THE DISASTER MITIGATION AND MANAGEMENT STRATEGY FOR BRIDGES

Ban-Jwu Shih[1], Kun-Chung Wu[2]

[1]Associate Professor, [2]Research Assistant, Department of Civil Engineering, National Taipei University of Technology, Taipei, Taiwan, ROC

Abstract: This article aims at the needs for bridge disaster-prevention and repairs in Taiwan. It discusses disaster-prevention planning and establishes a Geographical Information System (GIS) database which has the capability of spatial analysis and visual display to form a dynamic real-time disaster-prevention management system. The GIS database contains the bridge inventory data module, the periodical inspection data module, the bridge emergency repair team module, the dynamic information module, the emergency reporting module, the bridge disaster repairs module, and the GIS inquiry module.

Keywords: disaster mitigation, geographical information system, GIS, bridge disasters, emergency repairs

1. INTRODUCTION

The Executive Yuan of the Republic of China announced the "Disaster Rescue Plan" on Aug. 4, 1994. According to this plan, the Ministry of Transportation and Communications is the central authorities in charge of serious plane wrecks, shipwrecks, and car accidents. If serious disasters such as earthquakes, floods, nuclear accidents happen, the Ministry is responsible to provide consultation and coordinate the repairs and rescue efforts between different government agencies. Thus, the Ministry of Transportation and Communications should establish its own disaster-prevention plan and compile the real-time spatial data of bridge disaster-prevention management system from its subdivisions through networks to build up various disaster-prevention task forces. If the Emergency Reporting System of Bridge Disasters and the Geographical Information System of Disaster Bridge Repairs can be integrated into the Bridge Management System, the effectiveness of our national disaster-prevention system will be considerably strengthened.

2. BRIDGE DISASTER-PREVENTION PLANNING SYSTEM

Regarding the general procedures of emergency repairs and restoration of traffic facilities, they can be divided into three stages—the emergency repair stage, the restoration stage, and the disaster preparedness stage [1]. The followings describe the main tasks involved in each stage:

2.1 The emergency repair stage

These are the tasks to be performed in the emergency repair stage:

1. Establish emergency communication systems during disasters:
   - The Central Radio Communication Network for Disaster Mitigation: The network includes organizations such as the Presidential office, the media, power companies, gas companies, the army, fire departments, and local governments.
   - The Radio Communication Networks for Disaster Mitigation of Local Governments: The networks include organizations such as county governments, medical facilities, the Department of Transportation, schools, the media, financial organizations, power companies, and gas companies.
   - The Disaster Mitigation Communication Networks for Central and Local Governments: Establish communications with fixed, mobile, remote controlled, and satellite equipment. If a bridge is damaged, the transportation team of the central government's emergency response center should report the disaster to the center and relevant authorities (e.g., the Ministry of Transportation and Communications). The relevant authorities should notify their emergency repair teams to orchestrate the repair plans. Finally, after receiving

reports from the emergency repair teams, the emergency response center should issue instructions to allocate resources and coordinate tasks with the Public Construction Commission of the Executive Yuan.

2. Establish a command center for emergency bridge disaster repairs [2].
3. Establish a real-time monitoring and reporting system to restore damaged traffic facilities.
4. Formulate traffic control plans for the disaster area.

2.2 The restoration stage

1. Implement restoration plans for damaged transportation systems.
   According to the relative importance and the extent of damage, implement restoration plans and exercise strict progress control of the restoration process. Review the restoration plans and their schedules as necessary.
2. Perform in depth safety inspections of existing transportation facilities.
   Because there could be hidden or minor damages to a variety of structures, the apparently safe transportation facilities should also be inspected for possible safety concerns. These inspections should be included in the restoration plans.
3. Establish systems of alternate routes and provide the public with the most up-to-date information on restoration processes.

2.3 The disaster preparedness stage

During restoration, review the causes of damages and establish the rehabilitation plans for damaged transportation facilities. Follow the construction standards and prepare for future natural disasters.

3. FUNCTIONAL MODULES OF THE BRIDGE DISASTER-PREVENTION MANAGEMENT SYSTEM

Aiming at the need of preventing bridges disasters in Taiwan, an ideal Geographical Information System (GIS) database should include the following data: bridge inventories, geological information, bridge repair teams, traffic networks, repairs equipment and supplies, emergency response procedures [3]. By using Global Positioning Systems (GPS), notebook computers, and digital cameras, the real-time reports on disasters can be sent to the authorities and be connected to the disaster reporting and locating module (such as the one shown in Fig. 1) automatically. This will facilitate the dispatching of repair teams and mission assignments [4].

Figure 1. A screen shot of an emergency reporting system of bridge disasters [5]

The functional modules of bridge disaster-prevention management system are as follows:

3.1 Module for locating bridge repair teams

Use databases of bridge emergency repair teams and road networks to find the proper bridge emergency repair teams and medical personnel's to be dispatched. This will maximize the efficiency of emergency response. An example module is shown in Fig. 2.

3.2 Module for repair operation assignments

When the bridge emergency repair teams receive the dispatch orders, they should immediately assemble the repair professionals and depart for the repair operation. With the help of GPS, the repair missions can be accomplished more efficiently. Through radio or satellite communications, field reports are sent back to the command center for better management and control of the repair operations.

3.3 Module for finding the shortest path

Rapid response and repair is the top priority of disaster bridge repairs. When a serious disaster happens, it could come with damages to the traffic network. To arrive at the desired location quickly, it is necessary to find the shortest path based on the current conditions of the traffic network.

3.4 Module for locating alternate routes and bridges

Use inventory data of existing bridges and roads for network analyses. The system should immediately find several alternate routes for the authorities for consideration. An example is shown in Fig. 3.

3.5 Module for bridge inspection programs

No matter it is emergency repair or normal inspection, inventory data of existing bridges and highways should be used for network analysis. The system should immediately determine a number of

most important inspection criteria for the authorities to consider in order to save inspection time and related cost.

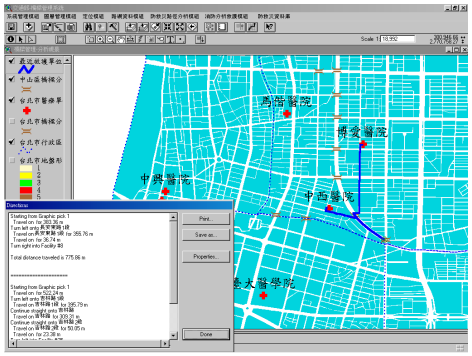

Figure 2. Selecting base camps for the repair operations

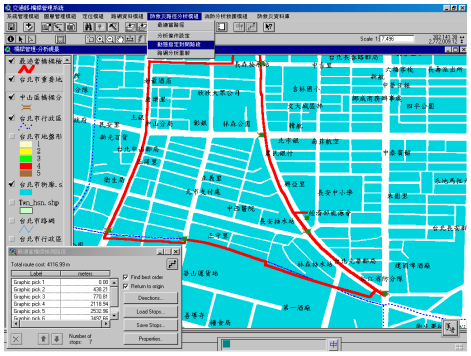

Figure 3. Locating alternate bridges and roads

3.6 Module for allocating repair equipment and supplies

Because the repair equipment and supplies are limited and distributed among different bridge emergency repair teams, this module is needed to handle the effective allocation of resources.

4. INTEGRATION OF NETWORKED BRIDGE MANAGEMENT SYSTEM (BMS) AND GIS

The present system used by the domestic bridge management authorities only emphasizes text descriptions and numerical calculations. It has not yet considered the capability of spatial data analysis and visual display, not to mention the disaster preparedness and prevention. To establish a better bridge management and disaster-prevention system, it is suggested that the GIS software, which has the capability of spatial analysis and visualization, be combined with the networks connecting the central and local authorities, regional engineering departments, and maintenance teams to share recourses [6,7,8]. Such an example is shown in Fig. 4.

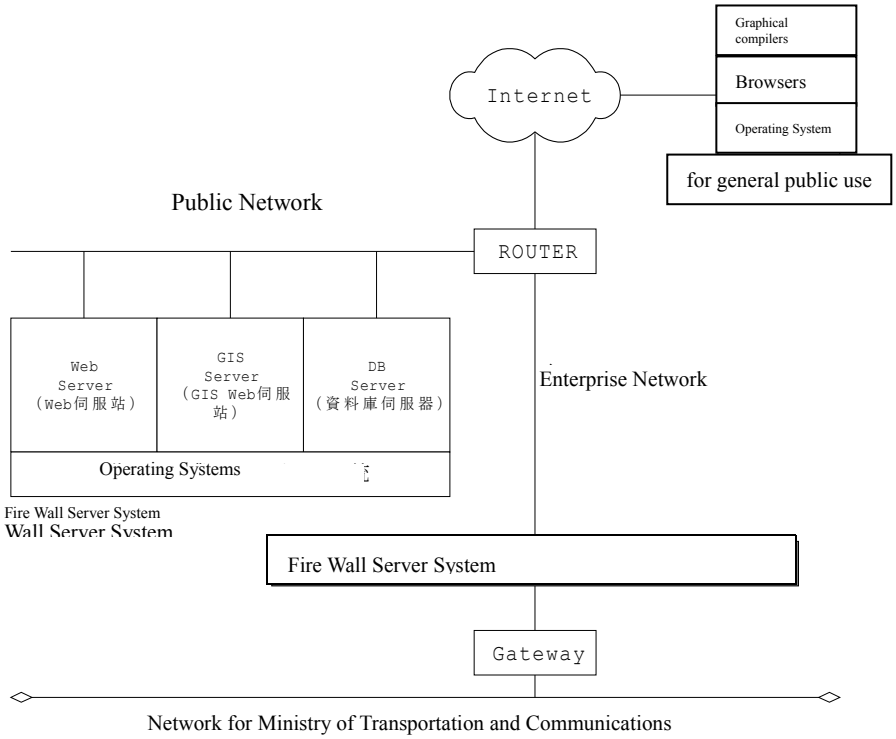

Figure 4 Integration of networked BMS and GIS

5. CONCLUSIONS

To enhance the functionality of a bridge disaster mitigation system, the authorities in charge of bridge maintenance should actively encourage the researches in the field of disaster prevention and analyze the sensitive areas prone to potential disasters to establish a database for geologically dangerous areas and possible site remediation technologies. With highly integrated interfaces, fast data transfer rates, and reduced costs, the network technology is the key ingredient of future development in bridge management systems. But, the issues on security, bandwidth, reliability, and backup management can not be overlooked. They should be taken into account when planning the new and improved bridge management systems of the future.

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