Network-Level Bridge Management Using GIS

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1. Introduction

With the rapid deterioration of bridges, applying effective bridge management approach is becoming important for the bridge agency to keep the bridges up to date with the growing transportation demands. In this research, by integrating the spatial and attribute data of bridges, the digitized data of roads and rivers, soil data, and so on, GIS is applied for several practical issues in the primary stage of bridge planning, and the service and monitoring stage.

2. Development of Bridge Management System Using GIS

For the purpose of bridge management, geographical data coverages of bridges, roads, and rivers are created by digitizing from the authorized maps with 1:25000 scale in the ARC Digitizing System (ADS). In the bridge coverage, 287 bridges managed by Nagoya city are digitized as a line coverage in order to determine their directions and locations. These directions are important for relating bridges and roads, or bridges and rivers. The district borders, river centerlines, highways, national roads, regional roads, and main local roads in Nagoya city are also digitized as line coverages. Four types of roads are adopted because they belong to different management agencies. The 27 rivers of Nagoya city are digitized because 240 of the 287 bridges are river-crossing bridges, and the river attributes are registered. The coverage of district borders is useful for the administration of bridges.

Besides the digitized spatial data, the soil data of 4190 previous borings in the area of Nagoya city, and the general and seismic inspection data of Nagoya city bridges in 1992 are linked with the bridge coverage. More than 5000 pictures of these bridges are input into the system. These several types of data were discussed elsewhere.[1] In order to utilize the geographic information efficiently, a menu-driven interactive user interface has been developed with the programming language of ARC/INFO as shown in Fig. 1. Menus provide users an easy way to display, list, operate, and retrieve data of one coverage or several coverages interactively.

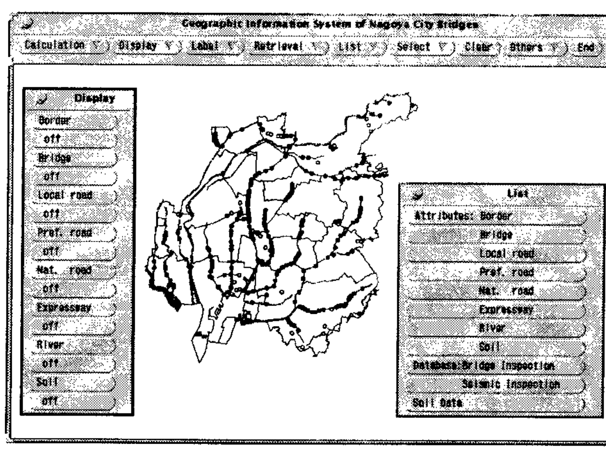

FIG. 1 Interface of GIS System

3. Examples of GIS Applications

3.1 Advisory Support for Bridge Type Selection

Selecting the type of a new bridge is important because of its influence on all the stages of bridge lifecycle. However, it is difficult to select a suitable type unless a designer has enough experience and a wealth of knowledge. This is because many factors influence the bridge type selection, and some factors such as the landscape are difficult to be quantified. An advisory system was developed to select the types of superstructures and substructures of river-crossing bridges, and to quantitatively evaluate the landscape of different bridge types based on the knowledge of expert designers and the specification rules.[2] By integrating with the previous advisory system, GIS can display the images of available bridges, and help the selection of new bridge type considering the landscape of available bridges, and visualize the effect of the additional bridge on the current landscape.

For example, Fig. 2 shows the landscape of several bridges crossing Syonai river. This figure is helpful for bridge engineers in evaluating the landscape of a new bridge type according to the images of other bridges at a network because of the common surrounding landscape for the bridges crossing the same river. Furthermore, the bridge type is decided by considering the possible change of landscape due to the construction of the new bridge.

3.2 Spatial Retrieval of Bridges

GIS was used to implement the spatial retrieval in the developed system for the purpose of seismic or general maintenance management of network-level bridges. In the case of general maintenance management, the system makes it possible to retrieve all bridges in the same road or crossing the same river. In the case of seismic bridge strengthening before an earthquake or emergent maintenance after a severe earthquake, some bridges are closed for traffic for the purpose of efficient strengthening operations or traffic safety, or because of the earthquake damages. The system is helpful in selecting the alternative bridges and controlling the traffic.

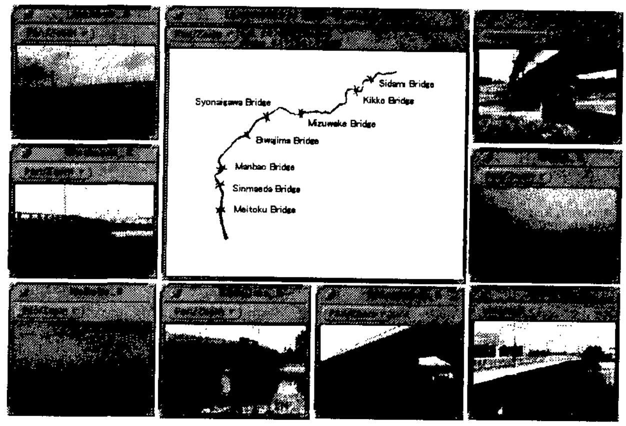

FIG. 2 Landscapes of River-Crossing Bridges

Fig. 3 shows an example in which the system can help the bridge engineers to screen the network-level bridges according to the following steps. First, the river-crossing bridges that are older than 30 years are selected and displayed in the ARCPLOT display window as black circles, as well as other coverages such as the district borders and center lines of rivers. Then, buffers of 500 meters around these old bridges are created in order to view the specific environment of each bridge. Finally, the river-crossing bridges constructed in the past 10 years are retrieved and displayed on the computer screen with white circles. These bridges are considered as the possible alternative bridges of the above old bridges. Detailed relationships among the above mentioned coverages at a local area can be investigated in the View window created through the *Pan/Zoom* button of the ARCPLOT display window. As shown in the View 1 window, seven old river-crossing bridges are available in the selected area. However, only bridges 2 and 3 are with young alternative bridges with white circles in the buffer. The retrieval results are helpful for the bridge engineers to allocate the maintenance budget and plan the maintenance strategies. The traffic flow passing the old bridges that may be out of function can also be managed by investigating the roads near these bridges.

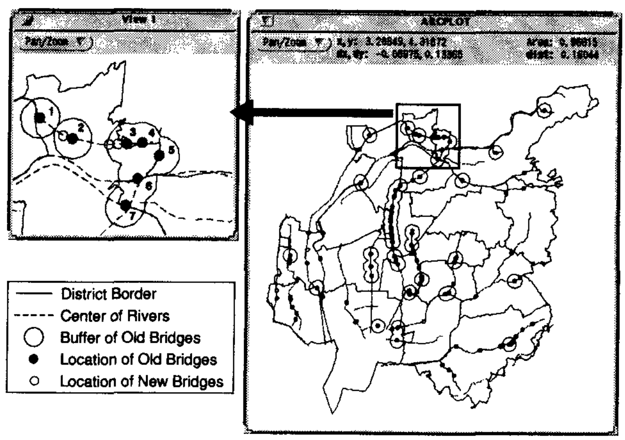

FIG. 3 Retrieving Alternatives of Old River-Crossing Bridges

4. Conclusions

The conclusions of this study are summarized as follows: (1) GIS was an efficient approach for integrating the spatial and attribute data of bridges, the digitized data of roads and rivers, soil data, and so on; and (2) The developed system was helpful for bridge engineers to manage the network-level bridges at several lifecycle stages.

References

1) Itoh, Y., Shintoku, Y., Hammad, A., Satake, S., and Liu, C. (1996) "Development of Bridge Lifecycle Management System." *Journal of Civil Engineering Information Processing Systems*, JSCE, Vol.5, 171-178 (in Japanese).

2) Nishido, T., and Itoh, Y. (1993). "Advisory System for Evaluating the Landscape of Different Types of River-Crossing Bridge Quantitatively." *Journal of Structural and Earthquake Engineering*, JSCE, 474/I-14, 95-104 (in Japanese).