INFORMATION ACQUISITION AND STRUCTURAL HEALTH MONITORING OF BRIDGES IN BANGKOK

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ABSTRACT

The aim of this project is to provide information on bridges under the superintending of BMA namely name, location, type of structure, dimension of structure, and year of construction, etc., in order to subsequently create the Geographic Information System (GIS) of the bridges in Bangkok in the near future which will be handy for operation, repair, and maintenance of the structure. In addition to the aforementioned information of the bridges, the health and durability monitoring of the structures were also performed. The intention is to detect and locate damage or degradation in structural components and to finally provide this information to GIS in the next stage. In regard of the damage survey, carbonation was found to be the most serious durability problem for concrete bridges in Bangkok due to the traffic in the city. The secondary problems found are caused by poor construction like non-homogeneity of concrete in the form of honeycombs and insufficient thickness of concrete cover, which led to early steel corrosion. Settlement of the ground is another problem causing many wide cracks and consequently leads to corrosion of the steel reinforcement

1. INTRODUCTION

Bangkok is the capital of Thailand with the population of about 10 million. The public infrastructures in Bangkok are mainly taken care by the Bangkok Metropolitan Administrative Office (BMA). Only bridges are targeted in this paper. From searching and surveying, it was found that there are totally 1953 bridges under the control of BMA in the year 2003, i.e. 31 flyovers, 598 pedestrian bridges, and 1324 canal bridges. For management of the maintenance and repair of all bridges in Bangkok, BMA has adopted a database software to collect information on the situation of all bridges under the care of BMA. Due to huge amount of bridges under its control, BMA is still lacking detailed information of the condition of most of the bridges. At the same time, many bridges have been considered severely deteriorated by visual judgment of the pedestrians. It is therefore urgent for the BMA to conduct a global survey on the situation and identify the degree of seriousness and need of maintenance and repair of the damaged bridges for safety of the publics. This study was therefore initiated and undertaken by The School of Building Facilities Engineering and Civil Engineering,

Sirindhorn International Institute of Technology (SIIT) of Thammasat University in association with the Bangkok Metropolitan Administration (BMA) (Tangtermsirikul, 2003). The project was also supported by the International Center for Urban Safety (ICUS), the University of Tokyo. The paper introduces the database system used by BMA for management of repair and maintenance of the bridges and also reports examples of some surveyed bridges.

2. INFORMATION OF BRIDGES

In 2003, there are totally 1953 bridges that are under the responsibility of BMA, i.e. 31 flyovers, 598 pedestrian bridges, and 1324 canal bridges. This section presents sample of bridge information (originally in Thai) and the database computer program used by the BMA's Civil Works Department for management of bridge maintenance. The program is named "Bridge". The characteristics of the program will be illustrated in the following section.

3. COMPUTER PROGRAM FOR BRIDGE MANAGEMENT

The front page of the user interface is shown in Figure.1. There are four main sections in the front page of the user interface, classifying the types of structure into pedestrian bridges, canal bridges, flyovers, and tunnels. The user interface page, with the details of input information shown in the figure, for flyover bridges is illustrated as an example in Figure.2. Figure.3 shows the interface page with the information on history of repair and maintenance of a selected bridge.

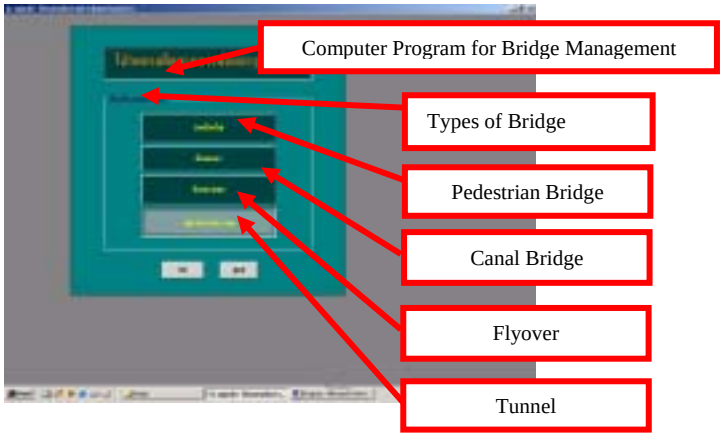

Figure 1: User interface of the program "BRIDGE"

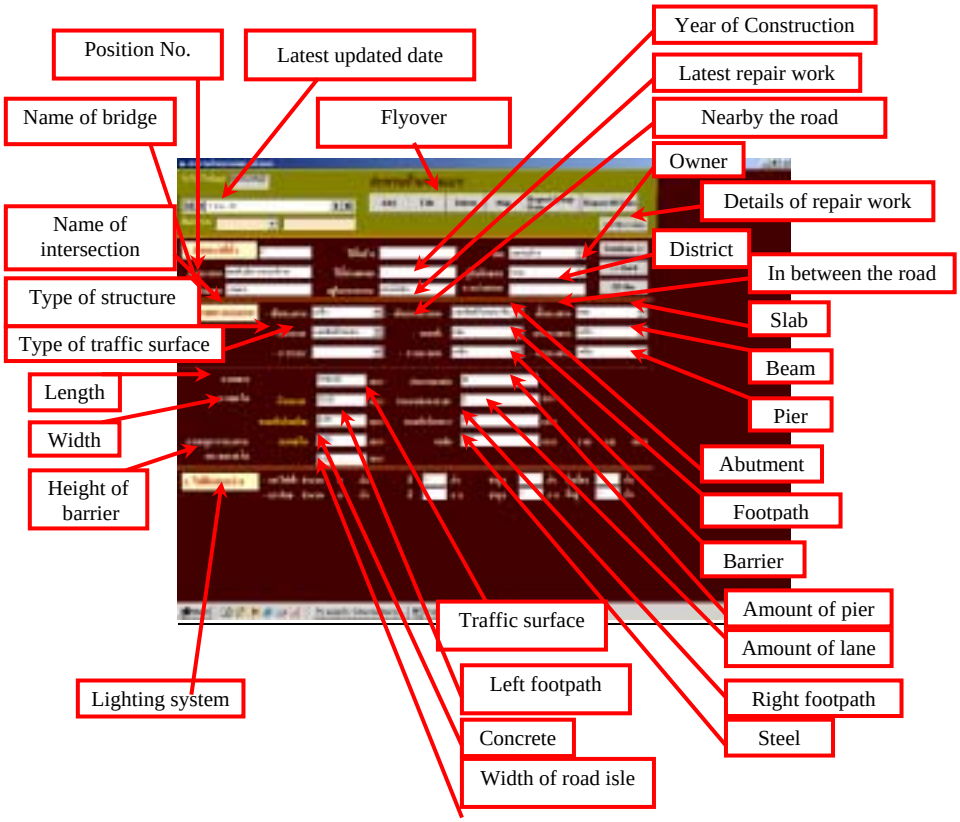

Figure 2: User interface to input the information of flyovers

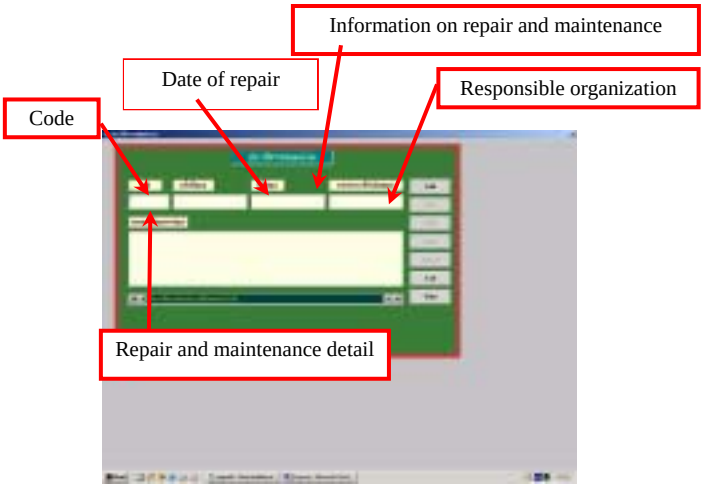

Figure 3: User interface to input information on repair and maintenance

4. GEOGRAPHIC BASED INFORMATION

This geographic based information shows the location of the selected bridge on the map of Bangkok including the scale and also all information that are previously input on the user interface. The users can choose to view highways, collector road, and their names, rivers, canals and their names, district boundaries and their names, and the locations of the important landmarks. There are totally 1953 bridges, which have been input into the

program. Shown in Figure.4 is an example of the GIS information of canal bridges.

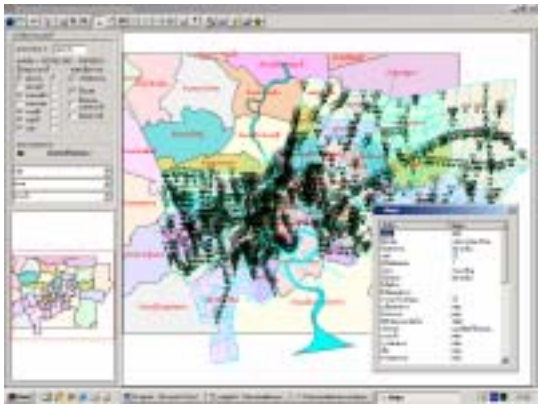

Figure 4: Geographic based information of canal bridges

4.1 Tabulated Information of the Bridges

Tabulated information of the bridges indicates location of bridges on the map, name of the bridges, types and size of pier, beam, girder, slab, year of construction, information about repair and maintenance work. Figure.5 shows an example of the tabulated information of the canal bridges.

Figure 5: Example of the tabulated information of the canal bridges

5. INTENSIVE INSPECTION OF SELECTED BRIDGES

This section presents the deterioration of structural components of the selected bridges. It was found that in most cases, the bridges in Bangkok are damaged due to durability problem rather than due to load. This is because in the past, the structural design in Thailand was mainly conducted mainly based on working stress design concept with high values of load factors provided by the design code of the Engineering Institute of Thailand than the original ACI's recommended factors. This resulted in larger safety factor when compared to the presently used ultimate strength design concept.

Carbonation was found to be the most severe and serious durability problem for concrete bridges in Bangkok due to the traffic in the city (see Figure.6 and Figure.7). Carbonation depth was measured up to 8 cm in some severely corroded old structures. The secondary problems found are caused by poor construction such as non-homogeneity of concrete in the form of honeycombs and insufficient thickness of concrete covering steel reinforcing bars, which led to early steel corrosion (see Figure.8 and Figure.9). Settlement of the ground is another problem causing cracks in the structures with differential settlement (see Figure.10). Figure.11 shows examples of cracking in the repair concrete due to relatively larger shrinkage of the repair concrete when compared with that of the concrete in the existing structure. Figure.12 shows many bending cracks on the tension surface of an eccentric column. Though the measured crack width is within the allowable limit defined by the design code, the cracks are not recommendable when durability is considered since they will lead to premature steel corrosion problem in the near future.

Figure 6: Spalling of concrete due to carbonation causing corrosion of reinforcement

Figure 7: Severe steel corrosion due to carbonation

Figure 8: Premature carbonation induced steel corrosion found at various parts of many structures with insufficient concrete cover

Figure 9: Honeycombs caused by poor concrete placing

Figure 10: Damages due to differential settlement

Figure 11: Cracks due to shrinkage of the repair concrete

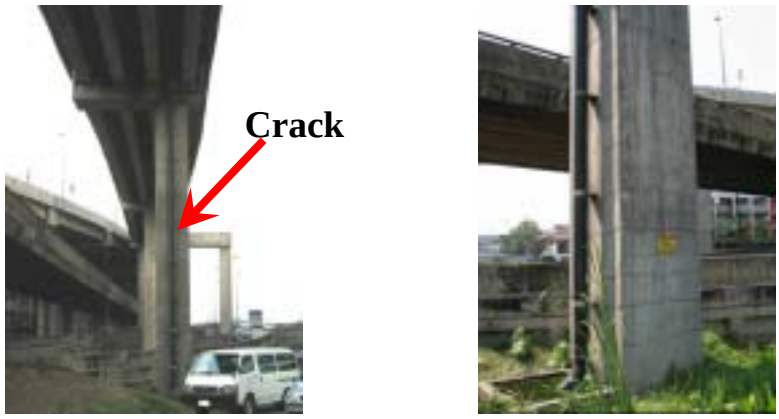

Figure 12: Cracks along tied bars on the tension side of a column with eccentricity

6. CONCLUDING REMARKS

A computer software adopted by the Bangkok Metropolitan Administration Office for maintenance management of bridges under the control of the Office was introduced. A survey on condition of some selected bridges was conducted. It was found from the surveyed that few damages were caused by load whereas majority of the damages were caused by durability problems though many structures are under service for more than 20 years. This was considered to be due to the use of working stress concept for design in the past. In regard of the damages, carbonation was found to be the most serious durability problem followed by poor construction and settlement of the ground.

ACKNOWLEDGEMENT

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REFERENCE

Tangtermsirikul, S., 2003. *Information Acquisition and Structural Health Monitoring of Bridges in Bangkok*, A report submitted to the International Center for Urban Safety, the University of Tokyo, March 2003.