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THE JKR BRIDGE MANAGEMENT SYSTEM (JKR BMS)

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ABSTRACT

The Bridge Unit of JKR (Public Works Department Malaysia) is currently developing a computerised bridge management system as a management tool to provide information and decision supports to managers. It is hoped that this would afford a more effective and efficient approach to the management of existing stock of over 4500 bridges under JKR jurisdiction in Peninsular Malaysia.

This paper describes the concept of the prototype JKR BMS as a computerised database management system and also a decision support system. It explains and discusses the functions of the system, as well as how the various components work together to achieve such functions. The importance of the "man" component of the *man-machine* system is also highlighted.

INTRODUCTION

The National Axle Load Study Phase I & II (1986-1990) has identified that out of 2,386 federal bridges inspected in Peninsular Malaysia, at least 500 bridges are rated as undercapacity, in dangerous states or in unsatisfactory conditions. This means that one out of every five bridges in the federal route network needs some

sorts of improvement actions. It is believed that the conditions of state bridges are even worse in view of the fact that generally less attention is being paid to state bridges.

With such large quantity of bridges needing immediate attention and so scarce the maintenance fund; compounded by the limited information regarding these bridges, the attempt to solve the present bridge problem remains a management problem rather than a technical one! It calls for a more systematic approach to replace the traditional ad hoc approach.

JKR has long realised the need to systematically inventorise its bridges. However, no serious effort was exercised to initiate a maintenance management system until in 1988.

A prototype system has now been developed using the dBASE IV database management system. It is developed in-house by a task group formed within the Bridge Unit of JKR. The system has been called JKR Bridge Management System or JKR BMS. The background towards the development of the JKR BMS has been reported in [1].

This paper briefly describes the concept used in the prototype system. It explains and discusses the functions of the system, as well as how the various modules work to achieve such functions.

WHAT IS A BRIDGE MANAGEMENT SYSTEM?

A bridge management system (BMS) has been defined as "any system or series of engineering and management functions which, when taken together, result in the actions necessary to manage a bridge program" [2]. The National Cooperative Highway Research Program (NCHRP) report on Bridge Management System has defined it as a "rational and systematic approach to organising and carrying out the activities related to planning, designing, constructing, maintaining, rehabilitating and replacing bridges vital to the transportation infrastructure" [3].

In summary, a BMS could be viewed in three perspectives:-

- i. Objective: the management of bridge-related problems in a more cost-effective manner.
- ii. Approach: the use of a systems approach by systematically coordinating all related activities towards a common goal.
- iii. Techniques: the use of OR techniques (management science) in problem solving & decision making; and the use of computer and EDP (electronic data processing).

COMPONENTS OF THE JKR BMS

The activities within the JKR bridge management system as well as their inter-relationships could be shown in a data flow diagram (Fig. 1). In order that the system will continue to function, all these activities must be carried out appropriately in accordance with some established sets of procedures. The procedures that could be automated are programmed in the computer. Other procedures are set down as standard rules in manuals or guides.

The JKR BMS could be broadly divided into three main components; namely the Data Bank, Computer Programs and Manuals.

The Data Bank keeps all the necessary bridge data in the forms of computerised database, microfilms and manual files.

Computer programs are written in the dBASE IV language to customise the decision-making/problem-solving models used in each module.

The Manuals/Guides document everything related to the JKR BMS. One such manual sets forth the procedures to update the Data Bank.

FUNCTIONS OF THE JKR BMS

The JKR BMS has been designed to aid Bridge Manager (BM) in the following activities:-

- i. Ranking of bridges for improvement.
- ii. Selection of the 'best' improvement options.
(Options available are to do nothing and continue with routine maintenance, rehabilitation or replacement.)
- iii. Retrieval of bridge information.
- iv. Preparation of annual budget & cost estimates.
- v. Management of abnormal vehicle movement.

These functions are achieved through a suite of computer programs that constitute the problem-solving/ decision-making modules.

The basic modules in JKR BMS are:

1. The Prioritisation Module
2. The Prediction Module
3. The Data Bank Module
4. Bridge Information Module
5. Cost & Budget Module
6. Abnormal Vehicle Movement Module

The Prioritisation Module

The Prioritisation Module consists of computer programs which attempt to optimise a decision. It is divided into two submodules:

- i. 'Prioritisation at the network level' submodule
- ii. 'Prioritisation at the project level' submodule

The submodule of 'prioritisation at network level' helps the BM to decide which bridge(s) in the network to take action first. Ranking of bridges is done based on the decision tree approach where priority point is attributed to each bridge based on some criteria. The criteria affecting such ranking are:

- * structural integrity
- * carriageway widths
- * vertical clearance
- * average daily traffic

Weightages are assigned to each of these criteria depending on the significance attached to them.

The submodule of 'prioritisation at project level' helps the BM in deciding the 'best' action to a bridge. This is based on some simple economic analysis where discounted costs of various options of improvement work are computed and compared.

Fig. 2 & Fig. 3 show some examples of the outputs for prioritisation module.

The Prediction Module

The Prediction Module serves to provide supports to the Prioritisation Module by predicting the remaining service life or the extended service life (due to an improvement work) of an existing structure. The module works on a simple model representing the deterioration of bridge structures with time. This deterioration model is constructed using bridge information from the database. As such it is a dynamic one which will be refined as more data are collected and stored in the database.

The module also predicts future financial needs based on the *equivalent age* of the bridges in the network. This is assuming that deterioration is a function of some time-dependent parameters, for example, corrosion.

The Data Bank Module

The Data Bank Module involves the collection and storage of relevant bridge data. As was mentioned earlier, data are being stored in three mediums. Computerised database is the main one and is indeed the core of the JKR BMS.

Each bridge structure is uniquely identified with a reference number. To afford future integration with the BS(M) Pavement Management System, the reference system used in BS(M) has been adopted. In this system, a bridge structure is assigned with a Route Number followed by a Structure Number depending on its location from the point of reference pertinent to the route. Thus, structure FT001 329/41 is located along federal trunk route No.1 and is at 0.41 km from Section No. 329 which is approximately 329 km from the road origin, J.B. (At the moment the distance between two consecutive Section No. is 1.0 km but the Section No. will remain irrespective of any future change in the distance due to road realignment). This reference system is replacing the old system used in JKR's old inventory report [4].

Each bridge record in the database actually covers the data for a particular bridge system at a particular bridge location. As such, a 'hybrid' bridge consisting of two different structural systems, say, a two-span bailey bridge system and a one-span RC girder bridge will be entered in the database as two records having identical reference number.

Bridge data can be conveniently categorised into:

- * Bridge Inventory Data
- * Bridge Condition Data
- * Bridge History Data
- * Historical Cost Data

Bridge Inventory Data includes the data which describe the bridge in terms of location, type, sizes etc. They do not change unless there is a major rehabilitation or reconstruction.

Bridge Condition Data includes the data which describe the bridge in terms of its physical conditions. Examples are load-carrying capacity and condition rating. (Fig. 4 shows an example of bridge information output).

Bridge History Data summarise the projects that had been completed on the bridge. Some details about the projects, like the year of construction, name of main contractor, etc., are among the useful information under this category (See Fig. 5 and 6).

Historical Cost Data are the tendered prices of standard 'work items' in previous JKR projects. A work item is basically a bid item in the Bill of Quantity expressed in a standardised format. One example is 'Lin.m Expansion Joint of Type A'. The states where the project is done and the year the tendered prices have been quoted are also stored in the records along with the prices. These will permit adjustment to be made on the unit rates to cater for geographical differences and also inflation.

Data are updated in two instances, i.e.:

- i. After a bridge inspection
- ii. At the completion of a project

For convenience, bridge inspection is divided into three types depending on the purpose of the inspection. 'Maintenance Inspection' is done routinely at the district level by technician inspectors. The purpose is to identify any bridge problems that may require immediate maintenance interference.

'Measurement Inspection' is performed regularly at a certain fixed interval (usually two years) by full time bridge inspectors. The purpose of the inspection is to collect bridge data and update the computerised database.

'Improvement Inspection' is performed by bridge engineers who aim to find out the extent of a bridge problem, its root causes and possible ways to improve it.

Out of these three types of inspections, 'Measurement Inspection' provides the surest means to collect bridge data.

At the completion of a project be it a new construction or a rehabilitation work, an as-built report will have to be submitted by the JKR site supervisory staff to the Documentation Unit of Roads Branch. The report should include particulars of the project and any change in the inventory of the bridge. As-built drawings in microfilms are to be included in the submittal.

Bridge Information Module

Under this module the users are able to retrieve information for a specific bridge or a listing of bridges in a network that comply with user-specified conditions. For example, one may be interested to list out all the bridges over river that are located along route FT001, constructed between the years 1957 and 1990 in the state of Johor (Fig. 7).

Budget & Cost Module

(This module is not completed yet.)

The module when completed will provide standard unit rates for cost estimate purposes. It also output a list of prioritised projects with their cost estimates for the purpose of preparing the annual budgets.

Abnormal Vehicle Movement Module

This module is aimed to facilitate the process in approving the application for abnormal vehicle movement permit. The bridges to be crossed by a certain abnormal vehicle could be listed out from the computerised database. The load effect due to the abnormal vehicle is then compared with the load-carrying capacity of each of these bridges automatically. Those bridges that are found to be under capacity will be highlighted. The transporting company will be advised to change the configuration of the vehicle (so as to reduce the load effect) or strengthen those deficient bridges before the movement can be permitted.

HARDWARE REQUIREMENTS

The minimum hardware requirements for running the JKR BMS are:

- * An IBM PC, AT, PC/XT, or PS/2; or any 100 percent compatible microcomputers
- * IBM DOS or MS-DOS version 2 or higher
- * At least 640 k of RAM
- * A hard disk with capacity:-

- i. dBaseIV 3 MB
- ii. BMS programs 2 MB
- iii. BMS data (5000 records) 5 MB

Total capacity required: 10 MB minimum

CONCLUSIONS & COMMENTS

The JKR BMS is still in its infancy and work is still being done to complete it by 1992. The strategy now is to come up with a simple but complete system. Services of specialist consultants in bridge management and systems analysis will be engaged to review the prototype system to identify weaknesses and recommend ways to improve it. The system when fully implemented will be linked among the users in JKR HQ by Local Area Networking.

It is worthwhile pointing out that computer is only a part of any man-machine systems and hence the computerised database alone should not be taken as synonymous to an information system or management system. Indeed, a bridge management system will not be complete without the "man" counterpart. The system in operation must be maintained and managed by people. In this connection, the importance of having a good documentation cannot be over emphasised.

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REFERENCES

1. Tham, K.W. et. al, "Towards Evolving a bridge management system for JKR", 6th REAAA Conference, K.L., (Mar. 1990).
2. "Bridge Management System", FHWA Demonstration Project No. 71, Report No. FHWA-DP-71-01, Federal Highway Administration (Mar. 1987).
3. Hudson, S. W. et. al, "Bridge Management Systems", National Cooperative Highway Research Program Report No. 300, Transportation Research Board, Washington, (Dec. 1987).
4. "Road Inventory and Structures Inventory", Malaysia Highway Maintenance Study conducted by KAMPSAX in association with Sepakat Setia Perunding for PWD Malaysia, (Oct. 1974).

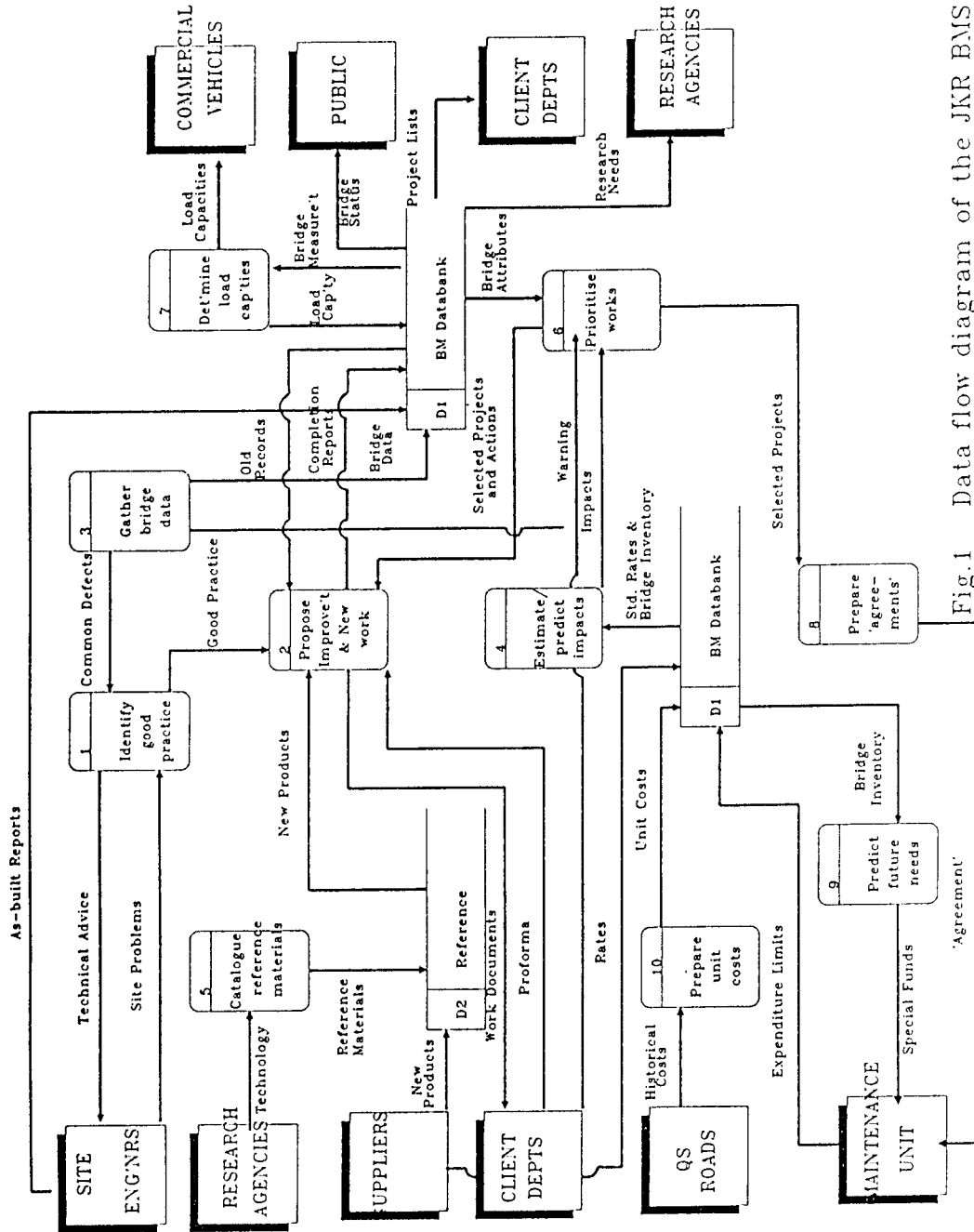


Fig.1 Data flow diagram of the JKR BMS

Bridge Ranking for District: J.B. in State : Johor

<u>RANK</u>	<u>ROUTE NO.</u>	<u>STRUC NO.</u>	<u>CROSSING</u>	<u>SYS-MAT</u>	<u>PRIORITY POINT</u>
1	FT001	297/10	RR	SG-T	76.770
2	FT008	350/00	RR	SG-C	73.400
3	FT001	297/10	RR	SG-C	27.380
.

Fig. 2 Example output obtained from 'Prioritisation at network level' submodule

Results of Economic Analysis

ROUTE NO: FT001		STRUC NO: 245/90	
<u>IMPROVEMENT ALTERNATIVES</u>	<u>DISCOUNTED COSTS</u>	<u>INITIAL COSTS</u>	
1. Rehabilitation option #1	\$1002000	\$300500	
2. Replacement option	\$1442900	\$1300000	
3. Do nothing option	\$1700000	\$0	
4. Rehabilitation option #2	\$1706700	\$150000	

Fig. 3 Example output obtained from 'Prioritisation at project level' submodule

ROUTE NO: FT008, STRUC NO: 350/00

DOC: INVENTORY CARD

DISTRICT, STATE: J.B.

CROSSING : River
SKEW ANGLE : Right DeckNAME OF RIVER : JOHOR
NAME OF STRUCTURE: SULTAN AHMAD

YEAR OF CONSTRUCTION : 1970

MATERIAL : CONCRETE

SYSTEM : Simple Girder

GEOMETRY -

NO OF SPANS : 1
MAX SPAN LENGTH : 25.00M
TOTAL LENGTH : 25.00M

TYPE -

DECK : P.C.Beam & R.C.Slab
ABUTMENT : Bank Seat
FOUNDATION : Steel Pipe Pile
PIER : No PierCLEAR WIDTH : 12.0M
OVERALL WIDTH : 12.9M

ENVIRONMENT : Severe

AV DAILY TRAFFIC (ADT) : 9000
% HEAVY VEHICLE : 0%
MODIFIED ADT : 9000CAPACITY : MTAL
DISCOUNTED CAPACITY : 5.0 SV

HORIZ. CLEARANCE : 12.0M

NAVIGABILITY : No
HIGHEST FLOOD CLEARANCE : -1.0M

STRUCTURAL CONDITION RATINGS -

FOUNDATION : 1
ABUTMENT : 1
BEARING : 1
GIRDER : 1
DECK : 2
PIER : 0SURFACING : 2
JOINT : 1
PARAPET : 1
APPROACH SLAB : 1
SLOPE : 2

WEIGHTED CONDITION : 1

EQUIVALENT AGE : 5 YEARS

SERVICES -

LLN CABLES : Yes TELECOM : YES WATERMAIN : YES LIGHTING: YES

MAINTENANCE COST : \$5000

CORRESPONDENCE FILE NO : 01/3.1/078

REMARKS :

LAST UPDATE : 14/11/90

Fig.4 Example of bridge data

ROUTE NO: FT008, STRUC NO: 350/00

STATE : JOHOR DOCUMENT: HISTORY CARD

NO.	PROJECT NO.	WORK NATURE	CONTRACTOR
1	0270035	NEW	SEE YOW HUAN
2	0285004	REHABILITATION	WENG FATT

YEAR	TOTAL COST	TENDER DATE	DESIGNER	DESIGN FILE
1970	\$800000	01/01/70	A. Latif	01/23/234
1985	\$80000	15/03/85	Roshid	01/23/006

Fig. 5 Example of bridge history report

BILL OF QUANTITIES FOR PROJECT

NUMBER : 0285004 NAME: AHMAD NATURE: M&R
 (ROUTE NO. FT008, STRUC NO: 350/00) YEAR : 1985

No.	Descriptions	Qty	Rates	Amount (\$)
1	CU.M GROUTING (CEMENT)	10	150.00	4500.00
2	SQ.M PATCHING (CEMENTATIOUS MORTAR)	10	30.00	300.00
3	SQ.M ROAD PAVEMENT (ASPHALITIC CONCRETE)	50	5.00	250.00
4	SQ.M PAINTING OF RAILING (OIL-BASED PAINT)	30	2.50	75.00
5	CU.M GUNITING (FIBRE-MESII)	30	100.00	3000.00

Fig. 6 Example of "work items" involved in a project

STRUCTURES WITH SPECIFIED CONDITIONS

ROUTE NO: FT001 STATE: JOHOR
CROSSING: RIVER 1957 < YEAR OF CONSTRUCTION < 1990

STRUC#	DISTRICT	SPAN	TOT LEN(M)	OV. WIDTH	YR CONST.
195/20	SEGAMAT	1	9.00	13.6	1965
197/00	SEGAMAT	3	30.00	1.1	1970
202/00	SEGAMAT	3	45.72	8.0	1970
228/40	SEGAMAT	1	1.23	16.9	1967
154/90	MERSING	3	26.90	11.0	1972
.....

Fig. 7 Bridge listing obtained using Bridge Information Module