BRIDGE MANAGEMENT IN MALAYSIA

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Abstract

Deterioration of bridges is becoming a common problem faced by bridge agencies around the world. Many bridges have been found to display signs of deterioration early in their design lives. In Malaysia, the Public Works Department (locally known as "JKR") headquarters is responsible for the management of some 6,000 federal bridges in the country. The Bridge Unit of the JKR, though originally a design office, has undertaken to also rehabilitate or repair some of these bridges which have experienced premature deterioration. The Bridge Unit has, through the years, evolved and developed into an authority not only in design standards but also in bridge inspection, maintenance and rehabilitation. The Bridge Rehabilitation Section was created in 1993 with the deployment of existing Bridge Unit staff. This recent development in the organizational set up was motivated by the growth in the need for effective bridge management and also as a result of a series of bridge related studies conducted by JKR from 1985 to 1996. These studies helped establish JKR's design and maintenance practices and had indeed shaped the department's policy in bridge management. This paper discusses the findings and impacts of these studies. Emphasis will be placed in the discussion of how these studies had affected the department's policy in bridge management.

INTRODUCTION

Deterioration of bridges is becoming a common problem faced by bridge agencies around the world [OECD 1992]. Many bridges have been found to display signs of deterioration early in their design lives. Concrete bridges, it is noted, are not really "maintenance-free" as many have believed. Failure to diagnose the damages due to

deterioration and/or to timely arrest the problem may jeopardize the structural safety of the bridge. There is thus a shift in focus from new bridge construction to the management of existing bridge stock. Bridge management encompasses all activities carried out to ensure that every bridge in a highway network remain fit for its intended purpose throughout its life span. Bridge management activities include bridge inspection and assessment, bridge reconstruction, bridge maintenance and rehabilitation. In Malaysia, the Public Works Department (locally known as "JKR") headquarters is responsible for the management of some 6,000 federal bridges in the country. Eighty percent of these bridges are made of concrete. The Bridge Unit of the JKR, though originally a design office, has undertaken to also rehabilitate or repair some of these bridges which have experienced premature deterioration. The Bridge Unit has, through the years, evolved and developed into an authority not only in design standards but also in bridge inspection, maintenance and rehabilitation. The Bridge Rehabilitation Section was created in 1993 with the deployment of existing Bridge Unit staff. This development in the organizational set up was motivated by the growth in the need for effective bridge management and also as a result of a series of bridge related studies conducted by JKR from 1986 to 1996. These studies helped establish JKR's design and maintenance practices and had indeed shaped the department's policy in bridge management. This paper discusses the findings and impacts of these studies. Emphasis will be placed in the discussion of how these studies had affected the department's policy in bridge management.

THE PWD ORGANIZATIONAL SETUP

The Public Works Department of Malaysia, locally known as JKR, has been the main agency of implementation for Government infrastructure projects. Through the years JKR has done a good service for the nation by providing, operating and maintaining the country's infrastructure. There are a total of 45,000 km of roads in Malaysia; 16,000 km of which are Federal roads. Recent bridge inspection exercise recorded over 6,000 bridges along the Federal roads. There is as yet no full inventory for state bridges. The Bridge Unit of JKR has been responsible for the upkeep of the Federal bridges and it also advises the states on bridge-related problems. Prior to 1985, Bridge Unit was under the Design and Research

Branch* (see Fig. 1). The main function of Bridge Unit then was to design bridges. By way of in-house designs and review of contracted consultants' designs the Bridge Unit had become the authority in bridge design in this country. In 1985, Bridge Unit was transferred to the Roads Branch. Although the main activity was still in bridge design, bridges were now seen as a component of a coherent road network system.

Bridge Unit has since early 1980's been engaging in bridge repair and rehabilitation works. Like other bridge agencies around the world, JKR saw the need to extend the service lives of existing bridges. This had come about due to the great number of bridges found to be in bad shapes and the replacement of all of them was simply not feasible. Also, expertise within Bridge Unit in bridge maintenance and rehabilitation had grown thanks to a number of bridge-related studies conducted by the department.

In 1995, the Director of Roads had directed the implementation of the Annual Mandatory Bridge Inspection Program (AMBI) [Yusof, N. M. 1996] in response to the collapse of the Songsu Bridge in Seoul [World Highway 1994]. The program mandated an annual visual inspection of all Federal bridges by the district technicians. Bridges with components rated as 'dangerous' or 'poor' are earmarked for "confirmatory" inspections by headquarters engineers. A bridge maintenance and rehabilitation program is subsequently scheduled based on these inspections. The AMBI program actually marked the official endorsement by the JKR Management of the Bridge Rehabilitation Section within the Bridge Unit which had existed since 1993.

BRIDGE-RELATED STUDIES

As mentioned above, the development that helped bring Bridge Unit to the present level of expertise in bridge management could be attributed to a number of studies conducted by JKR. They are:

- Bridge inventory (1972-74, 1978)
- National Axle Load Study I & II (1985-89)

* The Design & Research Branch is now called the Structural & Specialized Engineering Branch.

- Japan International Cooperative Agency (JICA) Study on Bridge Maintenance & Rehabilitation (1990-92)
- Study on the Determination of the Structural Capacity of Existing Bridges in Peninsular Malaysia (1993-95)
- JICA Study on the Standardization of Bridge Design in Malaysia (1994-96)

Bridge inventory (1972-74, 1978)

In 1972-74, Kamsax A/C of Denmark, in association with a local consulting firm SSP, Kuala Lumpur, was engaged to prepare an inventory for Malaysia's Federal bridges. This inventory was partially updated around 1978. The inventory was more a register of existing structures and was somewhat limited for the purpose of bridge management decision-making. Since the data which were in report forms did not serve any purpose there was no effort to update the inventory. Most JKR districts however continue to inspect their structures on an ad hoc basis, mainly during the rainy seasons. The JKR district offices kept their own registers of bridge inventory in log books quite distinct from the Kamsax inventory. An attempt to initiate a systematic bridge inspection and strength assessment program was made by Bridge Unit in 1984 (Mansfield and Ng 1984). Although not implemented, the effort had generated much interest among Bridge Unit engineers in bridge inspection, maintenance and rehabilitation; as well as computerized database management systems.

National Axle Load Study (1985-89)

Traffic study had revealed that a very high percentage of passenger and freight traffics in Malaysia rely on the road transport. To improve the efficiency of the road transport the National Axle Load Study I (NALS I) was started in December 1985 and completed in October 1987.

NALS I was conducted by British firm Rendel Palmer & Tritton Ltd. in association with local firm Minconsult Sdn. Bhd., Kuala Lumpur [Government 1988]. The main objective of the study had been to establish the optimal axle load limit to be implemented as a national policy. The study involved investigations on the capacities of existing infrastructure and traffic survey. In the conduct of the study a total of 2,500 bridges along Federal roads

were inspected and inventorized. The study had revealed that the existing infrastructure, especially the bridges, is a physical constraint to the intended increase in legal axle load limits. Three axle load policies were recommended to be implemented in phases: the Short Term Axle Load (STAL) Policy, the Medium Term Axle Load (MTAL) Policy and the Long Term Axle Load (LTAL) Policy. In order to implement the STAL policy approximately 20% of the inspected bridges need to be replaced or strengthened. In the interim, the Weight Restriction Order 1987 covering all Federal roads in the country, was revised and gazetted in 1989 [Government 1989] and later an amendment issued [Government 1991].

Other than serving the objectives of the study NALS I had also taken a closer look at the live load specifications for bridge design and the durability of concrete problems. These were in line with the current development in the UK in these two areas. NALS I had also pointed out a few bad maintenance practice within JKR: excessive overlay of bituminous surfacing over bridge decks and repair efforts by the JKR districts which were not properly designed for and therefore did not serve any structural improvement. An extension of the study called NALS II was later carried out and completed in 1991.

NALS I had benefited Bridge Unit in many ways. An immediate answer to the findings of NALS I was the replacement of the poorly rated or substandard bridges (in terms of design load) which were beyond economic repair. The need for an inspection and maintenance section within Bridge Unit was recognized [Tham 1987]. Further, the alarming status of the nation's Federal bridges now uncovered by NALS I, had helped convince the Treasury to approve Bridge Unit's project to computerize the office. The study had also generated much interest among Bridge Unit engineers in the study of the durability of concrete and non-destructive tests (NDT) of concrete structures. It had become well known that concrete is not really "maintenance-free" but subject to environmental "stressors" like carbonation, chloride attacks, alkali aggregate reactions (AAR); etc. This realization had prompted JKR to revise the department's standard specification for concrete to pay more attention to curing of concrete and provision of sufficient concrete cover. NDT became standard items of work in Bridge Unit's repair contracts. At the same time, the bridge data collected during NALS I became handy when the department created its own computerized bridge management system called JKR BMS [Tham et al 1990, Tham et al 1991, Wahid et al

1992]. The JKR BMS prototype model was later reviewed by two Bridge Management System experts appointed under the World Bank funding [Hudson & Moser 1991].

Also, a specification for bridge live loads based on the recommendations of NALS I was drafted and implemented [Ng et al 1990]. Among a few important innovations in the new specification were

- a new load intensity curve based on UK Department of Transportation's bridge document BD21/84 [DoT 1984] was introduced in place of the curve in BS 5400 Part 2 [BSI 1978]. This loading standard would conform to the futuristic LTAL policy.
- use of a fixed 2.5m lane instead of variable lane width
- introduction of a more realistic local abnormal vehicle called Special Vehicle or SV to replace the UK's HB loading as specified in BS 5400 Part 2 and earlier bridge codes

An equivalence of UK's bridge document known as DJ 1/89 was produced to formalize the implementation of the new specification. This specification was in use for JKR projects until the adoption of UK's bridge document BD 37/88 [DoT 1988] in the JICA Study on Bridge Standardization [JICA 1991].

JICA Study on Bridge Maintenance & Rehabilitation of Bridges in Malaysia (1990-92)

The proposal for this study [JICA 1992] came in response to the findings of the National Axle Load Study I and II and after the completion of the JKR BMS prototype model. The objectives of the study were:

1. To develop a systematic maintenance and rehabilitation program for the bridges in Peninsular Malaysia
2. To establish a manual of inspection, maintenance and rehabilitation work covering all the typical bridges in Malaysia.

The scope covered mainly all the poorly rated or substandard (in terms of design load) bridges located along the Federal roads in the Malaysian peninsula which were not already replaced in JKR's replacement programs. In addition to the two major objectives above, the

study team was asked to investigate specific deterioration problems identified during NALS I and II, and to effect technology transfer in the techniques of bridge testings.

The study had produced outputs which became the basis for the department's bridge inspection and maintenance practices. Further, the study had confirmed findings in NALS with regard to concrete deterioration. In particular, carbonation was found to occur mainly in the deck slab while chloride attacks are mainly severe for the piles in marine environment. Suggestion of Alkali Aggregate Reaction (AAR) phenomenon in the Rompin Bridge was also confirmed by the JICA study. However, it was acid attack and not sulfate attack that was severe in the few bridges reported in NALS I. The JICA study had made the following recommendations:

- need to eliminate design and construction deficiencies in new bridges
- need to strictly control overload vehicles
- need to establish an organization for systematic inspection and maintenance

JKR has responded to the recommendations by the approval of a special bridge maintenance fund and the creation of a Bridge Rehabilitation Section within the Bridge Unit in 1993. The study has also led to another JICA study: JICA Study on the Standardization of Bridge Design in Malaysia [JICA 1996].

Study on the Determination of the Structural Capacity of Existing Bridges in Peninsular Malaysia (1993-95)

The study on the Determination of the Structural Capacity of Existing Bridges in Peninsular Malaysia [Government 1995] was carried out by Canadian firm Dessau International Ltd., in association with local firm Ranhill Bersekutu Kuala Lumpur. This study was funded by the World Bank loan. The main objective of the study was to derive an assessment methodology for the calculation of safe bridge capacity of existing bridges in Malaysia. The study was proposed for two reasons:

- Growing concerns of the structural capacities of in-service bridges after the collapse of part of the passenger platform of the ferry terminal at Butterworth in which 32 persons lost their lives and there were over 1543 persons injured [Royal Commission 1988].
- Need of bridge capacities to complete the Abnormal Vehicle Movement module of the JKR BMS [Tham et al 1991].

The study involved the inspections and assessment

of over 200 bridges and full scale test of 15 of them. The Consultant had come up with an assessment methodology which involves:

1. analysis to determine the load effects
2. calculations for resistance
3. rating formula

The procedures were automated in two window-based software called "BRASS" and "RESIST". Also, the load capacity of 203 bridges were determined and became a major output of the study. In general, about 28 % of the bridges under study has a load rating below the STAL standard; and about 60 % of them has a rating below the LTAL standard. The high percentage of bridges with capacity below the STAL standard was largely due to the conservative assumptions made to compensate for the lack of information.

Bridge Unit is in the process of using the software to determine the load rating of every bridge in the JKR BMS database. In general, the study had brought Bridge Unit to a higher level of expertise in bridge appraisal and full scale load tests.

JICA Study on the Standardization of Bridge Design in Malaysia (1994-96)

The JICA study on the Standardization of Bridge Design [JICA 1996] had been a follow-up of the JICA study on Maintenance and Rehabilitation. It was indeed motivated by the earlier study's suggestion of the need to eliminate design and construction deficiencies in new bridges. The main objectives of this study were:

1. preparation of standard bridge design and drawings
2. development of computer-aided design and drafting (cadd) system for standard bridge design
3. preparation of manuals for bridge planning, design, construction and cost estimations

The scope covers only concrete bridges with spans between 5m and 45m; and skewness from 0 to 30 degrees. The study had produced the following outputs which had been used as the department's design practice:

- computer-aided design for superstructure
- computer-aided drawings
- quantity calculations
- substructure design

The standardization of the design had allowed Bridge Unit to speed up the in-house bridge design. It was expected that the automated process would also reduce human errors. However, since the Government is the owner of majority of the nation's bridges and JKR has hitherto been seen as the leader in bridge engineering in this country, the use of this standard designs had a far-reaching effect than is apparent.

First at all, JKR has now endorsed the use the limit state design philosophy in bridge design. The department has long been allowing the use of BS 5400 in the consultant's design but Bridge Unit has continued to use the Allowable stress method (ASM) because JKR's set of standard prestressed beams had been designed based on ASM. Also, the use of BD37/88 loading specification by the JICA study had also put a stop to JKR's very own specification for bridge live loads. In some situation where the British codes do not specify, for example, in hydraulic designs, Japanese practice was adopted.

A more significant impact would be to the local fabricators of precast prestressed beams who had hitherto been producing the old JKR beams and UK's M-beams. The implementation of the new standard design would require them to acquire new sets of molds. JKR has started using the standard sections in its in-house designs. Notwithstanding, a joint

research with a local university is underway to further investigate the behavior of these standard sections.

CONCLUSIONS

From the above discussions, it is apparent that the National Axle Load Study had benefited Bridge Unit in many ways. Besides fulfilling the study's objectives it has also triggered a series of other studies. These studies had helped bring Bridge Unit to the present level of expertise in bridge management. They had also determined the department's policy in design and other bridge management practices. A summary of how these studies had been triggered by NALS is shown in Fig. 2.

Presently three studies quite related to the National Axle Load Study are underway: 1) The enhancement of JKR BMS; 2) the Study on Asset Management for Main State Roads and 3) the Axle Load Study III. In the light of previous experience it is envisaged that Bridge Unit would tend to gain from these three studies besides the expected outputs as spelled out in the terms of reference for said studies.

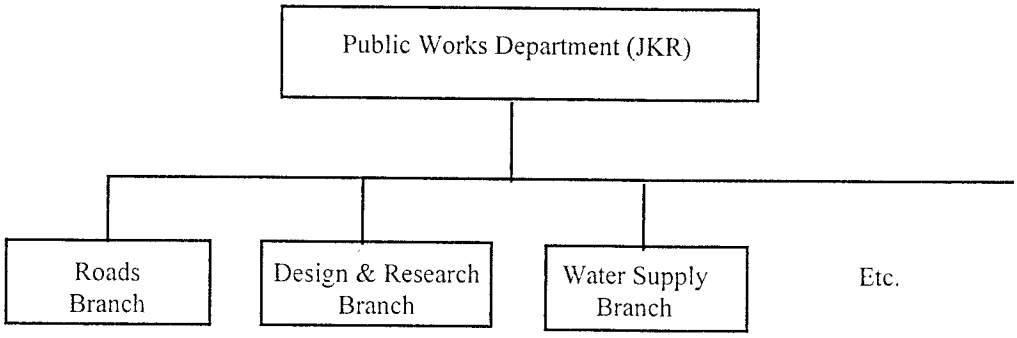

Fig. 1 JKR Organization

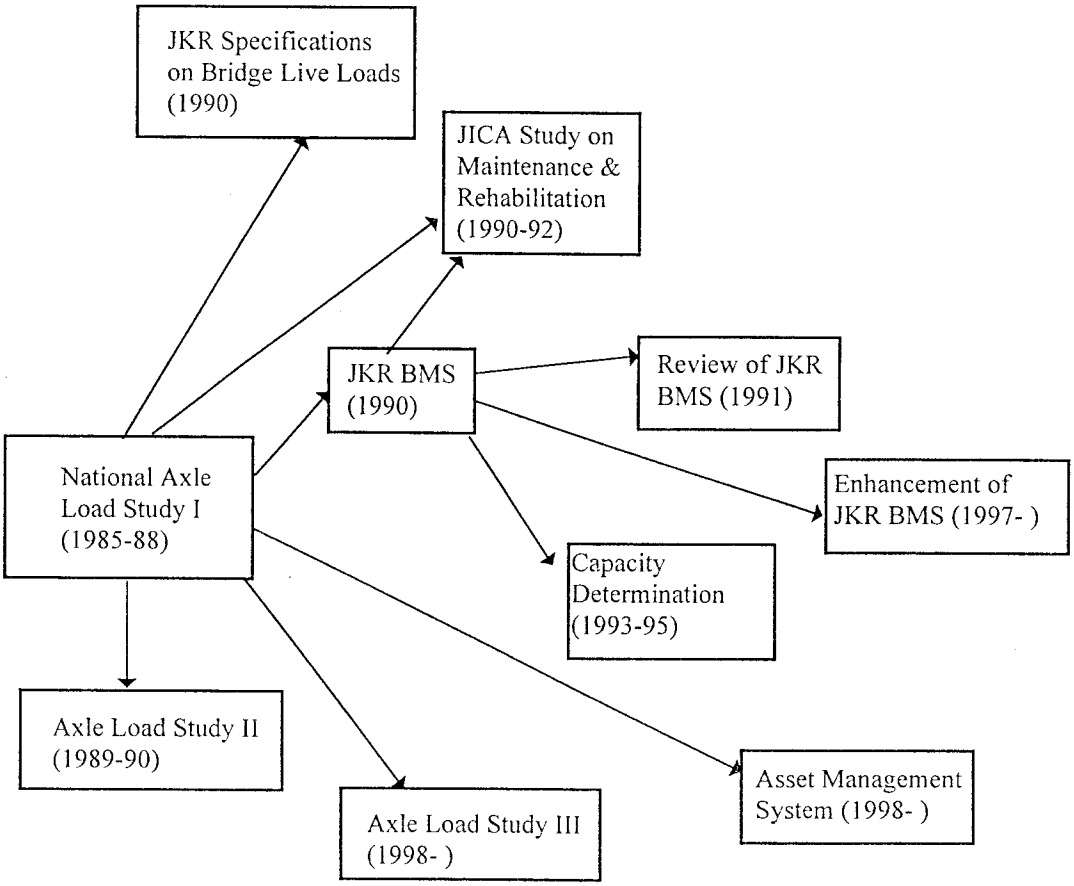

Fig. 2 Bridge-related Studies by JKR

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