MANAGEMENT SYSTEM IN OSAKA CITY

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Abstract

As of April 2006, Osaka City manages 763 bridges, having a combined area of approximately 720,000 m^2. Most of these bridges were built intensively at the beginning of the Showa era (period of the first urban planning program), when the urban infrastructure was improved drastically, and also during the period of high economic growth (when the world exposition was held). It is expected these aging bridges will simultaneously require intensive repair and renewal work in the near future. To maintain the service standard for users within a limited budget, it is necessary to equalize renewal times and minimize the cost of repair and renewal work. Therefore, it is essential to develop a comprehensive bridge management system to establish an optimal maintenance and management plan based on prediction of bridge deterioration and minimization of life cycle cost.

This paper introduces a study on our city's bridge management system.

1 CURRENT SITUATION OF BRIDGES IN OSAKA CITY

1.1 The number of managed bridges and their characteristics

As of April 2006, there are 880 road bridges in Osaka City. Among them, 763 bridges are managed as certified roads by Osaka City. The total length is 47.6 km with area of 723,000 m^2. (See Table 1, Current situation of bridges.) One of the characteristics of bridges in Osaka is that there are many steel bridges. Approximately 90% of the whole bridge areas are steels. One of the reasons for this is a limited girder height of bridges in Osaka due to overhead crossing of bridges that are laterally crossing the river or located in urban areas. Another reason is a measure being taken to alleviate dead load against constructions on the soft grounds and underground facilities such as subways. Another characteristics of bridges in Osaka are as follows. There are many large-scale and long bridges because they are located at the mouth of vast river like Yodo-river and Yamato-river. There are also many viaducts (amount of 82) across the roads and railways which are crowded in the city. (It seems that the underpasses(amount of 71) are chosen in consideration for environment and esthetics although they are more expensive than the viaducts .)

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1.2 Trends of the number of Bridges Managed by Osaka City and bridge areas

The Figure 1 shows the trends of the number of bridges managed by Osaka City and bridge area. When the city was municipalized in 1889, there were 196 bridges. During the first city expansion period in 1897, there were 395 bridges. After that, from the end of the Meiji era to the Taisho era, there were 400 to 500 bridges. During the second city expansion period in 1925 (Taisho 14), the number of bridges increased rapidly to 1629. Then the number decreased to 1200 or so due to reclamation of waterways. However, it increased again to 1470 bridges because of the third city expansion period in 1955. After the world war, Japanese economy entered the high growth period, and waterways were reclaimed because of improvements of the sewage system in Osaka City. Consequently, the number of bridges decreased to less than 800. Around the same time, Japan started constructing elevated bridges and large scale bridges. Along with it, the number of bridges decreased, however, the average bridge length and bridge area have increased up to the present date.

1.3 Year of bridge construction and bridge's age

The Figure 2 shows years of construction and ages of bridges managed by Osaka City. According to this figure, there are two peaks for construction years: one in prewar times and another in postwar times. In particular, the number of bridges built is the highest in 1970 (Showa 45) when the Japan World Exposition was held. An average bridge's age is approximately 40.

The oldest existing bridge in Osaka is the Honmachi Bridge built in 1913 (Taisho 2). The bridge has been used for transportation for 94 years. (See Figs 3, 4) However, there is no urgent need for reconstruction at this point so that it is possible that the bridge will be used for over 100 years. Factors for this longevity are daily maintenance and a large-scale repair implemented in 1983 (Showa 58). Replacement of damaged members and reinforcement of RC slabs have been conducted for other aging bridges also. A proper management after some years is probably a factor that lengthens a life of a bridge.

1.4 Distribution of managed bridges' ages

The Table 2 shows the number of bridges in Osaka by date. Bridges built during the first urban planning project, which is the first construction peak, account for approximately 10% of all bridges. When combining these bridges and bridges built before the first urban planning project, approximately 13% of all bridges are 70 years old or older as of today. These bridges will be 100 years old or so in 30 years. Additionally, bridges that will be 70 years old or older in 30 years from today will account for approximately 32% of all the bridges. The bridges built during the Japan world Exposition year, which is the second construction peak, will be also as old as 68 years old in 30 years. As a result, in the future we will face a situation where a wave of aging bridges will surge one after another. In preparation for such a situation, an urgent issue in addressing aging bridges is

development of a maintenance and management system to minimize life cycle cost through life extension (lengthening of life cycle) and a lower cost for maintenance and repair.

2 BRIDGE PROJECT IN OSAKA CITY

2.1 Current situation and budget of bridge project

We will show a trend of the budget situation and scale of each bridge project of Osaka City. Bridge projects in Osaka City can be divided into the following four groups.
(1) New construction : New construction or reconstruction of bridges
(2) Improvement : Widening, changing stairs to slopes, surrounding improvement
(3) Quakeproof : Pier reinforcement, prevention for bridge fall, series of girder
(4) Repair : Regular repair, repair and reinforcement measures, steel bridge recoating

The Figure 5 shows a trend of project cost in 10 years. A project cost for 2003 was approximately five billion yen, with a breakdown of 1.9 billion yen for new construction, 1.3 billion yen for improvement and quakeproof work, and 1.8 billion yen for repair work. Although necessity for repair and reinforcement is increasing, a budget for such work is decreasing, allowing only minimum level of maintenance work.

Next, the Table 3 shows bridges that were reconstructed during the last 20 years and reasons for such reconstruction. Traditionally, main reasons for reconstruction of bridges are to raise bridge girders and/or to expand span length along with river improvements, and to expand width along with road improvements. There have been few cases where bridges have to be reconstructed due to structural malfunction. There are five cases of reconstruction due to aging in 20 years. Such reconstruction takes place at a rate of one bridge in four years.

3 BMS (Bridge Management System)

3.1 Necessity of BMS (Bridge Management System)

Aging of bridges managed by Osaka City is advancing. A traffic control due to deficiency of trafficability of old bridges and a sudden increase in traffic restriction due to reconstruction and/or reinforcement of bridges can seriously influence social and economic activities. Therefore, in order to avoid such situations and to maintain proper municipal services for the citizens into the future, it is necessary to try to prolong lives of old bridges and to promote leveling of facility renewal. Additionally, concentration of reconstruction must be avoided since public investment will be restrained according to a prediction of a social condition in the future. It is imperative that reconstruction should take place in order from bridges with a low level of soundness and load bearing capacity among old bridges. Also, adequate maintenance and reinforcement must be taken to

promote measures to prolong lives of existing bridges. Besides these points, it is necessary to develop a maintenance and repair plan based on consideration for the following characteristics of bridges managed by Osaka City. Such characteristics can be roughly divided into three groups.
i) Approximately 90 of all managed bridges are steel bridges
ii) In urban areas, there are large-scale, elevated bridges that can seriously impact economic activities.
iii)There are two main construction periods: in the beginning of the Showa era and during the high economic growth period. Times for reconstruction, reinforcement and repair will be concentrated.

3.2 Future approaches of BMS

The maintenance works of bridges need the skills of inspection and diagnosis and the decision of the management plan and the update of the database and so on.
We arranged the bridge management cycle shown as the figure 4 in 2006 to carry them out smoothly as a cycle.
Mainly on the bridge database ,this management cycle consists of the inspection and diagnosis system of bridges and the evaluation of maintenance level and the decision of the management plan and the executions of repair and reinforcement and the inspection and update of the database after executions.
In addition, the bridge maintenance support system established in 2005 is recognized to be as a support tool for decision of the management plan.
In future, based on the bridge management cycle such as the above, it will be necessary for us to decide the management plan in consideration of characteristics of each bridge.

4 CONCLUSION

It used to be that a great emphasis was placed on bridge construction itself and technical investigation of newly constructed bridges. However, today, examination of measures to safely preserve existing bridges for a long time is required. A traditional way of bridge maintenance and management needs to undergo a drastic reform. As the bridge administrators, we must autonomously coordinate a series of process to gain citizens' consensus and establish a bridge maintenance and management system to draw results that are quantitatively easy-to-understand.

Table 1. Current situation of bridges
As of April 1, 2006

		Number of bridges (unit: bridge)	Total bridge length (unit: m)	Total bridge area (unit: m^2)
Management of Osaka City (Certified roads)	Steel bridge	508	41,351	640,820
	Concrete bridge	250	5,692	81,076
	Stone bridge	4	11	23
	Wooden bridge	1	614	1117
	Sub total	763	47,668	723,036
Management of Osaka City (other than certified roads)		68	7,856	142,441
Management of Osaka Prefecture or adjacent local governments		20	1,131	13,972
Management of the nation		29	7,867	235,877
Total		880	64,522	1,115,326

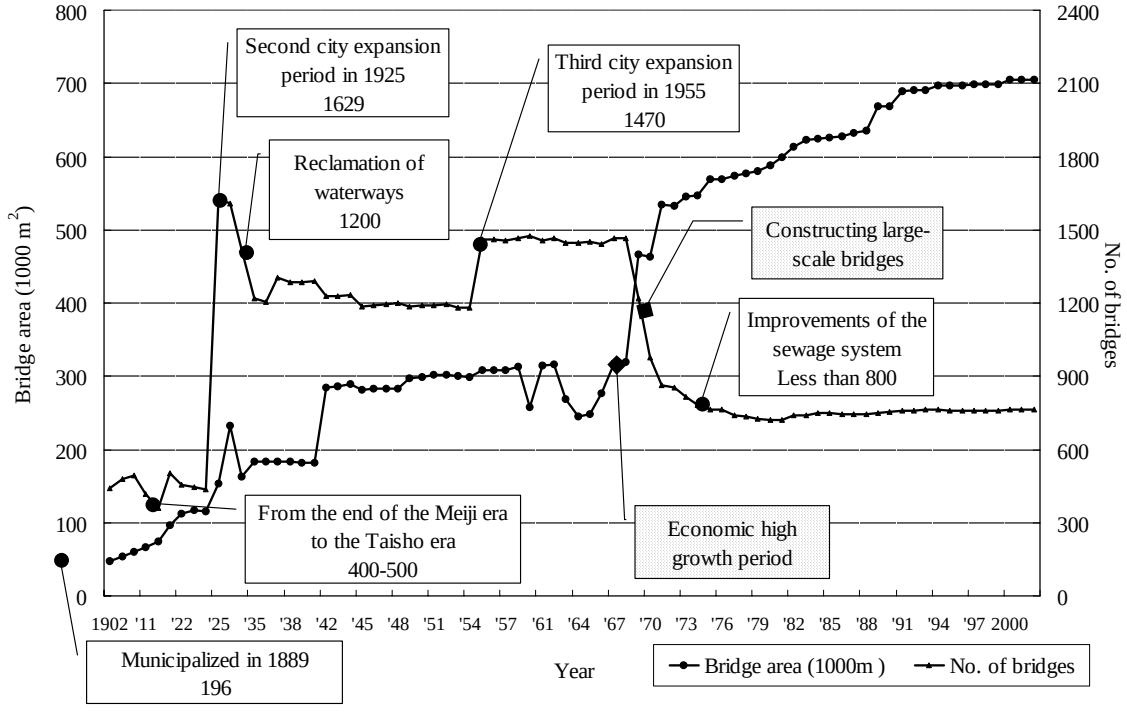

Figure 1. Trends of the number of bridges and bridge area

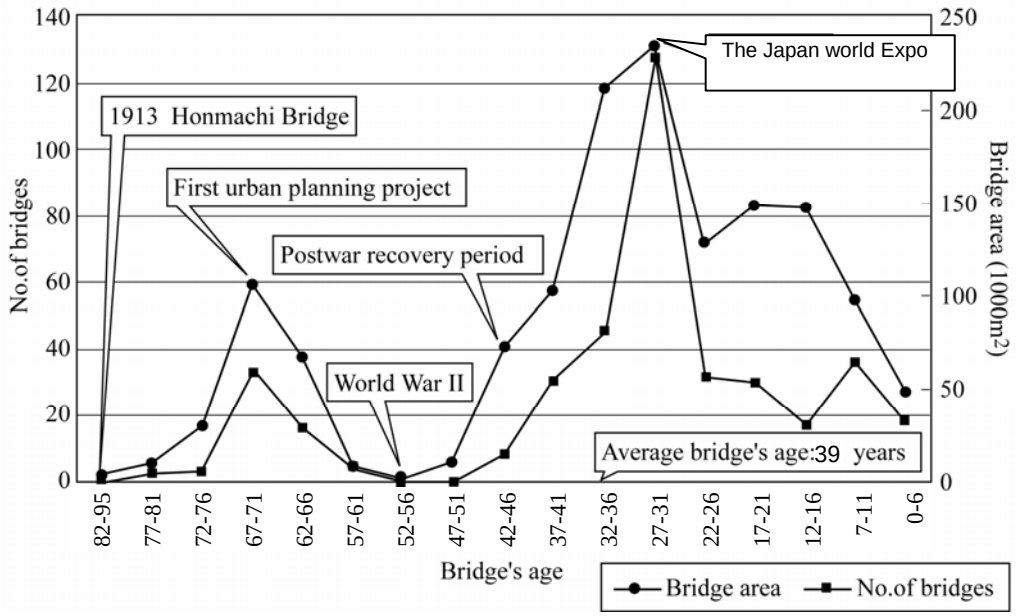

Figure 2. Relationship among bridge's age, the number, and bridge area

Figure 3. Side of Honmachi Bridge

Figure 4. Bridge face of Honmachi Bridge

Table 2. List of the numbers of bridges in Osaka by date (road bridges)

	Date	Years used	Number of bridges		Other
Bridges that are 50 years old or older	1912 - 1925	95-82	17	2.2%	Improvement through city electric project
	1926 - 1930	81-77	25	3.3%	First urban planning project
	1931 - 1935	76-72	54	7.1%	
	1936 - 1940	71-67	20	2.6%	
	1941 - 1945	66-62	2	0.3%	Wartime and postwar recovery
	1946 - 1950	61-57	2	0.3%	
	1951 - 1955	56-52	26	3.4%	High water prevention project
	1956 - 1960	51-47	29	3.8%	
	1961 - 1965	46-42	68	8.9%	1964, Tokyo Olympic
	1966 - 1970	41-37	161	21.1%	1970, Japan World Exposition
	1971 - 1975	36-32	72	9.4%	1973, oil crisis
	1976 - 1980	31-27	65	8.5%	
	1981 - 1985	26-22	90	11.8%	
	1986 - 1990	21-17	76	10.0%	1990, Osaka Flower Expo
	1991 - 1995	16-12	37	4.9%	1995, Kobe earthquake
	1996 - 2000	11-7	16	2.1%	
	2001 -	6-	3	0.3%	
	Total		763	100.0%	

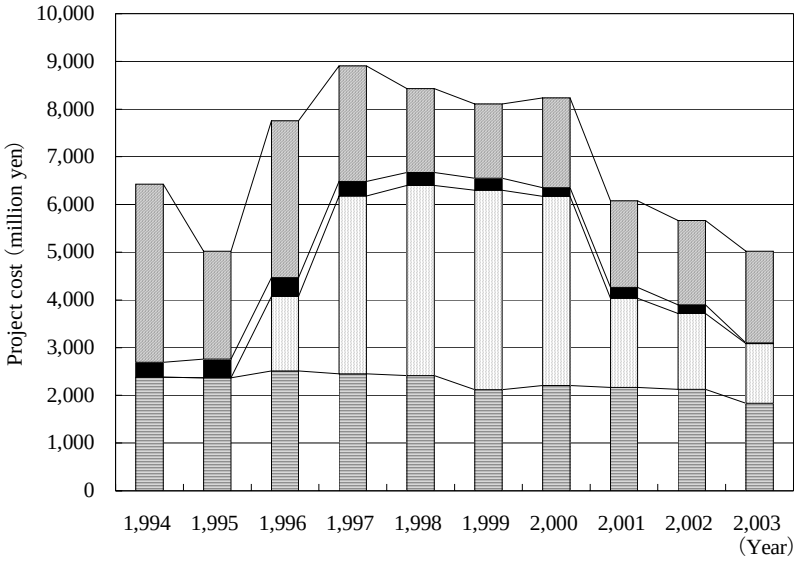

Figure 5. Trend of bridge project cost

Table 3. List of reconstruction in the last 20 years in Osaka City

	Bridge name	Style	Year of construction	Major reason for reconstruction	Year of reconstruction completed	Years in service
1	Iwamatsubashi	Plate girder	1922	Road improvement	1997	75
2	Onkishimabashi	Plate girder	1926	Highway project	1998	72
3	Hanatenobashi	Plate girder	1930	Road improvement	2001	71
4	Imabashi	Plate girder	1924	Aging	1994	70
5	Takatsuharabashi	Plate girder	1927	Subway	1997	70
6	Kamiyamatobashi	Plate girder	1925	Aging	1994	69
7	Kasugadebashi	Plate girder	1935	Aging	2005	70
8	Ukishimabashi	Plate girder	1925	Aging	1990	65
9	Hakurakubashi	Plate girder	1940	Road improvement	2005	65
10	Gokurakubashi	Plate girder	1932	River improvement	1992	60
11	Naniwabashi	Arch	1915	Subway	1975	60
12	Taishobashi	Arch	1915	Road improvement	1974	59

	Bridge name	Style	Year of construction	Major reason for reconstruction	Year of reconstruction completed	Years in service
13	Shimoyamatobashi	Plate girder	1928	Landscaping	1987	59
14	Nishifukubashi	Plate girder	1936	Aging	1995	59
15	Meijibashi	Plate girder	1930	Road improvement	1988	58
16	Emonbashi	Plate girder	1929	River improvement	1984	55
17	Nakamotobashi	Plate girder	1927	River improvement	1982	55
18	Furudutsumibashi	Plate girder	1939	River improvement	1992	53
19	Sigitabashi	Plate girder	1934	River improvement	1986	52
20	Kozaibashi	Plate girder	1919	Road improvement	1970	51
21	Nakatsurikubashi	Truss	1929	Road improvement	1980	51
22	Watayabashi	Plate girder	1922	Road improvement	1972	50
23	Sendannokibashi	Plate girder	1935	Landscaping	1985	50
24	Nakasumirebashi	Plate girder	1956	River improvement	1996	40
25	Minamiimafukubashi	Plate girder	1964	River improvement	1999	35
26	Imafukukitabashi	Plate girder	1968	River improvement	2003	35
27	Shinmorikobashi	Plate girder	1975	River improvement	1995	20

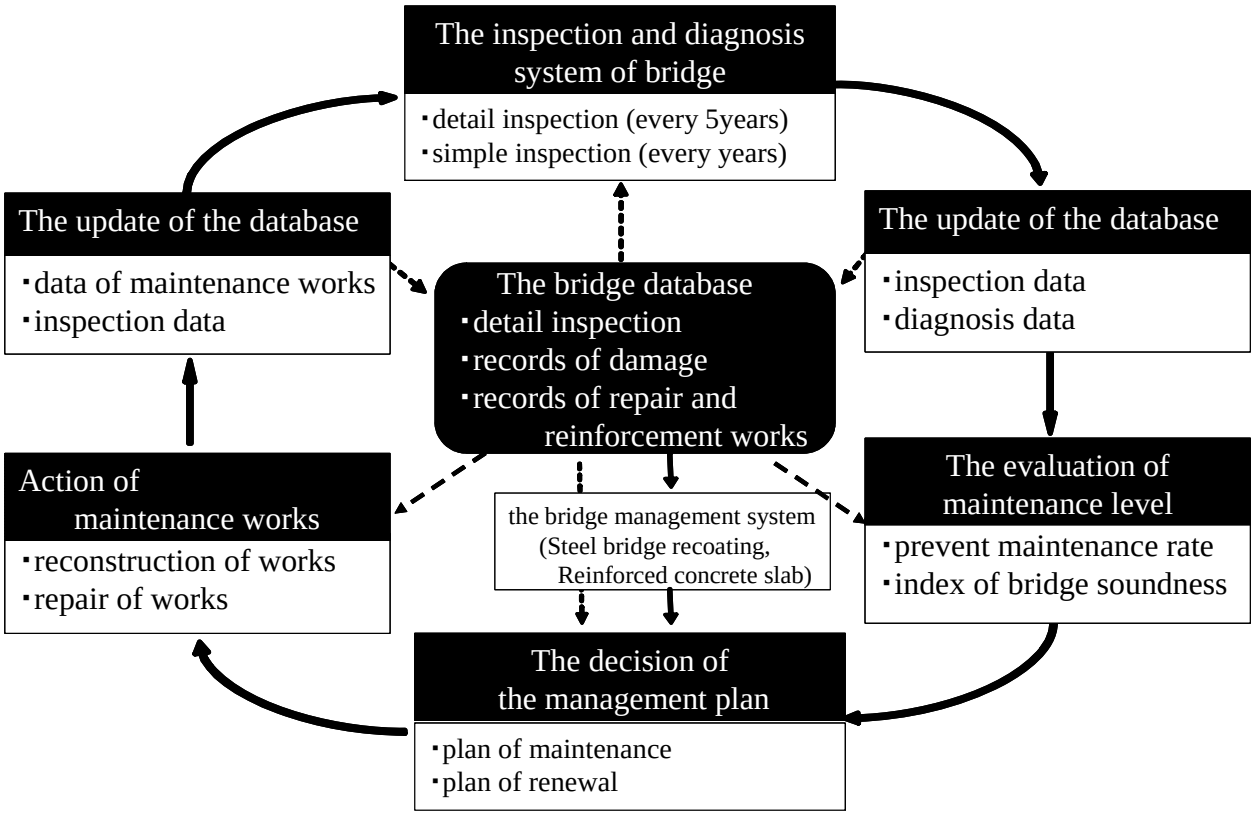

Figure 6. The bridge management cycle