In Japan, sediment-related disasters can occur anywhere. As they occur suddenly, they can cause significant human loss and social upheaval, depending on the scale and location of the event.

Against this background, prefectural erosion control departments and the local M.L.I.T, erosion control offices face increasing demands to meet the growing social needs, namely, to develop and improve rapid and effective non-structural measures that utilize electronic information. This imperative is augmented by the rapid progress in electronic information processing equipment over recent years.

To date, the Sabo Frontier Foundation has played a particular role in the erosion control field as a third party public organization – neither a governmental agency nor a private company. The Foundation has worked for processes such as the preparation of standard specifications for electronic erosion control information, the storage of backup data for electronic erosion control information accumulated nationwide, and development of various systems for the utilization of electronic erosion control information.

The Foundation will continue to assume the role of third party public organization specializing in erosion control. Specifically, the Foundation will act as a coordinator and serve the national interest concerning the standardization of specifications that may cause conflicting interests among private companies. The Foundation will also continue its nonprofit activities in service of the public interest, such as storing backup data and responding to disasters.

REFERENCES

"Law Concerning the Promotion of Sediment-related Disaster Prevention in Sediment-related Disaster Hazard Area (Sediment-related Disaster Prevention Law)" (2001)

"Production Guidelines on Digital Maps Used for Surveys Related to the Sediment-related Disaster Prevention Law (Draft)" by Sabo Frontier Foundation (2002)