UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN EXPERT SYSTEM FOR ASSESSMENT OF REINFORCED CONCRETE BRIDGE CONDITION

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DEVELOPMENT OF AN EXPERT SYSTEM FOR ASSESSMENT OF REINFORCED CONCRETE BRIDGE CONDITION

By

YAVUZ YARDIM

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for Degree of Master of Science

August 2002

Specially Dedicated
To my
Father(Ahmet Yardim)
Mother (Leyla Yardim)
My Grand Mother (Fatma Gencol)
Brother (Yasar Yardim)
Uncle (Cevdet Yardim)

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

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Faculty : Engineering

Condition assessment of Reinforced Concrete Bridge is a complex subject imbued with uncertainty and vagueness. This complexity arises from numbers and relations of problems in reinforced concrete bridges. Condition assessment process requires deep knowledge of the behavior of Reinforced Concrete Bridge, awareness of change, good understanding of design process and skillful person. This requirement can be achieved through a comprehensive expert system, which may represent human expertise.

The aim of this project is to develop an expert system for condition assessment of reinforced concrete bridges. The system should be an efficient tool to guide the field inspectors during identification of potential problems associated with existing reinforced concrete bridges. It is developed by integrating the existing condition assessment procedures by the Public Work Department (JKR), which is only based on visual inspection, and the results obtained through non-destructive test (NDT) techniques and finite element analysis.

The system has been successfully developed. Its final output, which not only is displayed on the monitor but also can be saved in a computer file and sent to a printer. Having this computation power, one file is created for each bridge at a particular area and quantitative comparison can be done faster and much more precisely than the available methods of condition assessment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk mendapatkan ijazah Master Sains

PEMBANGUNAN SISTEM PINTAR BAGI PENILAIAN KEADAAN JAMBATAN KONKRIT BERTETULANG

Oleh

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Penilaian keadaan jambatan konkrit bertetulang adalah merupakan suatu subjek yang kompleks dan melibatkan ketidaktentuan. Keadaan kompleks ini adalah disebabkan oleh berbagai dan masalah yang berhubungkait dengan jambatan konkrit bertetulang.

Proses penilaian keadaan jambatan ini memerlukan pengetahuan yang mendalam mengenai sifat-sifat perilaku jambatan konkrit bertetulang, keperihatinan tentang perubahan, kefahaman yang baik tentang proses rekabentuk dan kemahiran seseorang. Keperluan-keperluan ini boleh dicapai melalui sistem pintar yang komprehensif yang mana ianya boleh menggantikan kepakaran manusia.

Tujuan projek ini adalah untuk membangunkan sistem pintar bagi penilaian keadaan jambatan konkrit bertetulang. Sistem ini mestilah merupakan suatu alat yang cekap untuk membantu penyelia sewaktu mengenalpasti masalah berbangkit yang berkaitan dengan jambatan konkrit bertetulang. Sistem ini dibangunkan dengan mengintegrasikan prosedur penilaian keadaan jambatan yang sediada oleh Jabatan Kerja Raya (JKR) yang mana

ianya hanyalah berdasarkan kepada pemerhatian secara visual dan keputusan yang diperolehi melalui teknik Ujian Tanpa Musnah (NDT) dan analisis Kaedah Unsur Terhingga.

Sistem ini telah dibangunkan dengan jayanya. Hasil terakhirnya, bukan sekadar boleh ditayangkan oleh monitor komputer akan tetapi ianya boleh disimpan di dalam fail komputer dan kemudian ianya boleh dihantar ke pencetak bagi tujuan cetakan.

Menerusi perkembangan teknologi komputer, satu fail dicipta bagi setiap jambatan untuk sesuatu kawasan dan perbandingan secara kuantitatif boleh dilakukan dengan lebih cepat dan lebih tepat berbanding dengan kaedah penilaian keadaan jambatan yang sediaada.

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement of the degree of Master of Science. The members of the Supervisory Committee are as follows:

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1

INTRODUCTION

1.1 General

Highway is the highest form of technology for land transportation and a very important subject for the developed countries; even the length of highway could be shown to indicate countries' development level. Along the highways most critical and delicate points are bridges. The tragic collapse of the Silver Bridge in US on Dec.15, 1967, resulted in the deaths of 46 people (FHWA 2000). The collapse is a very good example of new technology's problems and it led to the development of bridge inspection standards. The standard outline defines qualifications of bridge inspector, the scope of bridge inspection programs, and provides standardized methods of evaluation and appraisal of bridge conditions. The condition assessment of bridge, however, requires extensive research to be conducted in the areas of distressed concrete structures.

The condition assessment process of bridge requires deep knowledge of the behavior of reinforced concrete bridges, awareness of changes, good understanding of design process, and, most importantly, skillful personnel. At the same time, bridge condition assessment is a laborious and expensive exercise. It requires a lot of quality and knowledgeable personnel to be on site. One possible solution to overcome this obstacle and to fulfill the

need for comprehensive inspection is by the use of computer-assisted tools such as expert system.

Expert systems have been defined as consulting systems that simulate the problem solving ability of human experts through the use of expertise drawn from an information base and specific rules employed to interpret such knowledge (Ignizio 1991). The expert system is used to aid in making recommendations, and it allows an expert to concentrate on more difficult aspects of the task, enforces consistency, and preserves valuable knowledge which would otherwise be lost. Expert system, moreover, is applied when expert is not available.

Currently, inspection practice for bridges depends on visual inspection to evaluate the condition assessment. The system requires an input not only from visual inspection but also from that of confirmatory non-destructive tests and distress investigations, through structural analysis. The actual role of the expert system in this area is to develop an engineering decision – making tool to assist an inspector during the inspection of an existing reinforced concrete bridges with consideration of non-destructive tests and structural analysis. The tool can identify the nature of problem, their causes assess and aid inspector to draw a proper conclusion regarding the condition of an existing bridge.

1.2 Research Objective

This project aims to develop an expert system for bridge condition assessment. The system is based on the following combinations:

a) Data- base system; includes all possible concrete bridge components
b) Sub-expert system; with the use of certainty factor method, an expert system tool, can be developed to give the probability of problem occurrences.
c) Knowledge base system; based on existing knowledge and JKR rating systems
d) File system; include all the information from field inspection and comprehensive expert system results.

1.3 Scope of Work

The scope of this study includes the following steps;

1. To study literature of early expert systems, which have been developed for commercial and research purpose, and inspection systems, which have been using currently by different countries for condition assessment of bridges.
2. To filter most popular expert systems and discover best way to adopt expert system on bridge condition assessment.

3. To chose suitable programming language for development of the bridge condition assessment program.
4. to collect data for bridge condition assessment and modify the data for programming purpose.
5. To develop the system based on selected expert system type, program language, and collected data.

CHAPTER 2

LITERATURE REVIEW

2.1 Human Mind and Problem Solving

The thinking of the human mind is an extremely complicated process. In modeling the information processing of the mind, separate short-term and long-term memories are identified. Data is continuously entered to the brain through the five sensory organs or sensors and stored in the short-term memory temporarily. The human mind filters this data, decides what is important, and stores the important information in the long-term memory in complicated networks of some kind. The information stored in the long-term memory is mostly in symbolic forms and patterns, i.e. objects and relationships among them. Research in human cognition suggests that this information is stored in the brain as clusters of symbols or chunks of information.

The human brain is slow in storing information. It takes approximately seven seconds to store a chunk of information in the long-term memory. This is the reason why it usually takes years to become an expert in a particular domain. On the other hand, the human brain is incredibly efficient in symbolic pattern recognition and retrieving the information stored in the long-term memory. The processing cycle for accessing a chunk of information is estimated at approximately 70 milliseconds (Townsend and Feucht, 1986). However human brain is slow and

weak due to long-term memory, people involved intelligent machines and systems which can store information faster and more save than human brain.

As a very simple example of the pattern recognition and information retrieval capability of the human mind, read the following and then try to remember it:

Dlgnoe tgae gdrbie si a nspsnsuieo rbgdei

Now, do the same thing with the following:

Golden Gate Bridge is a suspension bridge

Needless to say, storing and retrieving the second piece of information is much faster than the first one. For the second case, the reader clusters the information into seven chunks and therefore needs to remember only seven chunks of information. In contrast, in the first case he or she must remember 41 chunks of information. Research in human cognition suggests that the human brain can keep from four to seven chunks of information in short-term memory simultaneously. It is this pattern recognition and chunking of information that is used most effectively by an expert in a particular domain. Chess masters can duplicate the chessboard by observing a game for a few seconds. They cannot simply memorize the positions of 32 pieces on a given board. Instead, they cluster the pieces into a few recognizable patterns of pieces. While the human mind is weak in numerical processing compared with the simplest calculator, it can outperform the largest and fastest computers in symbolic processing and reasoning. Simulating the symbol processing ability of the human brain has been a subject of particular interest to people involved in developing intelligent machines.