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# RATING OF HIGHWAY BRIDGES IN LAHORE-PAKISTAN

M. A. Saleem<sup>1</sup> and S. B. Rafiq<sup>2</sup>

## ABSTRACT

Deterioration of highway bridges has been a critical problem across the globe. National Bridge Inspection Program in the U.S. unfolded that 41% bridges in the country are structurally inadequate and dangerous to use, and every week a bridge sags or collapse<sup>[1]</sup>. Inadequate sign boards, poor alignment and approaches annually kill 1000 American<sup>[2]</sup>. All of these problems also exist in Pakistan. This qualitative study focused on in depth inspection of bridges and assessment of their performance based on the condition, and load rating of bridge components. An index termed as Bridge Performance Index (*BPI*), which ranges from 0 to 10, has been developed to quantify the overall performance of a bridge based on the condition of the structural components, non-structural elements, geometric and safety features. *Mian Meer Bridge* and *Sherpao Bridge* over railway crossings near Lahore Cantt station were selected for this research work. Condition evaluations Performa were developed for various components based on literature. In depth inspection of both bridges has been carried out. Average condition rating of primary members for both these bridges comes out to be 7 on the scale of 9, which means that the primary members are in good condition. However bearing system, drains and expansion joints have been deteriorated and their average condition ratings is 6, 6 and 5 respectively. Around 60% expansion joints in *Sherpao Bridge* widened portion have been deteriorated. Load ratings of reinforced concrete and pre-stressed girders of both bridges have been calculated at the inventory and operating levels, which show that both of these structures are performing at satisfactory level. *BPI* for *Mian Meer Bridge* comes out to be 6.6/10 and 6.4/10 for *Sherpao Bridge*, which shows that bridges are in fair condition and require minor repair work. Research concludes that improper functioning of expansion joints and the drainage system is the primary cause of deterioration of bridges. Bridge rating awareness is very limited in engineering community of Pakistan. There is a dire need to establish an integrated Bridge Management System (*BMS*) in Pakistan.

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Deterioration of highway bridges has been a critical problem across the globe. National Bridge Inspection Program in the U.S. unfolded that 41% bridges in the country are structurally inadequate and dangerous to use, and every week a bridge sags or collapse<sup>[1]</sup>. Inadequate sign boards, poor alignment and approaches annually kill 1000 American<sup>[2]</sup>. All of these problems also exist in Pakistan. This qualitative study focused on in depth inspection of bridges and assessment of their performance based on the condition, and load rating of bridge components. An index termed as Bridge Performance Index (*BPI*), which ranges from 0 to 10, has been developed to quantify the overall performance of a bridge based on the condition of the structural components, non-structural elements, geometric and safety features. *Mian Meer Bridge* and *Sherpao Bridge* over railway crossings near Lahore Cantt station were selected for this research work. Condition evaluations Performa were developed for various components based on literature. In depth inspection of both bridges has been carried out. Average condition rating of primary members for both these bridges comes out to be 7 on the scale of 9, which means that the primary members are in good condition. However bearing system, drains and expansion joints have been deteriorated and their average condition ratings is 6, 6 and 5 respectively. Around 60% expansion joints in *Sherpao Bridge* widened portion have been deteriorated. Load ratings of reinforced concrete and pre-stressed girders of both bridges have been calculated at the inventory and operating levels, which show that both of these structures are performing at satisfactory level. *BPI* for *Mian Meer Bridge* comes out to be 6.6/10 and 6.4/10 for *Sherpao Bridge*, which shows that bridges are in fair condition and require minor repair work. Research concludes that improper functioning of expansion joints and the drainage system is the primary cause of deterioration of bridges. Bridge rating awareness is very limited in engineering community of Pakistan. There is a dire need to establish an integrated Bridge Management System (*BMS*) in Pakistan.

## Introduction

The problem of bridge deterioration is extremely important for a developing country like Pakistan. Reactive approach of authorities in the absence of any scheduled maintenance programs, lack of trained bridge professionals, ill planning due to excessive pressure of completion of a project, false construction practices, and rapid industrialization have resulted in gradual deterioration of bridge infrastructure. Many of the bridge structures have worn wearing surfaces, deteriorated expansion joints, poor riding and are near to expire their service lives. Inadequate funding, lack of attention and environmental effects have made the situation more adverse.

Figure 1(a) highlights the poor maintenance of a concealed expansion joint of a bridge in the city of Lahore. The expansion joint has been worn out with the passage of time, the deck slab

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at the edges of joint deteriorated and was locally repaired several times. To avoid any mishap bricks have been inserted in the joint, which is an improper way of maintenance.

Figure 1(b) shows the wear and tear of an armour steel joint. The expansion joint has been worn out with the passage of time, creating noise and debris collection in joint area. There is an urgent need of thorough investigation of bridges through a well formulated inspection and rehabilitation program.



(a)



(b)

Figure 1. Poor Condition of Expansion Joints: a) Deteriorated Concealed Expansion joint of a Link Canal Bridge; and b) Worn-out Armour Steel Joint of Bridge Over a Barrage.

### Objectives and Scope of Work

Main objective of this project was to carry out rating of *Mian Meer Bridge* and *Sherpao Bridge* near Lahore Cantonment. Secondary objective was to propose an index which could quantify the overall condition of bridge. Mian Meer Bridge is a 59 Span bridge on Mall road Lahore and sherpao bridge has 85 Spans (old arch bridge) and 33 Spans (widened portion) on Jail road Lahore. The objective was to explore the rate and level of deteriorations in both these bridges which have consumed half of their service lives. Both of these bridges were designed and constructed by Punjab Highway Department to reduce the traffic jams at the railway crossings in Lahore Cantonment. Guidelines provided by American Association of Highway and Transportation Officials (AASHTO) were followed to complete the project.<sup>[3]</sup>

### Condition Rating

The first step was to have reconnaissance survey of the bridge, taking the crew and verifying the dimensions of the bridge in full length and across its width for the development of as built drawings. Rating a bridge is primarily dependent on the accuracy of its physical record, that's why dimensional verification is a very important step. Figure 1.2 and 1.3 shows the as built cross section of Mian Meer and Sherpao Bridge respectively.

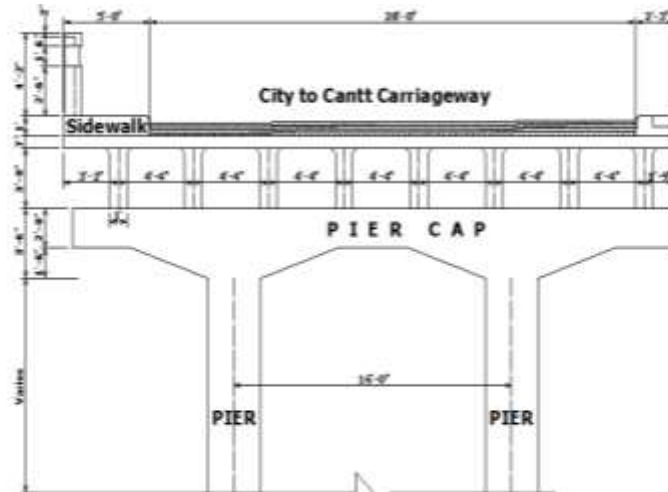


Figure 1.2 Cross section of Mian Meer Bridge

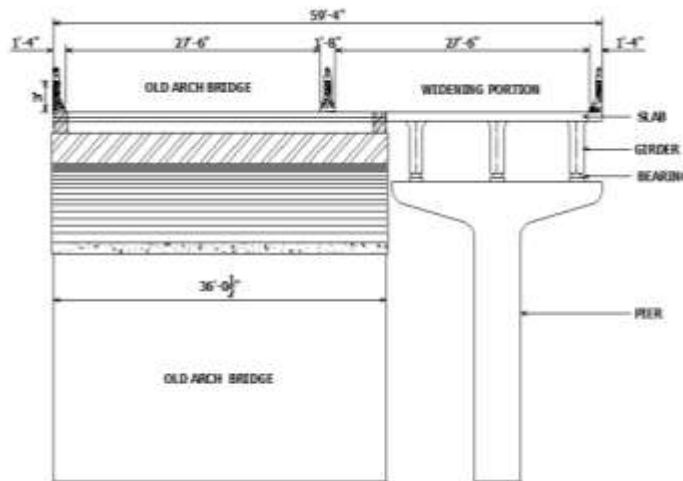


Figure 1.3 Cross section of Sherpao Bridge

After the development of as built drawing, condition evaluation perform were developed for various bridge components. A sample Performa has been shown in Table 1.1.

Table 1.1 Condition Evaluation Performa For Expansion Joints

TYPE	CONDITION	CAUSE	REMARKS
Type of joint			
Free to move?			
Soundness of adjacent Concrete deck			
Debris			
Rusting of joint			
Water tightness of seal			
RATING OF JOINT:			

Condition of various bridge components was assessed and rated out of 9 as specified by FHWA. Then the average condition has been calculated based on the results of the entire spans. For this purpose, the work was carried out from the top most bridge component (railing) to the bottom one (piers). Following is the rate of deterioration in railing and expansion joint, similarly deterioration of other components of superstructure and substructure was assessed and reported in Table 1.2 and graph 1.1.

### Condition rating of Deck Slab

#### *Mian Meer Bridge*

Deck slab is in good condition, except the edges near the expansion joints have been damp, and deteriorated. It is due to water penetration from the joint causing efflorescence and delamination of concrete adjacent to the expansion joint as shown in the figure 1.4 (a) and (b). Oxidation of reinforcement has started near edges. Span 6 of c/way from Cantt to City is the most critical portion. When edge was hammered, concrete spalled off showing rusting marks of steel. Average condition rating is 6 out of 9. Total Area inspected is 139250 sft, and % age deteriorated is 3500 sft.



Figure 1.4 Deck Slab of Mian Meer Bridge: a) Unsound concrete; and b) Rust mark

#### *SherPao Bridge*

The condition of Deck slab is better compared to Mian Meer Bridge. Light to moderate dampness was observed near expansion joint in few spans, as shown in Figure 1.5. Average condition rating is 7 out of 9, which means slab is in good condition. Total Area inspected is 1,81,000 sft, and deteriorated area is 3,600 sft.



Figure 1.5 Dampness in Deck near Expansion joint in SherPao Bridge

### Condition rating of Expansion Joints

#### *Mian Meer Bridge*

Mian Meer Bridge has concealed or buried type of expansion joints which are mostly employed for short spans bridge as shown in Figure 1.6(a) and (b). Due to poor maintenance, most of the joints have been worn out with the passage of time. Water has been penetrating through them to the structural components beneath. Total numbers of expansion joints are 120. Average condition rating (ACR) of Expansion joints is 6.



(a)



(b)

Figure 1.6 Condition of Expansion Joints in Mian Meer Bridge: a) Top view; and b) water penetration from the joint.

#### *Sherpao Bridge*

Carriageway from Lahore cantt to City is an arch bridge which does not have any expansion joint except in railway spans, and provides a very smooth surface to the commuters. Carriageway from city to Cantt has expansion joints as shown in Figure 1.7, which have been worn out severely only in 14 years. Almost 4” deep deterioration was observed in the joint

space. Water has been penetrating into the structure. Average condition rating is 5.



(a)



(b)

Figure 1.7 Condition of Expansion Joints in Sherpao Bridge: a) Top view; and b) water penetration from the joint causing efflorescence to the surrounding concrete

### Cumulative Deterioration Trend of Bridge Components

Statistical data of deterioration of bridge components has been presented in Table 1.2. Based on the condition rating of different bridge components, Figure 1.8 shows cumulative deterioration trend in both these bridges. Results indicate that poor drainage and pathetic condition of expansion joints are disturbing four other bridge components..

Frequency of inspection of bridge components should be based on the deterioration trends in Pakistan. These Bridge components don't require large amount of financial resources to be maintained but inspection and maintenance awareness in this regard is important.

Table 1.2 Deterioration of Different Bridge Components

Component	Total Area Inspected (sft)	% Age Deterioration	Avg. Condition Rating
Deck Slab	3,20,000	2.5	6
Wearing Surface	2,80,000	Negligible (Newly laid)	8
Expansion Joint	160 Nos.	27	5
Pier Cap and Bearing system	1,056 Nos. bearings	14.5	6
Masonry Retaining Wall	800 rft	25	5
Arch Piers	86 Nos.	Negligible	7
Drainage System	400 Pipes	27.5	5

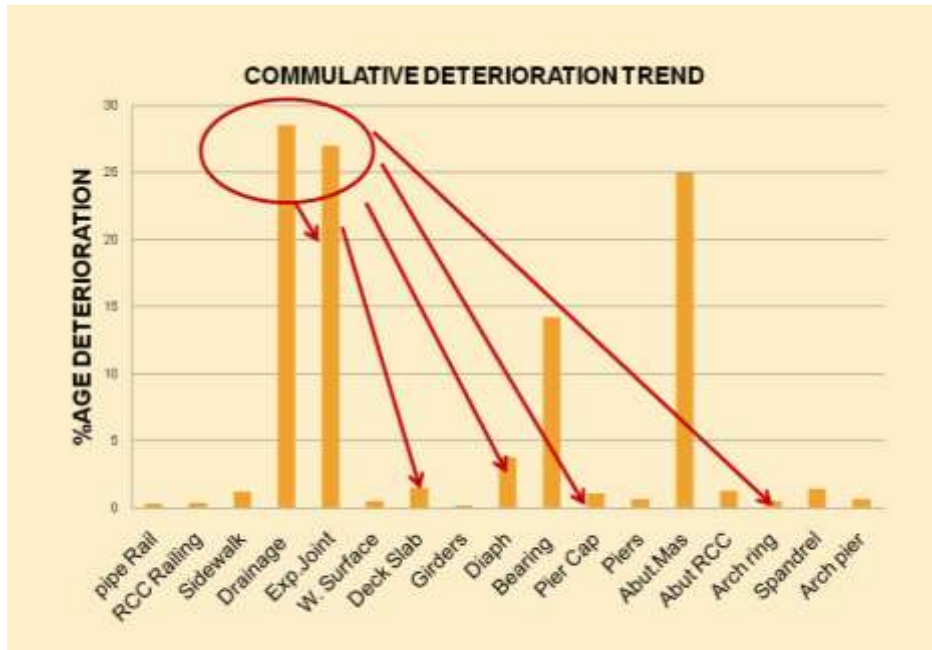


Figure 1.8 Cumulative Deterioration of Bridges

### Bridge Performance Index (BPI)

A new index design to check the performance and adequacy of bridges ranging from 0 – 10, based on:

- Structural.
- Non- Structural.
- Geometrical and Safety features of the bridge.

In developing BPI, 50% importance has been given to the structural components, 25% to non-structural components and 25% to geometric and safety features of the bridge. Refer to Table 1.3, Item (A) and (B) are qualitative based on the average condition rating of different bridge components already discussed above. Column 3 indicates the importance assigned to a component based on this research work. Since the non-structural components are seriously affecting the structural components, that's why they are also important for assessing the performance of a bridge. In column (2), bearing system alone has been given importance equal to piers + foundation, because bearings are more vulnerable to deterioration in Pakistan compared to piers and footings.



Table 1.3 Condition Evaluation Performa For Expansion Joints:

Description (column 1)	Bridge Element (column 2)	Importance Factor (column 3)	Mian Meer Weighted Number (column 4)	Sherpao Weighted Number (column 5)
A)-Structural	Girder + Diaphragm	15 %	1.17	1.2
	Deck+ wearing	5%	0.37	0.38
	Bearings	10%	0.55	0.7
	Pier Cap	10%	0.55	0.7
	Piers+ Foundation	10%	0.77	0.72
			3.37 / 5	3.7/5
B)-Non- Structural	Drainage	10%	0.45	0.6
	Expansion Joint	10%	0.65	0.25
	Utilities (Poles,etc)	5%	0.4	0.3
			1.5 / 2.5	1.15 / 2.5
C)-Level of Service	Traffic Capacity	15%	1.0	0.9
	Geometry + Safety (Clearance, Alignment, Signage)	10%	0.75	0.6
			1.75 / 2.5	1.5 / 2.5
TOTAL		100%	6.6/10 (66%)	6.4/10 (64%)

Items (c) are not qualitative; traffic capacity of a bridge depends on Level of service (LOS) it is offering either for ADT or for peak hour traffic. However no traffic counts have been conducted by any agency in Lahore and in the absence of any traffic count and traffic growth it has been assumed that the bridge is offering LOS C to the commuters which show a stable condition.<sup>[4]</sup>

BPI will be very helpful in dictating the funding allocation and financial requirements of a bridge as under:

- BPI >7: Bridge is in very good condition, satisfying present need of commuters and does not require any repair work.
- 7 < BPI < 5: Bridge is in fair condition, requiring minor repair which can be delayed if no funds are available.
- BPI < 3: Bridge is in critical condition, requiring urgent rehabilitation. It should be closed for service

## Conclusions

Following conclusion can be drawn in the light of the research:

- Improper functioning of expansion joints, bearing system and drainage system are the primary contributor of the bridge deterioration.
- A bridge component which is not visible is generally ignored by the maintenance agencies e.g. bearing systems. Most of the maintenance and repair funds are utilized on cosmetics. Highway agencies are not fully aware of bridge inspection and maintenance principles. Very limited awareness of Bridge Rating exists at present in the country.
- Bridge performance Index (*BPI*) can serve as a tool to evaluate the overall condition of the bridges. Compared to other Indices developed in world, it can be truly applicable for conditions in Pakistan. *BPI* of Mian Meer Bridge is 6.6/10 and Sherpao Bridge is 6.4/10, which fall within the satisfactory condition. These only require minor repair work. Funding on bridges can be optimized by using *BPI* and significant amount of money can be saved.

## References

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