ATTRIBUTES OF SMART BRIDGE MONITORING TECHNOLOGIES

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Dedicated to my mother, father, sisters and brothers.

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ABSTRACT

In the recent past, there have been rapid advances in the development of technologies for the evaluation of bridges. Advanced structural health monitoring has fast become a growing field in which non-intrusive damage detection techniques are integrated into a structure to monitor the complete bridge or individual bridge members. These integrated computer-linked sensors systems could subsequently alert the bridge engineers on the abnormalities inside the bridge structure. These bridge structures could be aptly described with the phrase ‘smart structure’. If properly maintained, it is believed that these smart technologies could extend the useful life of bridges by allowing deterioration to be identified earlier and thereby allowing relatively minor corrective actions to be taken before deterioration grows to a state where major actions are required. In addition, smart bridge technologies allow designers to learn from previous designs to improve the performance of future bridges. While a number of smart bridge monitoring technologies exist, a thorough compilation of these various technologies have not been done in this country. A comprehensive database would allow easy identification and review of smart bridge monitoring technologies and to facilitate the selection of technologies for a specific application. With this database, information on available monitoring technologies could be identified and their applicability could be selected.

ABSTRAK

Kebelakangan ini, berlakunya kemajuan yang pesat dalam pembangunan teknologi penilaian jambatan. Pengawasan kesihatan struktur yang maju dengan pantasnya telah menjadi satu bidang yang semakin meningkat di mana pengesanan kerosakan yang tidak menerobos diintegrasikan ke dalam struktur untuk mengawasi keseluruhan jambatan atau anggota jambatan tertentu. Penderia yang dintegrasikan dan yang dihubungkan dengan komputer ini akan memberitahu jurutera jambatan akan sebarang kemerososstan dalam struktur jambatan. Jambatan ini boleh digambarkan sebagai struktur yang pintar. Jika disenggara dengan sepatutnya, teknologi jambatan pintar ini dijangka dapat memanjangkan kebergunaan hidup jambatan dengan membolehkan kemerosotan dikenalpasti lebih awal dan seterusnya membolehkan tindakan pembetulan yang kecil diambil sebelum kemerosotan sampai ke tahap di mana pembaikan kerosakan yang komprehensif diperlukan. Tambahan pula, pengawasan kesihatan struktur yang pintar membolehkan pereka belajar daripada pereka yang terdahulu untuk meningkatkan prestasi jambatan pada masa depan. Walaupun terdapat pengawasan kesihatan struktur yang pintar, pengumpulan teknologi ini belum dilakukan di dalam negara ini. Satu pangkalan data yang komprehensif yang akan memudahkan pengenalpastian dan kajian pengawasan kesihatan struktur pintar ini dan juga memudahkan pemilihan teknologi yang sesuai untuk penggunaan. Dengan adanya pangkalan data ini, maklumat tentang pengawasan kesihatan struktur yang ada dapat dikenalpasti dan penggunaanya dapat dipilih dengan baik.

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CHAPTER 1

INTRODUCTION

1.1 Background

Bridges are not merely a major, long term investment but they are the flagship or in fact, vital link in highway transportation network. Inspection and evaluation of the structural health of bridge structures has been traditionally based on "hands-on" visual inspection by experienced personnel. The US Federal Highway Administration's (FHWA) Nondestructive Evaluation Validation Center recently completed the first comprehensive and quantitative study of reliability of visual inspection and the US National Bridge Inspection Program (NBI) condition rating system [1]. The study reported that a range of condition ratings of 3 or 4 categories can be expected routinely with different inspectors reporting results for same bridge in the same condition. Coupled with this variability is the inherent limitation of visual inspection that fails to detect invisible deterioration, damage or distress. Many of the aforementioned are difficult or impossible to detect visually unless they are severe.

Non-destructive Testing and Evaluation (NDT / NDE) has facilitated the examination of in-situ behaviour members and behaviour not ascertainable through traditional visual inspections. But this still does not resolve the problems of subjectivity and periodic nature of inspection. Therefore, continuous monitoring is the best way to resolve the aforementioned problem.

In recent years, there has been an increase in the applications of advanced structural health monitoring in bridge evaluation. Damage detection techniques are integrated into the structure to monitor the complete bridge or individual structural members. These integrated computer-linked sensors systems could subsequently alert the bridge engineers on the abnormalities inside the bridge structure. These bridge structures could be aptly described with the phrase 'smart structure'. If properly maintained, it is believed that these smart technologies could extend the useful life of bridges by allowing deterioration to be identified earlier and thereby allowing relatively minor corrective actions to be taken before deterioration grows to a state where major actions are required. In addition, smart bridge technology allows designers to learn from previous designs to improve the performance of future bridges [2].

While a number of smart bridge technologies are available, a thorough compilation of these various technologies have not been done in this country. This short study will attempt to compile information on the various smart bridge technologies and carry out comparative assessments of their merits. This study will also develop a database to assist practising engineers in selecting the technologies relevant to their respective needs. Such a comprehensive database would allow easy identification and review of smart bridge technologies and to facilitate the selection of technologies for a specific application.

1.2 Problem Statement

At present, various smart bridge technologies are available, yet the knowledge and level of awareness regarding them in this country is still quite low. A contributory cause for the low awareness is that information regarding these technologies is not readily available and not consolidated. There is a need for bridge engineers to be made aware of the significant benefits and working principles of these smart structure technologies. Hence this short study will consolidate information on them and conduct relative evaluations of their virtues. Besides that,

this study will also build a database to aid practising engineers in choosing the technologies appropriate to their respective requirements.

1.3 Aim and Objectives

Generally, this study aim to identify and compile bridge monitoring technologies which have smart attributes.

The related objectives in achieving the aim of this study are as follows:

a) To identify information that must be gathered to effectively monitor a bridge structure.
b) To identify criteria for selection of appropriate approach and technologies for bridge monitoring.
c) To carry out comparative and qualitative assessments of the ability of each technology to measure the metrics for bridge monitoring.
d) To develop a searchable database to provide easy identification and review of smart bridge monitoring technologies

1.4 Scope

The study will focus on identifying and assembling bridge monitoring technology with smart attributes. A user friendly database will be developed to provide practicing engineers with means of easy identification and appraisal of smart bridge monitoring technologies using Microsoft© Access™. Subsequently, prior to this development, criteria for selection of appropriate technology have to be identified.

1.5 Significance of Study

The study will provide consolidated information on smart structures attributes where details of smart structures technologies are compiled and analyzed to help increase knowledge and awareness about them. A user friendly database system developed in this study will be useful for engineers to identify, evaluate and select the most appropriate smart bridge monitoring technology for their structural health monitoring purposes. The database will serve as a starting point for the development of a more comprehensive information system on smart structures technologies.

1.6 Research Methodology

The methodology will be itemised as below:

Problem Identification

After the problem statement has been identified, the next step is definition of the objective and scope of study. At this stage, planning and scheduling are undertaken.

Literature Review

A background study on Smart Bridge Technologies is carried out. Besides that, information on Smart Bridge Technology is compiled and the requirement for database development is studied. A simple and brief review will also be carried out on database management system software.

Task 1

Under Task 1, the information (Monitoring Metrices) that must be gathered to effectively monitor a bridge structures and facilitate the selection of the appropriate technology is identified. Summary of the capability and applicability of soon-to-be identified Smart Bridge Technologies are also carried out.

Task 2

The focus of Task 2 is to collect and compile information on Smart Bridge Technologies currently used through review of technical reports and literature review.

Task 3

The collected information will be summarized and synthesis. Next, a searchable database aiming at providing easy identification and review of Smart Bridge Technology is developed. This work has been reported in Chapter 3.

Conclusion and Thesis Preparation

Lastly, is the preparation and compilation of thesis for submission.

1.7 Layout of Thesis

This section generally categorizes the thesis contents in terms of defined and systematic chapters. The thesis is divided into four (4) chapters and a summary of each chapter is presented as follows:

Chapter 1 Introduction

This chapter outlines the purpose of the study, the problem statement, and aim and objectives. Apart from aforementioned, it includes scope of the study, the significance of the study, and lastly the arrangement of each chapter in the thesis.

Chapter 2 Literature Review

This chapter discusses the needs and benefits of smart bridge structures applications. The discussions are relevant because they demonstrate the

reason for the task of identifying, compiling and synthesis of bridge monitoring technologies with smart attributes. In this chapter, bridge monitoring technologies with identified smart attributes were not only highlighted but also description on working principles of these smart technologies shall be carried out.

Chapter 3 Development of Smart Bridge Technologies Database

This chapter will start off with a brief description of the database management system aiming at providing conceptual understanding. The reasons behind the selection of Microsoft© Access™ 2007 are presented.

Included in this chapter is a concise description on the design development of the database. Prior to that the monitoring metrices are identified and presented.

Chapter 4 Conclusion and Recommendations

This last chapter concludes the study carried out and describes the outcomes of it. It also includes a few recommendations for the database developed.