Study for Bridge Renewal and Repair by Osaka Municipal Government

Shinsuke Yumoto[1]
Tetsuya Yokota[2]
Yasutomo Komatsu[3]

Abstract

There are 764 bridges which managed by Osaka Municipal Government (incl. about 100 old bridges that over 70 years old)

Although many old bridges will be 100 years old in coming 30 years, to replace the all old bridges within 30 years is impossible when consider the financial pressure in Osaka city. Therefore, it provided the replacement plan refereed to the Study Group.

Specifically, Osaka Municipal Government created the own Replacement Judgment Policy through the Evaluation of Health Assessment by bridge inspection and Evaluation of Functionality by structure collation. This is the report of the Judgment Process.

Introduction

Osaka is the second big city next to Tokyo where has an area of about 222 km2, population is about 2,600,000 that is the metropolis in the western part of Japan (Fig.1).

Fig.1 Location of Osaka

There are many bridges which loved by citizens such as Tenjinbashi-Bridge, Tenmabashi-Bridge and Naniwa-Bridge (Naniwa major three bridges). Osaka is called “Naniwa Happyaku-Ya-Bashi” whereas Tokyo is called “Edo Happyaku-Ya-Cho”.

Osaka Municipal Government is managing about 764 bridges (Bridges Area is about 720,000m2 (2009.1st. Apr.), including Consecutive viaducts (such as Midosuji to have traffic density more than 100,000 per day) (Photo. 1), long bridges over the vast river, well known bridges (Photo. 2), and many kinds of bridges.

On the other hands, many bridges were constructed during the First City Planning Stage, started from 1921, the ratio of old bridges which over 50 years old

[1] Public Works Bureau, Osaka Municipal Government, Osaka, Japan
[2] Public Works Bureau, Osaka Municipal Government, Osaka, Japan
[3] Public Works Bureau, Osaka Municipal Government, Osaka, Japan

holds about 20% of all bridges. Compared with about 6% of the Japanese average, it indicates that how the aging of the bridge progress in Osaka city. Furthermore, about 100 bridges will become 100 years old in coming 30 years (Fig.2). To provide of the maintenance principle for these old bridges becomes the urgent important problem.

Osaka Municipal Government is considering maintenance and the replacement plan with the Study Group on the Bridge Maintenance and Renewal of the Osaka Municipal Government from 2007. This is the report of the maintenance process of the old bridges through this examination.

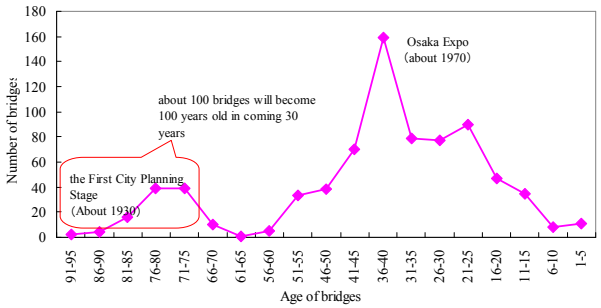

Fig.2 Distribution of the Number of Bridges (As of Apr.1, 2008)

Photo 1 Shinmido Viaducts

Photo 2 Naniwa Bridge

The background of the examination

Recently, Osaka Municipal Government is very severe financial status. Although it controlled to build the new bridge and replacement such as reconstruction costs or the earthquake proof construction, cost reduction by new maintenance technique is demanded. It because that the conventional expense measure was insufficient. (Fig.3)

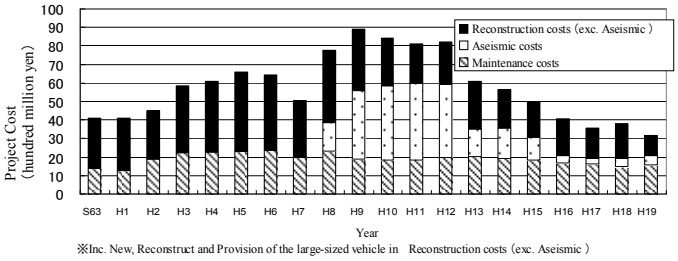

Fig 3 The Process of the Bridge Business Expense

Osaka Municipal Office has started to operate the Bridge Maintenance System (OBMS) since 2005. OBMS was developed from 2003 which introduced technique of the asset management.

Although Osaka Municipal Office is basis on the bridge prolongation by the

prevention maintenance, it found out that replacing the minimum percentage of bridge is very important. Therefore, it required classify bridges into prolongation and replacement to consider the maintenance and the replacement plan for old bridges. Next contents are explaining the process of Replacement judgment.

Replacement judgment policy of old bridges

As an object of 100 super old bridges older than 70 years old which constructed before WWRII (except the bridges which have replacement or removal plan), Osaka city had made the 1st selection for bridges which necessary the detail analysis through the Replacement judgment matrix. Then, evaluated general evaluation based on LCC analysis and selected bridges which are necessity renewal or not (Fig.4).

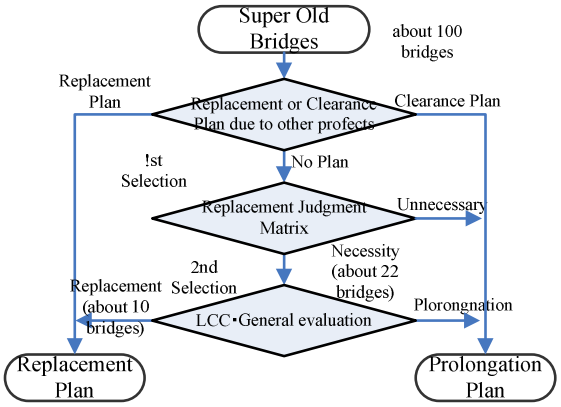

Fig.4 Diagram of Replacement Plan

Replacement judgment matrix

(1) Evaluation method

It is common way to consider the maintenance plan based on the result of by the bridge inspection when made the plan for maintenance plan.

However, the judgment on the bridge replacement only on the basis of the bridge health assessment may lead to wrong decisions. This is caused by the view of the fact that the old bridges built before the World War II were designed using different codes from now with respect to loads, earthquake-resistant design and river conditions and do not correspond to the present design codes.

For the reason, the final decision of replacement of old bridge was judged to use evaluation both 1.Evaluation of Health assessment and 2.Evaluation of Functionality.

(2) Evaluation of Health assessment (by bridge inspection)

As for the evaluation of health assessment, Osaka city evaluated it on the basis of future deterioration progress based on particularity inspection (nearness viewing) and the result of Nondestructive testing (Fig.5).

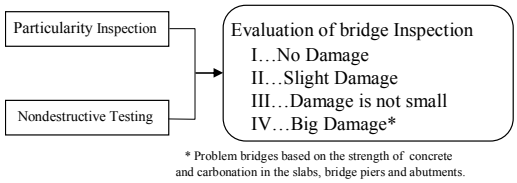

Fig.5 Evaluation of Health Assessment

About the Nondestructive testing, it is the quantitative evaluate which cannot to

confirm by viewing kind of the measurement of the neutralization depth and the salt content and concrete strength testing. It could be anticipate the precision improvement of the evaluation of health assessment.

Furthermore, I-III was judged to use status index[1)] by National Institute for Land and Infrastructure Management as trial. Evaluation IV that the damage was the most remarkable defined it that concrete strength deteriorated remarkably.

(3) Evaluation of Functionality (by Structure collation)

The functional evaluation was instituted whether load resistance, seismic resistance and river conditions could take adjustment for a current standard (Fig.6). The river conditions are impediment ratio of river flow, standard diameter length and the height under the girder.

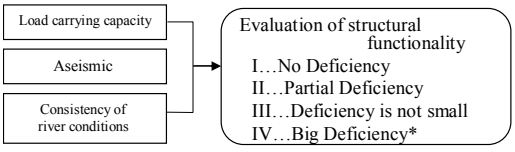

Fig.6 Evaluation of Functionality

About the bridge which road linear shapes extremely bad were evaluated IV as the bridge that lack of function was remarkable such as pilling-stones abutment (Photo.3), the liquefaction ground, the bridge which raises a figure (Photo 4) and the bridge that a girder soaks in water at the time of rise of the river.


Photo3 E.g. of Masonry Abutment

Photo4 Raising Bridge Floor Bottom by a Steel Beam.

(4) Extraction result of bridge renewal examination

The bridges divided into to two groups “The bridges for prolongation” and “The bridges to be replaced” through the result of both evaluation of Health assessment and Functionality. Fig.7 is shown that the Replacement judgment matrix.[2)]

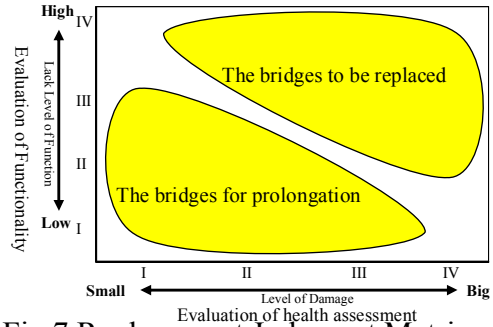

Fig.7 Replacement Judgment Matrix

According to the result of the replacement judgment matrix, the bridges which did not satisfy a current

standard were chosen as the bridges renewal examination which should have examined reconstructs in future despite of the soundness was no problems in inspection. The standard is changing with the times, so that old bridge does not adapt the current standard properly. On the other hand, many of old bridges which kept soundness enough even now were confirmed.

From these results, there is a limit to judge the condition of the bridge from only a check result by the viewing. It means that admitted it is necessary to examine a characteristic each bridges in detail when makes an important decision for replace and so on.

General evaluation based on LCC Analysis

The economical evaluation was assessed by LCC of the next 50 years which based on the result of replacement and prolongation analysis in the replacement detail judgments （2nd selection) of super old bridges.(Fig.8) In addition, it were judged whether necessity the replacement or not which basis of the consistency of higher plan. The next expression is shown the detail of LCC.

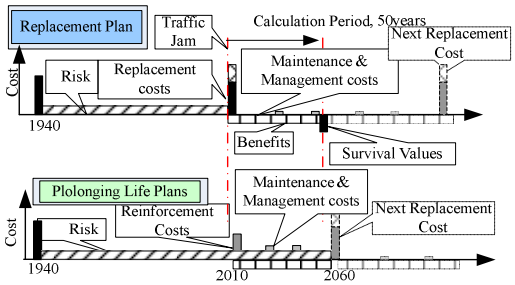

Fig.8 Idea of Life Cycle

LCC = [Replacement Costs] or [Reinforcement (Improvement) Costs] + [Maintenance & Management Costs] + [Traffic congestion losses due to construction] + [Risks] - [Benefits] - [Survival Values]

While Replacement costs and Maintenance & Management costs are evaluation objects normally, Risks, Benefits and Survival values were appropriated as costs in this examination, then, the replacement bridges are judged objective and quantitatively.

[Replacement costs] was calculated based on structural calculation and Maintenance & Management costs. In the case of reconstruct, as those old bridges are still usable even after 50 years, [Survival values] is to be considered. Additionally, traffic regulation is required when renewal the bridges, therefore, [Traffic congestion losses due to construction] need to be considered. Traffic congestion loss was calculated by carrying out traffic estimation using traffic network assignment of all area of Osaka City, then calculated 3 benefits such as traffic time, traffic costs and loss of traffic accident basis on the current situation and discrepancy of traffic regulation.

As for [Reinforcement & Improvement costs], it calculated to consider the seismic reinforcements, the necessity of the anti-vehicle upsizing measure and reinforcement structures. In the case of the shiftlessness, it assumed that appropriated the amount of damage when an earthquake occurred as [Risk]. It is attributed to be

damaged at the time of an earthquake.

[Benefits] was appropriated it when the function of the bridge improved in both case of renewal and reinforcements and improvements.

The case of Test Calculation

Fig.9 is shown the examples that the result of LCC analysis of the bridges which chosen prolongation or reconstructed. As comparison, in case of minimum maintenance and management of LCC was shown without reconstruct and prolongation measure (the following "Shiftlessness plan"). The most suitable plan of LCC ratio is 1.0. The cost of reconstruct is subtracted for survival value.

	A Bridge	B bridge
	Gerber girder bridge, Wooden posts	Arch Bridge
Present Condition	Wooden Posts in Liquefaction Ground, Less seismic	No rooms under the girder, obstruction of the water transportation
Prolongation Plan	Pier, Basic reinforcement	Floor reinforcement
Replacement Plan	Steel Flooring Bridge	Arch Bridge
Shiftlessness plan	Damage from Earthquakes	Only repair

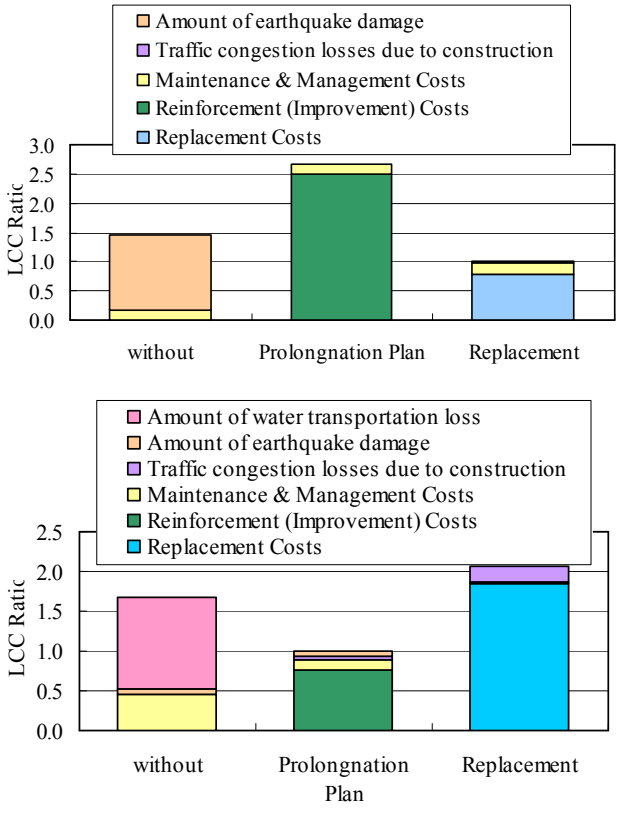

Fig.9 Result of LCC Analysis

A bridge is the Gerber girder bridge which has the wooden posts of about 80 years. Although the girder had rose, it required the foundation reinforcement in the result of the seismic verification. However, according to the LCC analysis, the reconstruct plan is economical rather than foundation reinforcement. In shiftlessness plan, the earthquake damage were occurred sort of traffic suspension or the recovery costs, besides the amount of damage by stops of the production activity will increase.

B bridge is the arch bridge, seismic is secured, used about 80 years. While the project of the water transportation activation is promoted by the Water Metropolis Revival Plan, there is few girder bottom room of the bridge it becomes the obstruction of the water transportation, so that the water transportation loss was appropriated. This is caused by the girder bottom room was not secured by the refinement construction work or reconstruct plan in Shiftlessness plan.

As a result of having evaluated LCC or consistency with the higher plan in object bridges, it is judged the prolongation plan is the most suitable plan through the refinement construction work of the upper side of the bridge. Moreover, reconstruct plan were assumed as the same type of now, because of the well known bridges have historical values.

Conclusion

Osaka city is considering the maintenance and the replacement plan of the old Bridges based on a basic policy. Fig.10 is shows the result of these examinations

(1) As the result of the 1st selection by Replacement judgment matrix, about 20 bridges were selected as an object of replacement judgment from about 100 old bridges except bridges which were to be rebuilding by other plans.

(2) As the result of the 2nd selection by LCC analysis, about 10 bridges were selected after the 1st selection.

(3) To other object of reconstruct bridges is to be trying for the precision improvement of the project plan based on the enforcement of the close inspection of the local condition and the detailed design in future including valuable in the history of civil technology (Photo.5,6) and so on. Osaka city will also examine how manage these bridges in the future.

As regards to the plan theory of LCC analysis when consider the reinforcements or replacements, it investigated with various way[3)4)5)]. This examination was important to provide the maintenance plan of bridges on the basis of the results of the past studies.

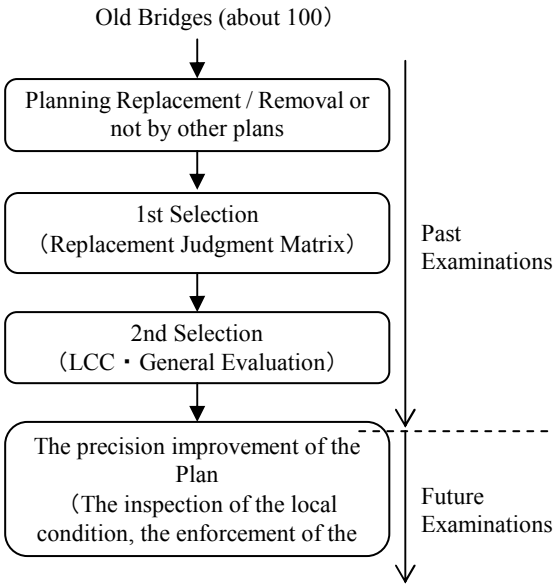

Fig.10 Schedule of Examinations

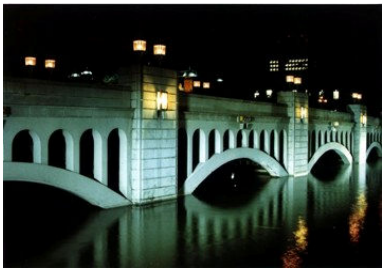

Photo 5 Suisho Bridge
(Well-known Bridge)

Photo 6 Honmachi Bridge
(Oldest Bridge built in 1913)

Acknowledgments

This is the report that explaining the basic concepts regarding the project on the reconstruct of old and historical bridges. Thanks to the well-preserved drawings, documents of summary of works and records of works on the bridges built before the World War II, the project has been promoted quite smoothly. Thus, the effort and tradition of the bridge engineers of the Osaka Municipal Office must be highly respected. The importance of the succession of the important documents and information to the next generations is becoming more and more important.

Finally, we would like to take this opportunity to express their appreciation to the member of the Study Group on the Bridge Maintenance and Renewal of the Osaka Municipal Government for their precious opinions and advice., Chairperson: Mr. E.Watanabe (Emeritus of Kyoto University), Committee: Mr. H. Furuta(Professor of Kansai University) and Ms. M.Tanaka (Assistant Professor of Osaka Industrial University).

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