MALAYSIAN BRIDGES – STATUS AND CONDITION

Dr. Ng See King
Bridge Unit, Roads Branch
PWD Malaysia
Kuala Lumpur

1.0 Introduction

In Malaysia, JKR is the custodian of majority of the nation's road bridges. Based on recent bridge inspection the total number of JKR bridges along the federal roads is 6,647*. There are probably the same number of JKR bridges along the state roads in Peninsular Malaysia but a complete inventorisation is yet to be carried out. Some bridges in Malaysia are operated and maintained by private concessionaires of tolled highways. The names of various concessionaires are given in Table 1 [1]. In Kuala Lumpur, the City Hall (DBKL) has more than 155 bridges [2]. JKR bridges constitute more than 90% of the nation's bridge stock. It is deemed appropriate, therefore, that discussions in this paper will focus mainly on JKR bridges although the title calls for 'Malaysian bridges'.

JKR has since the 1970's been inventorying bridges. To facilitate the data management of these bridges a computerised bridge management system (BMS) was developed in house in 1990. Some brief account of the history and background of the JKR BMS is presented in [3]. From 1972 till 1996, there are also a number of bridge-related studies conducted by JKR either under JICA aids or through consultancy services. These studies steer the direction of JKR's Bridge Management policy [4]. These studies, through bridge inspections, had also uncovered some common bridge problems in this country.

TABLE 1 CONCESSIONAIRES OF TOLLED HIGHWAY

No	*Highway/Expressway*	*Toll Operators*	*Regulatory Body*
1	North-South Expressway	PLUS	MHA
2	North-South Expressway Central Link	ELITE	MHA
3	Shah Alam Expressway	KESAS	MHA
4	Malaysia-Singapore Second Crossing	LINKEDUA	MHA
5	Kuala Lumpur-Karak Highway	MTD PRIME	MHA
6	Penang Bridge	PBSB	MHA
7	Damansara-Puchong Highway	LITRAK	MHA
8	New Pantai Highway	MAXTRO	MHA
9	Sungai Besi Highway	BESRAYA	MHA
10	Cheras-Kajang Highway	GRAND SAGA	MHA
11	Ampang Elevated Highway	PROLINTAS	MHA
12	North Klang Straits bypass	SHAPADU PROP.	PWD
13	Kuching Road	KAMUNTING CORP.	PWD
14	Seremban-Port Dickson Highway	MELEWAR CORP.	PWD
15	Kuala Lumpur City Roads	METRAMAC	KL CITY HALL
16	Kulim-Butterworth Highway	KLBK	MHA

JKR started the annual mandatory bridge inspection (AMBI) program in 1995 [5]. Under this program, every district inspects its bridges and submits the reports to the HQ (Bridge Unit) annually. For bridges with poorly rated components engineers or technical assistants from Bridge Unit (JKR HQ) would conduct a second round of inspection and come up with a maintenance program. For some bridges, the sites are re-visited for a detailed inspection. In addition to the inspection exercise under the AMBI Program,

* This figure does not include bridges in Sabah and Sarawak.

Bridge Unit bridge inspectors would often inspect bridges when requested by the districts to attend to some bridge problems. All these inspections have afforded the author and his colleagues a good opportunity to assess first hand the status and condition of our bridges.

In order to present a general view of the nation's bridges two areas are covered in this paper: 1) summary of findings from previous JKR studies and inspection programs; 2) observations made by this author and his colleagues in the course of their duty in Bridge Unit.

TABLE 2 BRIDGE TYPES

Structural system types	*Frequency*	*Percentage*
Simples girder	1767	26.58 %
Continuous girder	91	1.37 %
Cantilever	26	0.39 %
Arch	153	2.3 %
Bailey	2	0.03 %
Frame	56	0.84 %
Trusses	0	0
Box culverts	1310	19.71 %
Pipe culverts	3228	48.56 %
Suspension	1	0.02 %
Others	13	0.20 %
	6647	

2.0 JKR Bridges – Some Statistics

The JKR database has 6,647 bridges along the federal roads. These bridges include culverts of span more than 0.5 m. Common bridge types and their percentages are presented in Table 2. It is noted that more than 68% of the bridge stock are culverts. The number of 'true' bridges is 2,096; 84% of which are simple girder bridges.

In terms of the material of the superstructure, JKR record shows that about 88% of the structures are made of concrete (Table 3). This high figure is due to the large number of concrete culverts in the population. Without pipe culverts there are about 77% of concrete structures. This figure drops to about 62% if all the culverts are excluded from the calculations.

TABLE 3 CONSTRUCTION MATERIALS OF SUPERSTRUCTURE

Material types	*Frequency*	*Percentage*
Concrete	5849	87.99 %
Steel	626	9.42 %
Masonry/stone	172	2.59 %
	6647	

Table 4 presents JKR federal bridges in three age groups. As a general guide, we take 40 years of age as the mid-life of a typical bridge when a major rehabilitation is needed; and 75 years as the useful life of a typical bridge. From Table 4, it is seen that about 82% of the bridge stock have an age of less than 40 years old and only 0.41% of the population are over 75 years. Fig. 1 presents the distribution of bridges by the years built. From Fig. 1 it can be seen that in 1999, about 142 bridges will reach the age between 39-40 years; and about 27 bridges have an age over 75 years. Although this is only a rough guide the statistics does indicate that the status of our bridges is not that bad. Indeed, many of the 142 bridges reaching the age of 39-40 next year may have already been rehabilitated earlier.

TABLE 4 BRIDGES OF DIFFERENT AGE GROUPS (AS OF 1998)

Age groups	*Frequency*	*Percentage*
< 40 years	5429	81.68 %
40 – 75 years	1191	17.92 %
>75 years	27	0.41 %
	6647	

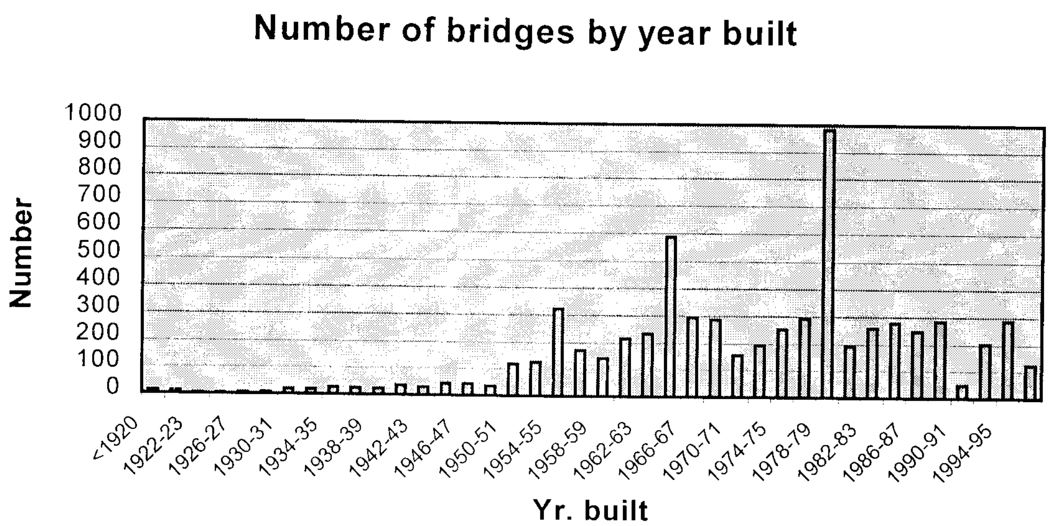

Fig. 1 Distribution of bridges by year built

3.0 Bridge-related Studies and Inspection Programs

JKR has conducted a number of bridge-related studies from 1972 till 1996, which involved inspection of some bridges along the federal roads. These studies are:-

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

- 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)

Some discussions of these studies are given in [4]. This section will highlight only the major findings that would throw some lights about the conditions of our bridges.

Fig. 2 Effect of excessive overlay [6]

The National Axle Load Study I (NALS I) [6] was completed in 1988. It involved inspection of 2,500 bridges along Federal roads. This study revealed that about 20% of the bridge population are in need of some actions ranging from rehabilitation and replacement. Almost all the bridges rated as 'substandard' due to inadequate design load or badly corroded had since been replaced. The NALS I also uncovered many problems related to "naïve" maintenance practices. First, bridge decking is often excessively overlaid with bituminous surfacing; some are as thick as 300 mm. This additional overburden has reduced extensively the live load capacity of the bridge (Fig. 2). Second, remnants of old bridges are often left behind in the river. These bridge remains would obstruct flow of water and cause local scour. Third, a number of repair works performed by district personnel are not effective and gave a false sense of security. Fourth, many concrete structures were found to suffer from carbonation, chloride attack and other environmental agents due to lack of maintenance, provision of insufficient concrete covers and lack of emphasis on assuring concrete durability in standard JKR specifications. JKR has since rectified many of these shortcomings in maintenance practices.

One of the JKR efforts was to conduct of ***JICA Study on bridge maintenance and rehabilitation***[7]. The study involved visual inspection of typical bridges located along the federal roads in Peninsular Malaysia and Sabah and Sarawak; and detailed inspection on a few selected bridges. Five bridges were also load tested. In addition, a few state bridges in Perak, Selangor and Negeri Sembilan were also inspected. 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. Alkali Aggregate Reaction (AAR) phenomenon in the Sg. Pontian Bridge was also confirmed by the JICA study. However, it was observed that the acid attack cases reported in NALS I were indeed due to a combination of acid attack and high water-cement ratio in the concrete. The JICA study also made the following observations:-

- Steel and concrete beams have suffered advanced deterioration as compared to other members such as concrete deck, abutment. Steel beams of buckle place construction are the most badly corroded members.
- Concrete deck slabs are the most sound members among the bridge components.
- The concrete cover for deck slab varied from 25mm to 50 mm and was considered adequate. The concrete cover for beam soffit averaged at about 30mm and is slightly inadequate. It was also found that the concrete cover of about 40mm provided for R.C. piles and substructure was not adequate and a cover of 70mm was recommended.

The study on the Determination of the Structural Capacity of Existing Bridges in Peninsular Malaysia [8] was carried out for the purpose of deriving an assessment methodology for the calculation of safe bridge capacity of existing bridges in Malaysia. The study involved inspections and assessment of over 200 bridges and full-scale test of 15 of them. 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 have 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.

The JICA study on the Standardization of Bridge Design [9] was a follow-up of the JICA study on Maintenance and Rehabilitation. It was indeed motivated by the earlier JICA study's suggestion of the need to eliminate design and construction deficiencies in new bridges. The study again involved bride inspection and this had afforded us the opportunity to assess the condition of our bridges.

* STAL stands for Short-term axle load limit. It represents the standard in conformance with the Weight Restriction Order of 1989 [10].

♦ LTAL stands for Long-term axle load limit. It represents the standard in conformance with the then JKR standard specification for design.

Among the findings of these inspections we summarise only those relevant and noteworthy ones:-

- Severely damaged bridge was not found
- Most elastomeric expansion joints were damaged
- Many elastomeric bearing pads were not sufficient in thickness compared with JKR's standard design
- Some rubble pitching (slope protection for abutments) were damaged due to insufficient embedding or no weepholes.
- Most old bridges were too narrow
- Pavement overlay became very thick
- At some bridges near the towns, water mains were installed on side walks and hinder pedestrians
- Use of rubberised asphalt plug type of expansion joint seems to be successful
- Many pile caps for piers were not buried under the riverbed or not sufficiently buried.

Annual Mandatory Bridge Inspection (AMBI) Program [5], which involves a series of bridge inspections was started in 1995 following the failure of Songsu Bridge in Korea in 1994 [11]. Table 5 presents the results of mandatory bridge inspections carried out in 1995 up to 1998. It is noted that the percentage of bridges inspected that were found to be in the ratings of 4 or 5 is rather high every year. The percentage of bridges in that category does not seem to dwindle (except for 1996) despite regular annual maintenance works. Regardless, the maintenance funding needed to repair the damages is in the region of RM 5 million annually.

TABLE 5 RESULTS OF MANDATORY BRIDGE INSPECTIONS

Year surveyed	*No. inspected*	*Frequency*	*Percentage*
1995	3170	746	23.5 %
1996	4810	677	14.1 %
1997	2861	716	25 %
1998 (up to September)	2580	539	20.9 %

4.0 Discussions and Conclusions

The bridge inspections conducted at different points in time under different studies provide us with a scheme to appraise the status of our bridges. Maintenance prior to 1980's was lacking and NALS had revealed to us the bad states of our bridges. Many efforts were made by JKR to improve the situation: creation of JKR BMS, conduct of JICA study on bridge rehabilitation, Study on capacity determination, JICA standardisation study and finally the formation of the Bridge Maintenance Section within Bridge Unit. It is no wonder that bridge inspections carried out in the last study (JICA standardisation study) did not report any severely corroded bridges. We would take this observation as an indicator that the status and condition of Malaysian bridges had since been improved.

Nevertheless, there are still weaknesses in the current JKR practice, which somehow remain with us. They are:

- Rampant failure of elastomeric typed expansion joint
- Excessive overlay of premix surfacing
- High pile caps for piers

One other lacking in JKR maintenance practices, is failure to recognise the severity of scour problem in this country. It is suspected that the reduction of fixity of the piers due to local scour had been the cause of excessive vibration experienced by many road users. Examples are Sultan Ismail Bridge in Muar, Plentong Bridge in Johor Baru, Tempias Bridge in Sabah and Golok Bridge in Kelantan. JKR Bridge Unit is hoping to conduct "echo-sounding" surveys to verify this observation.

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