BRIDGE MANAGEMENT SYSTEM:
REVIEW ON CURRENT SYSTEM AND A CASE STUDY

NOOR HIDAYAH BINTI MUHAMAD JAMIL

Report submitted in partial fulfilment of the requirements
for the award of Bachelor of Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2012

ABSTRACT

Over the centuries, bridge agencies faced a common problem which is deterioration of bridges. However, even after acknowledge of the problem, the agencies still unable to settle it down because of unorganized of the obtained data. Thus, the bridge agencies started to adopt an approach in managing their bridge which is called bridge management. The bridge management system are then develop as a tool to operate and analyse the bridge management activities.

Ussually, each country have their own bridge management system. For examples, Malaysia (JKR BMS), Denmark (DANBRO) and U.S.A (PONTIS). The modules installed in these systems made the systems differ with one another. Each modules offer different functions for the system and made the systems unique. The quality of the bridge management systems depends on the installed modules and the systematic and effective bridge management depends on the systems. The systematic and effective bridge management system is able to manage bridge activities efficiently.

ABSTRAK

Agensi jambatan telah mempunyai masalah dalam isu kemerosotan jambatan sejak berabad yang lepas. Walaupun masalah ini dikenalpasti, masalah ini masih gagal diselesaikan oleh pihak agensi jambatan kerana ketidaksusunan maklumat jambatan yang diperolehi. Oleh itu, pihak jambatan mula menerima pakai satu pendekatan dalam menguruskan jambatan mereka iaitu pengurusan jambatan. Selepas itu, sistem pengurusan jambatan mula diperkenalkan sebagai alat untuk mengurus dan menganalisa aktiviti-aktiviti pengurusan jambatan.

Setiap negara mempunyai sistem pengurusan jambatan yang tersendiri. Contohnya Malaysia (JKR BMS), Denmark (DANBRO) and Amerika Syarikat (PONTIS). Modul-modul yang dipasang di dalam sistem membezakan satu sistem dengan sistem yang lain. Setiap modul menawarkan fungsi yang berlainan dan menjadi faktor utama keunikan sistem. Kualiti sistem pengurusan jambatan bergantung kepada modul yang dipasang dan pengurusan jambatan yang sistematik dan berkesan bergantung kepada sistem. Sistem pengurusan jambatan yang sistematik dan berkesan mampu menguruskan aktiviti jambatan dengan cekap.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BMS	Bridge Management System
EDP	Electronic Data Processing
FHWA	Federal Highway Administration
FRP	Fiber Reinforced Polymer
JKR	Public Work Department Malaysia
MR&R	Multi-year Rehabilitation and Reconstruction
NBI	National Bridge Inventory
OECD	Organization for Economic Co-orperation and Development
PBMS	Penang Bridge Management System
PBSB	Penang Bridge Sdn Bhd
PC	Personal Computer
U.K.	United Kingdom
U.S.A.	United State of America

CHAPTER 1

INTRODUCTION

1.1 Introduction

Over the centuries, bridge agencies faced a common problem which is deterioration of bridges. In Malaysia, there are more than 7000 of federal bridge. A great number from that bridge are showing varying degrees of deterioration (Masjuki, 2010). This situation is not unique to Malaysia because many others countries facing the same problem.

Moreover, even after acknowledge of the problem, the agencies still unable to settle it down. This is because unorganized of the obtained data. In order to cope with both problems, the bridge agencies started to adopt an approach in managing their bridge which is called bridge management.

Bridge management encompassed all activities carried out to ensure that bridge remains fit for its intended purpose throughout its effective life span. Bridge management activities include bridge inspection and assessment, bridge reconstruction, bridge maintenance and rehabilitation.

In Malaysia, Public Work Department (locally known as JKR) is entrusts in managing all federal bridge in country. Establishment of the Bridge Unit turned as a design standard, bridge inspection, and maintenance and rehabilitation authority. In 1984, an attempt to initiate a systematic bridge inspection and strength assessment program leads to development of computerized bridge management system called JKR BMS. Bridge inspection provides some necessary inputs for the JKR BMS.

This research discussed on the different types of bridge management system practiced worldwide and Penang Bridge as a case study. Analysis will be done by highlighted the merit and demerit of bridge management system that Malaysia currently practiced.

1.2 Problem Statements

Distress, defects, damage, deterioration and faultiness during bridge construction were the example of the bridge problem. Bridge problem caused by a various factors such as deficient design, construction fault, or vehicular impact. These problems will lead to the bridge failures and shorten the life span of the bridge.

Distress in bridge can be divided into three main categories which are structural defect, non-structural defect and defect due to faulty installation of bridge equipment (Masjuki, 2010).

All above problems are acknowledged by the bridge owner last a decade ago. Unfortunately, because of the lack of knowledge and system, the problems were not properly organized by the owner. This situation worsens the bridge condition.

However, the problem settle when Roman appears to became the first to realize that the constructed bridge requires some special attention. Bridges like the Alcantara Bridge over the River Tagus in Spain (more than 200 years old) and Pont du Gard near Nimes in southern France are examples of well-constructed and maintained Roman bridges. Roman practices are good examples of bridge management system (Ryall, 2010).

Bridge management system is a system that used to manage all the bridge management activities in order to make the bridge maintain fit and safe throughout its life span.

1.3 Objectives

The related objectives of this research are as follows:

i) Study on different types of bridge management system.

ii) Study on current practices of bridge management system (Case study: Penang Bridge).

iii) Compare and to highlight the merit and demerit of Bridge Management System in Malaysia.

1.4 Scope of Study

This research concentrates on the study of the bridge management system (BMS) worldwide. BMS for each country is differs with one another. For example, Malaysia used a bridge management system called as 'JKR BMS'. Other examples of bridge management system for other countries are DANBRO (Denmark) and PONTIS (U.S.A).

Besides, this research also highlight on the current practices of bridge management system used in Malaysia which Penang Bridge was used.

As for the analysis section, this research will do the comparisons between the bridge management system that practice in Malaysia and worldwide and highlight the merit and demerit of the systems used in Malaysia.

1.5 Study of Methodology

The flowchart below explained the research methodology that was implemented in order to complete this research.

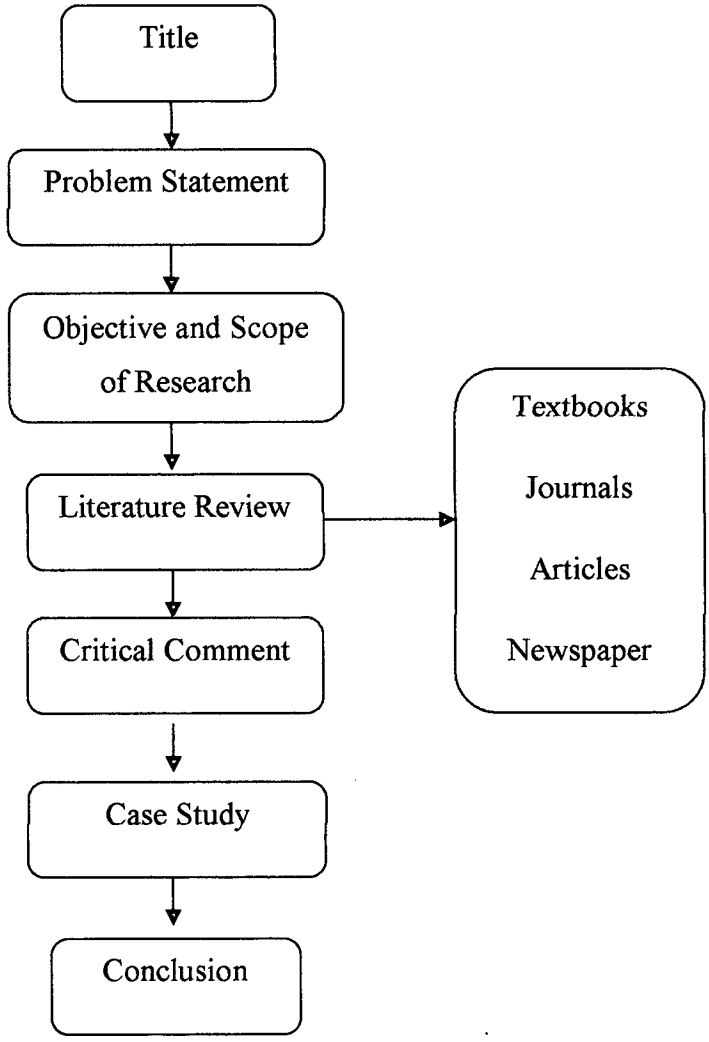

Figure 1.5.1: Flowchart of the methodology.

1.6 Significant of the Study

The study of bridge management system becomes very important after a great number from the bridge in Malaysia are showing varying degrees of deterioration. Bridge management systems need inputs that obtained from inspection process and will produce the maintenance that need to carry out as well as the cost for the maintenance work.

A systematic bridge management system helps in reducing the deterioration of the bridge. Thus, the bridge is safe to use by the public throughout its life span. Besides, the systems also help to figure out most economic solution for each bridge problem.

CHAPTER 2

LITERATURE REVIEW

2.1 Bridge Management

2.1.1 Introduction

Bridge management became an important task that every country needs to pay attention over last decade. Almost all bridges show the signs of deterioration even just after the construction completed (Omar, Razak, King, & Arshad, 1992). Unfortunately, the bridge engineers and authorities that acknowledge the problem failed to plan for future planning at the conception and design stage to prevent the problem repeatedly and in the mean time able to maximise the bridge durability and reduce number of maintenance.

2.1.2 Bridge Management

Bridge management consist of all activities carried out to ensure the bridge is safe and serviceable throughout its life span. The activities are bridge inspection and

assessment, bridge reconstruction, bridge maintenance and rehabilitation. According to M. J. Ryall (2010), the bridge management activities are collection of inventory data, regular inspection, assessment of condition and strength, repair, strengthening, or replacement, prioritising allocation of funds and the safety.

Bridge management activities lies in the six critical stages of the bridge life span.

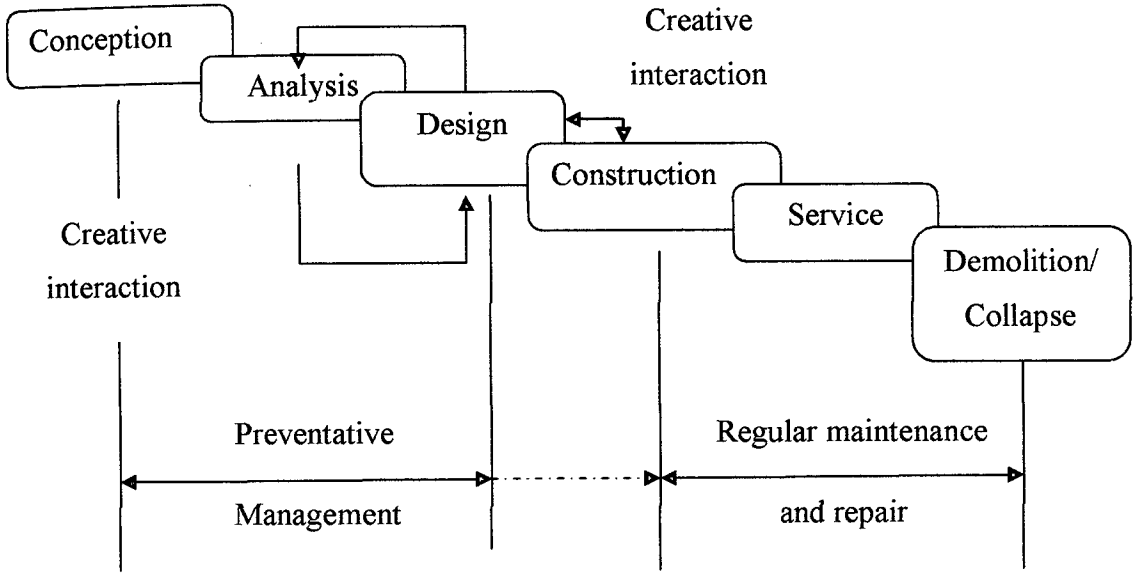

Figure 2.1.2.1: The six stages of bridge life span.

The six stages explained that the management activities divided into two stages. Preventative management is important to ensure the bridge was design with implementation of sound principle. Thus, the durability of bridge could be maximise and reduce the maintenance needed. Preventative management is in conception, analysis and design stage.

Conception is the first step in translating the criteria and site constraints into a workable design. At this stage, the objective is primarily to select concepts and identify and solve major design problems. It is basically the verification that there are no physical constraints which will prevent meeting the production goals and purposes of the project.

The conception stage identifies, assesses, and recommends design alternatives for meeting production goals. These alternatives should reflect the use of local construction techniques and materials where applicable.

Analysis and design stage are closely related and usually run at the same time. In analysis stage, there are two important parameters that need to be analyzed; project evaluation and project finance.

Following preparation of the cost estimates, a preliminary financial analysis can be made to determine if there are financial constraints to proceeding with the project as it has been conceptualized. The financial analysis must consider the objectives of the project, including cost/benefit requirements of the owner and financing organization.

In design stage, the project were design based on the concept that done earlier. In the meanwhile, the design must also consider all the analysis done.

At regular maintenance and repair stage, here the actual management exist. This started with collection of the basic bridge data in the form of a database followed by the regular logging and recording of information through inspections to examine the bridge condition and also the rate of deterioration.

Then, the information from both managements and other information are used to analyze load-carrying capacity which that bridge able to withstand. Besides that, the information also helps in order to prior the financial resources for maintenance purposes.

At bridge management, there are two types of approach that could be practice which are bridge management at project-level and bridge management at network-level.

2.1.3 Bridge Management at Project Level

The bridge management research on the individual bridge can be categories as project-level type. Project-level contains several modules that deal with activities that related to individual bridge such as (Omer, 2004):-

a) Inspection Module

The engineer records observation of the condition of the bridge during inspection. The extent and severity of major defects on structural elements are recorded in detail. This module helps in identifying the causes of defects and distress in structural elements. The knowledge-based system in this module contains a hierarchical knowledge structure; the most important component is usually addressed first in top-down design. This design is used when the knowledge-based system is designed to achieve goal/or sub-goals, based on the resolutions of rules that are establish. An example of a typical defect diagnostic system is shown partially in *Figure 2.1.3.1.*

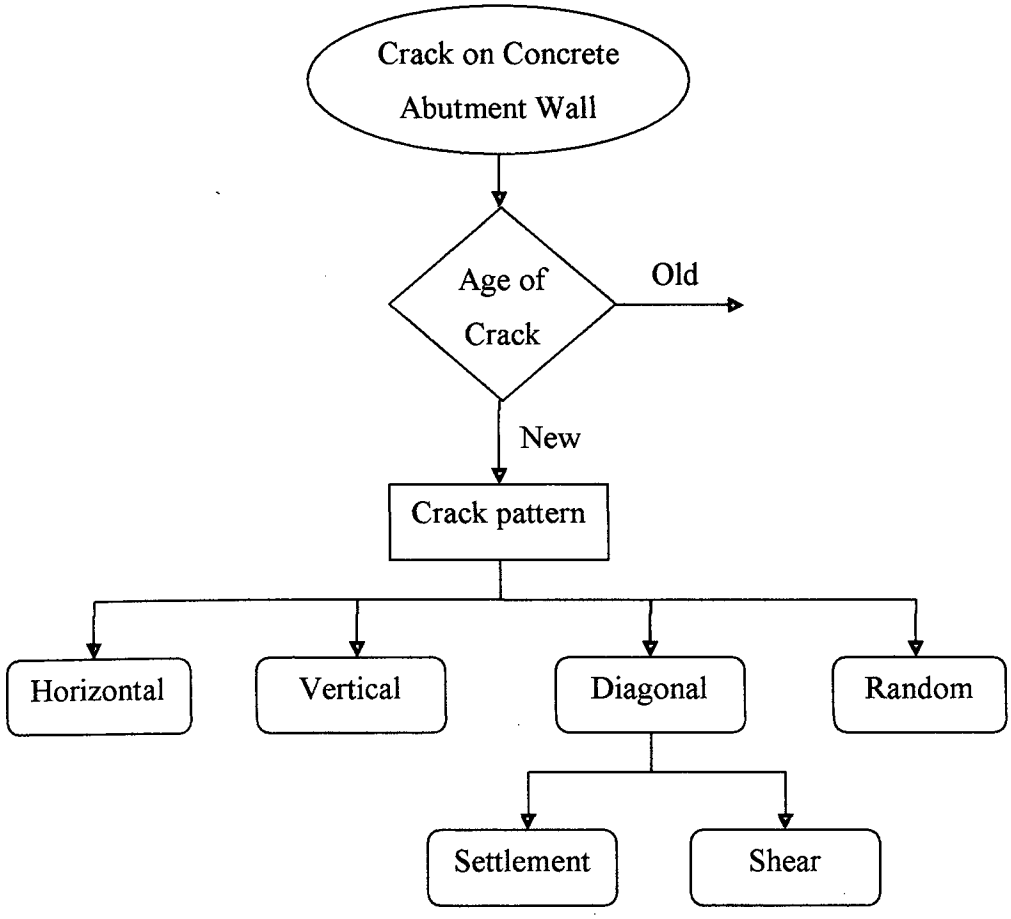

Figure 2.1.3.1: Example of Rule based hierarchical knowledge structure for defect diagnosis.

b) Deterioration Module

Deterioration modelling is used to conduct an analysis of the possibility of the defects worsening over the period of time once the cause, extent and severity of defects on a bridge are recorded (usually the worst affected) to determine the remaining life of that structural element. This module identifies whether the element needs attention.

The analysis of the deterioration rate is carried out using a Markovian deterioration model shown in ***Figure 2.1.3.2*** as described by Thompson and Kerr (2000). The model uses the information gathered during the inspection process to provide an easy way to explain possibility of each possible change in circumstances from time to time. The Markov model assumes that measurements are taken or used at evenly spaced intervals, and that the condition in the next interval depends only on the current condition state and not on any other attribute.

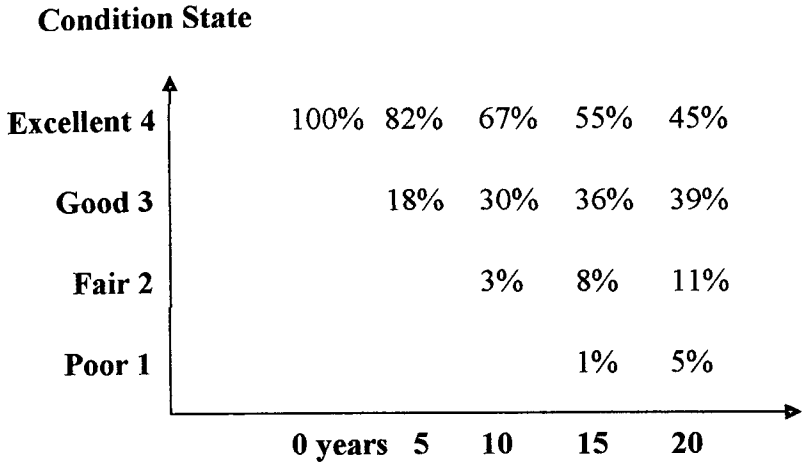

Figure 2.1.3.2: Markov Model (Markov et al 1993).

Since the deterioration modelling conducted at the project level, an adjustment factor is required to calculate the deterioration probabilities. The adjustment factor would come from knowledge-based models that reflect any relevant bridge or element attributes in the database, including the behaviour of other elements on the same bridge, and attributes of the environment in which the bridge is located.

c) Treatment Alternative Module

Alternative treatment can be identified based on the result of the deterioration model. The deterioration model predicts the condition of the element at the end of each treatment period. This condition is predicted to become the basis for generating a list of appropriate treatment for the second period, which in turn allows the model to predict the deterioration condition at the end of the second period for each treatment. This simulation pattern is a traditional life cycle cost analysis that can be repeated for as many periods as possible.

Each possible combination of element-level treatment on a bridge is a potential alternative projects. Although this theory is hundreds of possible alternatives can be found on a typical bridge, only a few are practical from the economic and engineering aspects. The system uses a knowledge-based model to reduce the list of alternatives to a manageable number.

The benefit of a project alternative is the saving in life cycle social cost that is achieved by implementing the project rather than doing nothing. It includes the difference in life cycle cost between subject project alternative and the do-nothing alternative, plus the predicted savings in user cost. Issues such as political pressure and interrelationship of the project, determined manually or by knowledge-based models can also contribute to the calculations of interest.

d) The Maintenance Module

An important part of the maintenance activity is the rehabilitation or repair methods. The treatment alternative model to identify the technical options for rehabilitation of various bridge elements and the maintenance model determines how