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ASSET MANAGEMENT: TECHNICAL INPUTS TO DECISION MAKING

Makio KAYANO
Road Bureau, Ministry of Land, Infrastructure and Transport, Japan
kayano-m29e@mlit.go.jp

Road Asset Management Strategy in Japan

ABSTRACT

Roads in Japan were built quickly during the period of high economic growth through the 1950s to the ‘1970s .For example the number of bridges over 15 meters in length now exceeds 140,000, making up about 37% of all bridges. The majorities of these bridges was built intensively during the period and is now aging quickly.

Characteristics of road asset management in Japan are complicated structural conditions and threat of major earthquakes typhoons, torrential rain, and snowfalls. Furthermore, in the urban area of Tokyo, completed routes account for less than 25% of planned road length, lagging behind compared to building of ring routes. A higher percentage of large vehicles is found in central Tokyo than that in other major areas in the West.

In Japan, the budget for public works has been cut down in recent years. The budget for roads also continues to be decreasing, and budgetary outlays earmarked for road maintenance and management was drastically curtailed. Expenses for aging-related repairs and renewal of building structures including bridges are also expected to significantly increase in the future as compared to recent years. Therefore, it becomes necessary to reduce lifecycle costs by shifting from “post-event maintenance” to “preventive maintenance” and make belt-tightening efforts by cutting daily maintenance costs for cleaning, weeding, and pruning.

For making road facilities last longer, it is important to focus on repairs for preventive maintenance before any damage becomes evident. Intensive measures are under way to address the “three major damages” (fatigue, chloride attack, and alkali-aggregate reaction) that threaten bridge safety.

Japan’s important challenges for the future include finding a way to make effective use of accumulated facilities in an attempt to meet the needs of a society with a declining birthrate and aging population and addressing global environmental issues. In that sense, Japan has shifted from an “age of production” to an “age of promoting more effective use.”

To sum up, it is possible to say that Japan is entering an era where the social infrastructure should be managed and strategies to meet the needs of the times become essential.

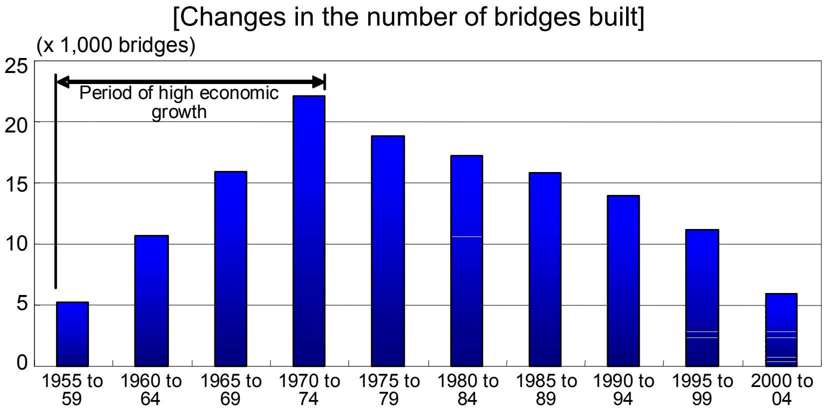
1. INTRODUCTION

Much of the social infrastructure in Japan was accumulated during the period of high economic growth from the postwar recovery period after World War II through the 1950s to the ‘1970s.As Japanese society and the nation’s economy have developed, Japan’s important challenge for the future is to find an effective way to use accumulated facilities to meet the needs of a society with a declining birthrate and aging population, and to address global environmental issues. Japan has shifted from an “age of production” to an “age of promoting more effective use.” As the nation is thus entering an era where the social infrastructure should be managed, strategies to meet the needs of the times are required.

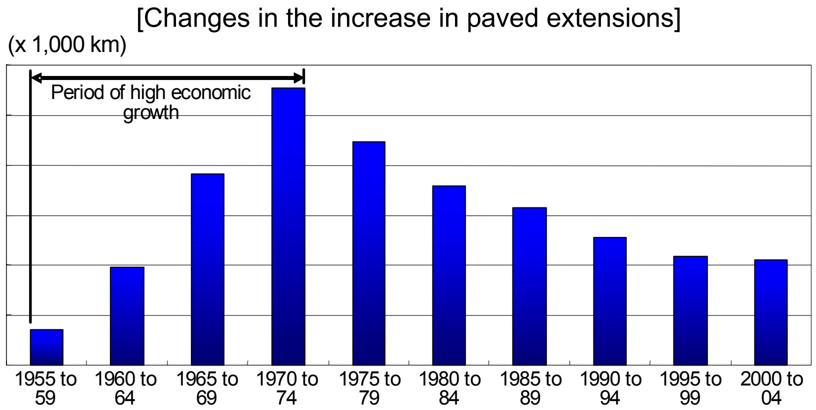
2. CHARACTERISTICS OF ROAD ASSET MANAGEMENT IN JAPAN

2.1. Increasing road facilities

Roads in Japan were built quickly after the period of high economic growth. For example, the number of bridges over 15 meters in length now exceeds 140,000 and many of which were built intensively during the period of high economic growth, and their number accounts for a percentage as high as about 37% of all bridges. Moreover, pavement (excluding surface dressing) currently covers 310,000 km of roads, of which the increase in paved road length newly built during the period of high economic growth accounts for about 39% of the total. In view of the fact that the roads built during the period of high economic growth will age in the future, expenses for road management are expected to grow.



* Above figures are aggregated from data in the field survey of road facilities, “Field Survey of Bridges,” on April 1, 2004



* Above figures are aggregated from data in the Road Statistics Yearbook on April 1, 2004 (excluding surface dressing)

Figure 1 - Changes in the number of roads built

2.2. Road assets in Japan in a severe environment

(1) Complicated structural conditions

Mountainous areas account for four-fifths of Japan's land mass, with small portion of plains concentrating on the coasts and shores. For that reason, road maintenance and improvement involve bridges and tunnels. As a result, these bridges and tunnels account for more than 10% of the total length of arterial roads (including roads and express ways managed by the Government of Japan).

(2) Threat of major earthquakes

History shows that the Japanese archipelago has suffered many earthquakes. Looking its seismic activities closely, it is found that seismic active period and quiet period come interchangeably. The first half of the 20th century saw the Great Kanto Earthquake and other major earthquakes, while the latter half of the 20th century enjoyed a prolonged period of inactivity. However, during the last decade starting in 1995, when the Southern Hyogo Earthquake (the Great Hanshin-Awaji Earthquake) struck, Japan experienced 12 earthquakes with magnitudes of 6 or higher, of which two-thirds or eight of these earthquakes occurred during the last two and a half years.

(3) Roads exposed to typhoons, torrential rain, and snowfalls

Japan, except for Hokkaido, is located in the Asia-Monsoon region. In June to August, the southeastern monsoon brings high temperature and humidity, along with heavy rainfall. Moreover, fiscal 2004 saw as many as ten typhoons lashing the country, resulting in many landslide disasters due to typhoons and torrential rain. Furthermore, about 60% of Japan's land mass is in a snowy and cold region, which is home to about 30% of the national population. In these areas, road management for wintertime snowfall including snow removal, the construction and enhancement of snow sheds and snowslide protection facilities, installation of thawing devices, is necessary.

2.3. Inflow of large vehicles into the cities due to poor development of beltway network

The urban area of Tokyo, which is the capital of Japan, is almost fully equipped with routes extending in a radial manner from the center of the city. However, completed routes account for less than 25% of the planned road length, thus lagging behind in the building of ring routes. Therefore, many motor vehicles only pass through the center of Tokyo, resulting in generating excessive traffic volume. In addition, the center of Tokyo experiences a higher percentage of large vehicles in the city than in those of other major areas in the West [About 20% in Japan (the center of Tokyo), about 6% in the USA (New York), about 3% in the UK (London),]. This means that bridges and structures in the center of Tokyo are vulnerable to fatigue-induced damage. In that sense, it is considered that Tokyo has severe traffic conditions. Further, social impact deriving from traffic closure by damaged roads is significant where sufficient network system does not fully function. Therefore, it is extremely important to ensure that transport functions properly through appropriate day-to-day road management.

3. JAPAN'S CURRENT CONDITIONS

3.1. Aging roads

As one of the indicators for deterioration, the number of bridges built over 50 years ago will increase threefold from the present level in 10 years, and then rapidly rise sevenfold in 20 years as shown in Fig. 2. Similarly, road tunnels built over 50 years ago will double from today's level in 10 years, and threefold in 20 years.

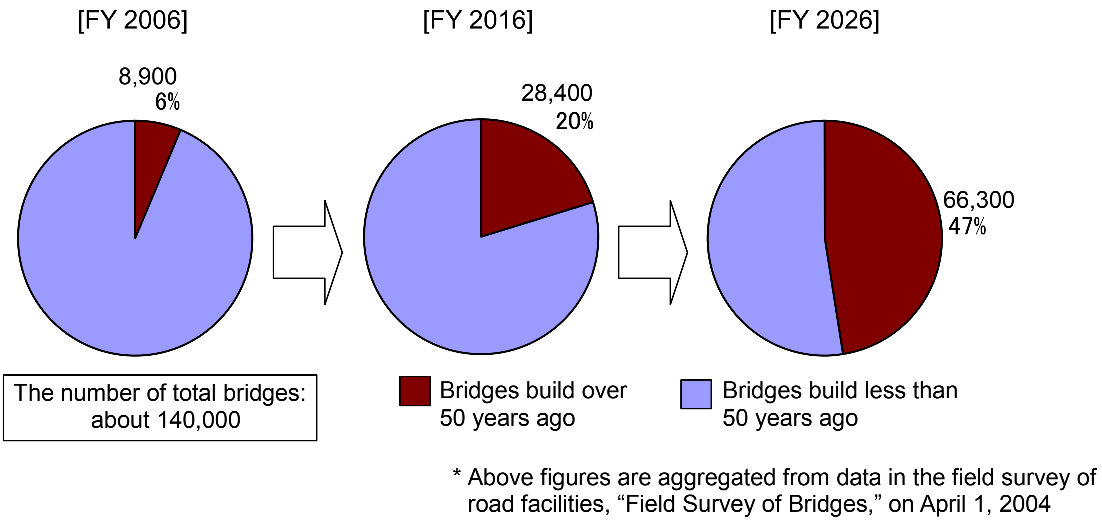


Figure 2 - Number of road assets built over 50 years ago

3.2. Three major damages to bridges

About 9,400 bridges over 15 meters in length are managed by the central government. Many of them were built during the period of high economic growth. They are now aging quickly. For making road facilities last longer, it is necessary to focus on repairs for preventive maintenance before any damage becomes evident. Intensive measures are under way now to address the "three major damages"(fatigue, chloride attack, and alkali-aggregate reaction) that threaten bridge safety.

(1) Fatigue
In Japan, most of urban and industrial zones are concentrated in narrow coastal areas. Moreover, transport depends heavily on trucks, resulting in generating heavy traffic. Due to the necessity to save weight of superstructure given soft ground and the ability to withstand earthquakes, steel bridge piers and steel bridges have been widely used. Although welding gained in popularity in and after the 1970s, people did not understand fatigue fully. For that reason, the fatigue phenomenon is occurring mainly on heavy-traffic routes.

(2) Chloride attack
As an island country, Japan has many structures in its coastal areas, with salt-rich seasonal winds blowing frequently in winter. With concrete quality and coverage regulations established as standards for the salty environment, adequate considerations were not given.

(3) Alkali-aggregate reaction

During the period of high economic growth, the aggregates widely used for constructing bridge were taken from mountains and other defective sources because the supply of aggregates from rivers had been exhausted. Many of the bridges built before the launch of aggregate regulations and related rules now pose risks.

Within state-managed road sections, there are about 800 bridges where three major damages are in progress. If left as they are, these bridges will further deteriorate. Unless the causes of trouble are addressed at an early stage or reinforcement or some other measure is taken, the bridges will fall into a serious situation, such requiring reconstruction. The longer a project is delayed, the higher the cost. It is therefore necessary to take necessary action as soon as possible.

Photo 1. Deterioration due to chloride attack

Photo 2. Decay of floor board due to fatigue

Photo 3. Deterioration due to an alkali-aggregate reaction

3.3. Reality of periodic inspection

To monitor the reality of road facilities, it is important to inspect them with appropriate frequency. As shown in Table 1, within state-managed road sections, the bridges are now periodically inspected once every five years. The frequency is once every two years in the USA and UK, and once every three years in France. The frequencies of inspections are higher in all those advanced countries than in Japan. Reflecting the fact that bridges in Japan are increasingly aging as described before, from 2004 up, the frequency of periodic inspections increased from every 10 years to 5 years.

The tunnels within state-managed road sections are visually inspected for “cracks,” “peeling,” “water leakage,” and other damages, with the status recorded once every other year or every five years by inspectors using tower wagons and other inspection vehicles.

For state-managed roads, the pavements are inspected to check for rutting, cracks, flatness, and other road surface characteristics once every three years so that safe and comfortable travel are ensured.

On the other hand, roads managed by most local governments are insufficiently inspected. Thus, the status of bridge and tunnel deterioration is not adequately monitored.

To ensure the safe use of road facilities, daily inspection tours and periodic inspection, along with other operations, must be conducted to monitor the status of such facilities. Repairs must then be conducted at appropriate times when necessary.

Table 1 - Bridge inspections in selected countries

Country	Inspection frequency	Description of the target bridges	The number of the target bridges
USA	Once every 2 yrs	Bridges longer than about 6 m on public roads	594,000
UK	Once every 2 yrs	Bridges longer than 3 m on highways	9,500
France	Once every 3 yrs	Bridges longer than 2 m on national roads	23,000
Japan	Once every 5 yrs	State-managed bridges longer than 2 m	20,000

Sources:
National Bridge Inspection Standards, Federal Road Agency, USA
Inspection of Structures, British Road Agency, UK
Instructions for Inspection and Maintenance of Structures, Road Bureau, France

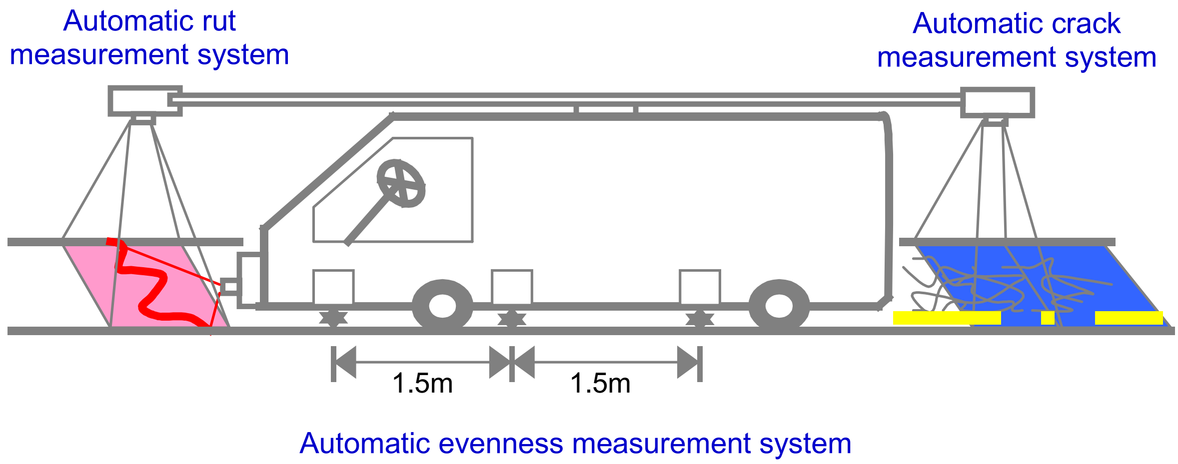


Figure 3 - Overview of inspection vehicles to monitor road surface characteristics

3.4. Diseconomy due to post-event maintenance

As the number of roads increase, their administrative expenses also grow. Previously built road facilities incur some renewal expenses at the end of their service lives. If the facilities continue to be managed in a post-event maintenance manner, the need for bridge reconstruction and large-scale repair work will grow quickly, resulting in even higher demand for repair and renewal expenses.

To ensure road safety while minimizing the increases in repair and renewal expenses, it is imperative to conduct “preventive maintenance,” where appropriate measures are taken before roads becomes so damaged that high expenses are needed for repairs.

4. MEASURES TO REDUCE THE TOTAL COST

As Japanese society matures, it is entering an era where existing bridges should be used more effectively rather than building new ones. Given such a trend of the times, conceivable measures for road management in the upcoming age may include switchover to preventive maintenance, streamlining of daily management, development of technologies for road management.

4.1. Switchover to preventive maintenance

The Government of Japan announced its maintenance targets for about next ten years, the number of the projects for fulfilling those targets, and other details in its “Draft Mid-term Vision for Road Maintenance” in June 2006. Of the total 58 trillion yen budgeted for maintenance expenses, the expenses for maintenance projects, repairs, and renewal make up a large portion and the predicted increase rate is unprecedentedly high, amounting to 15 trillion, making up a high percentage.

In this document, it was decided to switch bridge repairs from “post-event maintenance” where measures are taken only when damage becomes evident to “preventive maintenance” where preventive measures are taken before damage becomes evident. Bridges are classified into 10 patterns and an estimate made. As shown in Fig. 4, “preventive maintenance” reduces the lifecycle cost. In the future, it will be important to properly monitor the status of bridges and predict the future status scientifically, while considering “what to do and when and where, to minimize the lifecycle cost” and select methods of management for preventive maintenance.

Moreover, bridges will come to the end of their service lives in about 60 years on average should there be a lack of proper maintenance. If maintenance is conducted at appropriate times, the lives of bridges can be extended for another 100 years. By doing this, the repair and renewal expenses will be reduced in future significantly than when conducting no sufficient maintenance.

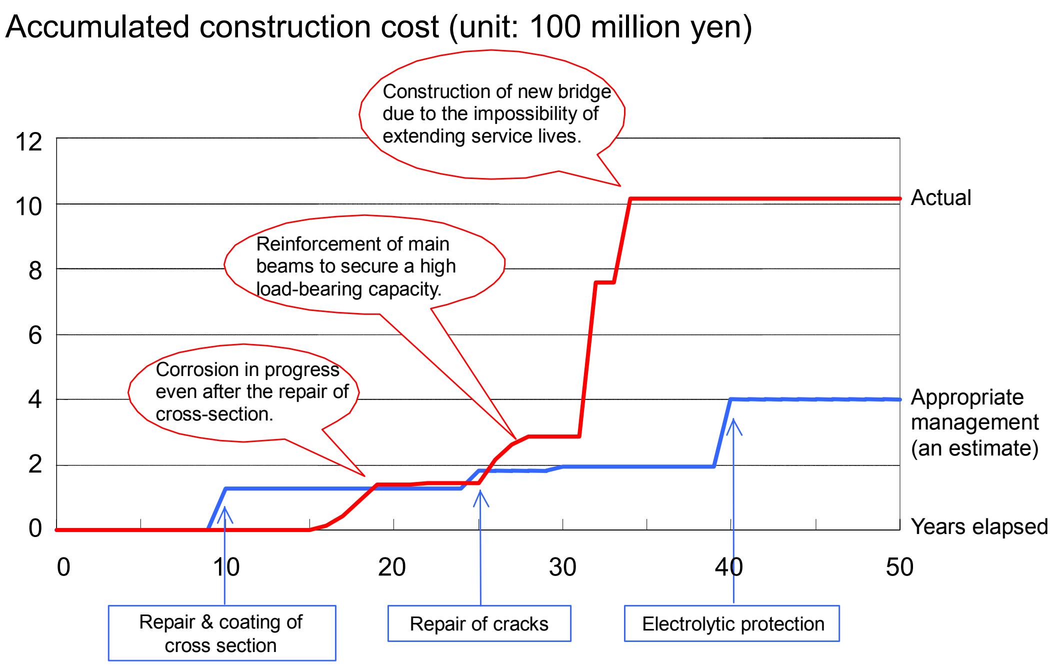
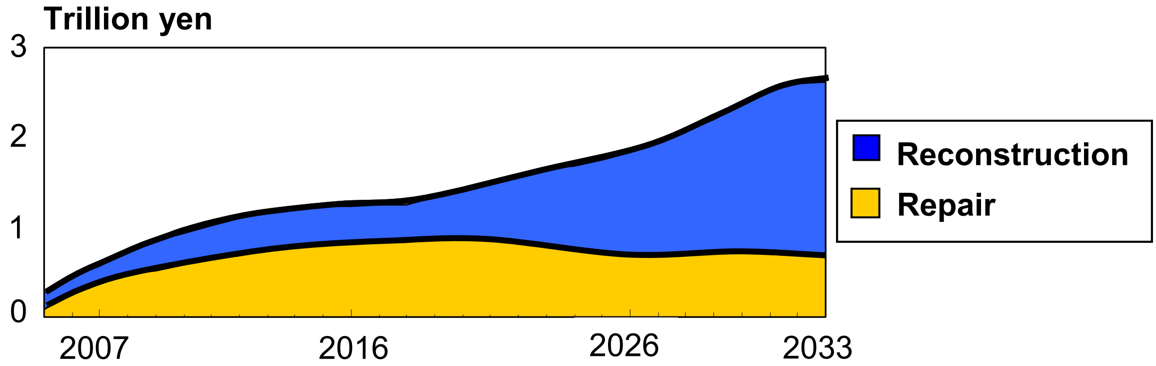
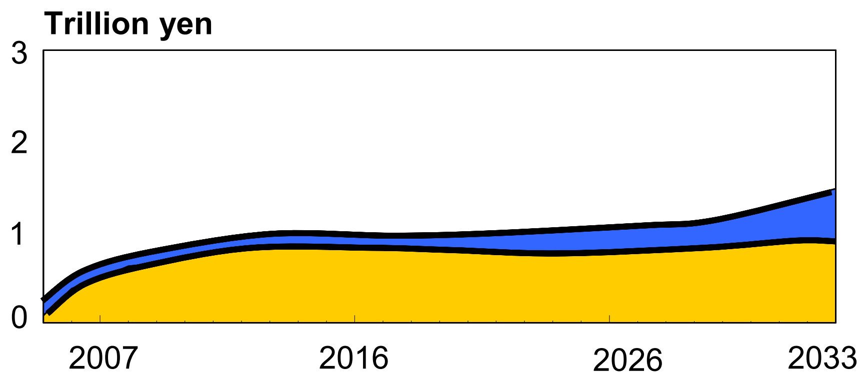


Fig. 4 - Comparison of accumulated construction costs at Kubetsubobashi Bridge (source: Ministry of Land Infrastructure and Transport)

[Management cost with insufficient maintenance (an average service life: about 60 years)]



[Management cost with maintenance at appropriate times (a service life: about 100 years)]



Source: National Institute for Land and Infrastructure Management

Figure 5 - Reduction of long-term expenses by continuing and proper management

4.2. Streamlining of daily management

Repairs of road facilities and other operations to ensure road safety must be given top priority. Nevertheless, given the limited budget, efforts to reduce daily management costs as cleaning and weeding should be made. For state-managed roads, such daily management expenses for 2007 as cleaning, weeding, and trimming are scheduled to be reduced by 30% from 2002.

4.3. Development of road management-related technologies

(1) Development of a road asset management system
Systems are being developed to monitor future damage and structural deterioration, standardize the timing of renewal by extending the service lives of facilities, and reduce total costs ranging from maintenance to renewal. These systems are being developed for bridges (BMS, or Bridge Management System) (Fig. 6 and pavement (PMS, or Pavement Management System) (Fig. 7). In Japan, road inventory is well established. Road inventory designed to manage information about road assets. The compilation of such inventory is mandatory under the Road Law.

Information about road facilities needed to make these systems function efficiently is managed collectively by using a database called the MICHI Database (Ministry of land, Infrastructure and transport Comprehensive Highway management system). The MICHI Database includes data on road conditions (e.g. traffic conditions, traffic regulations, regulated areas), road structure (e.g. routes, longitudinal gradients, horizontal alignments), road structures (e.g. bridges, tunnels, slopes), and road accessory structure (e.g. guard fences, traffic signs, road lighting). Moreover, in order to manage roads of high quality and support efficient road construction and enhancement, information concerning road facilities on directly managed roads is compiled in a database for the centralization and sharing of this information. By using this system, the road inventory and the survey report showing accumulated statistics of local records can be outputted, and retrieval, processing, and analysis of accumulated data becomes possible.

The MICHI Database promptly and accurately provides road managers not only with the status of road facilities but also with information necessary in case of a disaster (e.g. inventory indicating the specifications of disaster-affected facilities and a list of facilities having structures similar to disaster-affected facilities), so that user safety and reliability will be ensured.

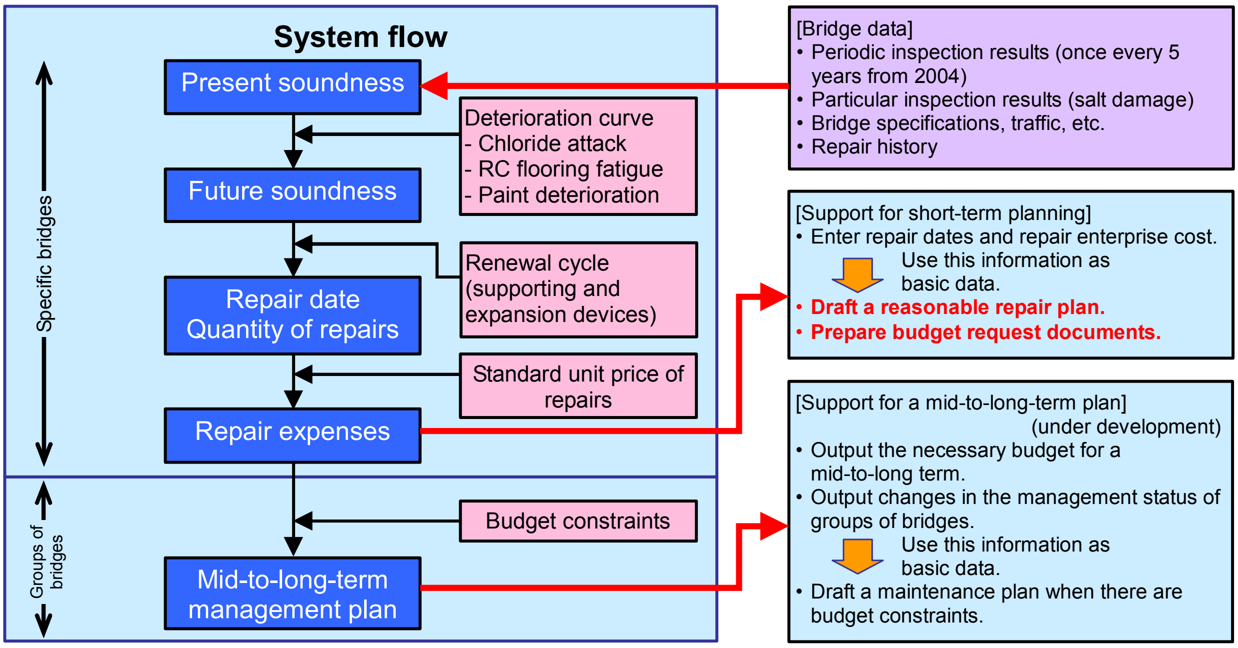


Figure 6 - Overview of the bridge management system

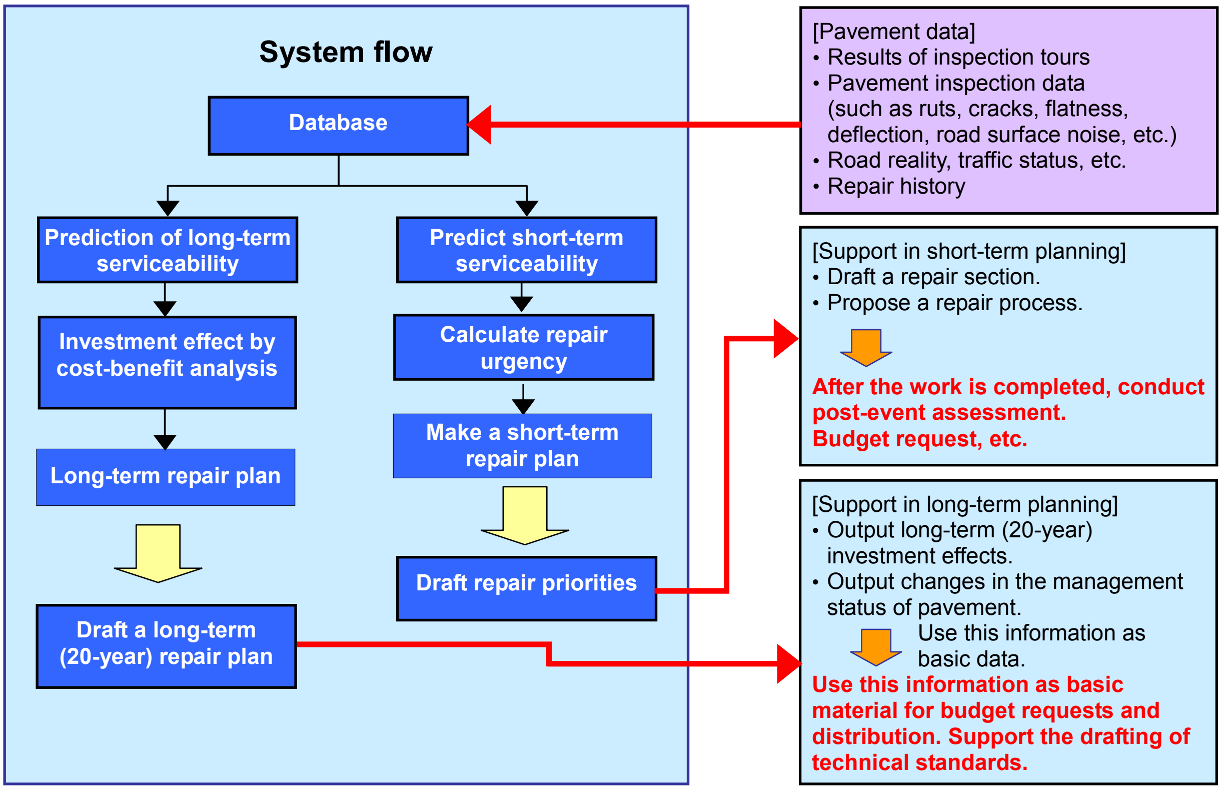


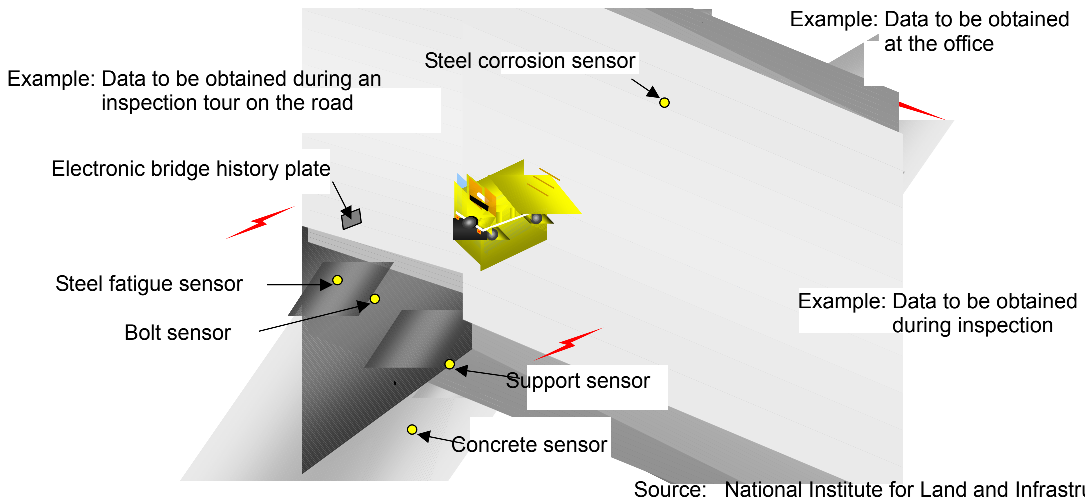
Figure 7 - Overview of the pavement management system

(2) Advanced, efficient inspection technology
The bridges and tunnels are checked by inspectors who pay a visit to the structures in the form of visual or hammering test. Nevertheless, these inspection methods involve disparities in assessment results depending on the inspector, the difficulty in detecting internal damage, and other problems. To address these problems, inspection methods based on nondestructive inspection technology have been developed in recent years, such as processes based on ultrasonic diagnosis, infrared rays, electromagnetic waves, and other means. Nondestructive inspection technology can be used to check structures efficiently in terms of accurate appearance status, internal status, strength, and other details without damaging the structures.

(3) Advanced monitoring technology
By installing sensors on bridges and other structures to monitor structural status whenever necessary, it possible to monitor safety in case of a disaster and quickly recognize sudden changes in the bridges.

As shown in Fig.8, the sources of data include the records stored in sensor at the time of inspection, the ones obtained during road patrols, and the ones sent by wireless LAN to the administrative office.

Research and development is being conducted for such monitoring systems, and hopes run high for such systems to be put to practical use.



Source: National Institute for Land and Infrastructure Management Civil Institute (an independent administrative agency)

Figure 8 - Image of the monitoring system

(4) Development of various repair technologies
In the field of repair technology, it is important to develop repair and reinforcement technologies that are effective and durable against the main factors of damage. Looking at bridge construction, new raw materials are actively introduced. The use of carbon fibers for repair and reinforcement of concrete is one of these examples. In addition, repair and reinforcing technologies are being developed to counter fatigue of steel and protect concrete from salt damage. Pieces of concrete falling off tunnels may become direct causes of traffic accidents and other third-party damage. Such a concern has prompted the introduction of a reinforcing method by which carbon fibers are wrapped around tunnel lining concrete.

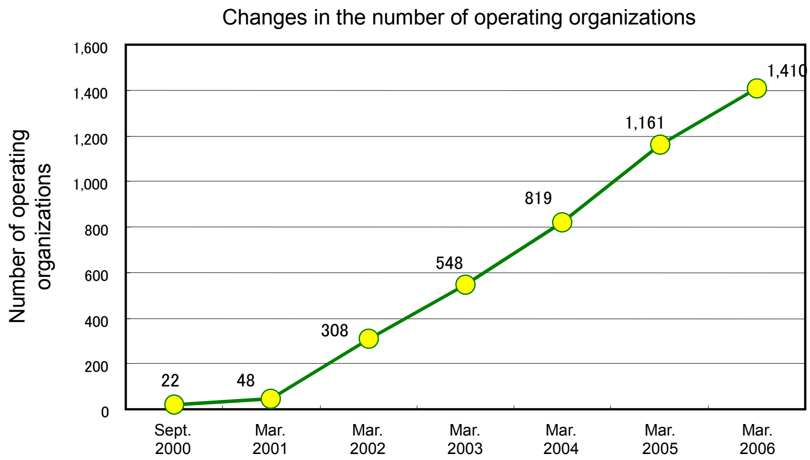
5. RELATIONSHIP WITH ROAD USERS

5.1. Volunteer support program

There is a demand for identifying public needs for road management, and for managing roads meticulously according to local realities. In recent years, students, housewives, NPOs, and other groups of citizens have steadily increased their awareness about participating in social activities. Under these circumstances, efforts are under way as shown in Fig. 6 to fill the gaps between road users, local residents, and road managers.

One such effort is the “volunteer support program.” Road managers conceived this program in an attempt to help citizens attach importance to the roads and embody their spontaneous wishes to keep their hometowns clean. For example, one of the volunteer support programmes is road beautification activity.

At present, as shown in Fig. 9, organizations that implement such volunteer support programs are steadily increasing in number on a nationwide level, reaching a total of 1,410 organizations as of March 2006.



Source: Ministry of Land Infrastructure and Transport

Figure 9 - Status of participation in volunteer support programs

5.2. Monitoring system

Road monitoring system is run based on information provided by local business owners who operate gas station or teashop on mountain paths and local inhabitants on a chargeable basis The aim is to quickly collect information about the status of roads and other details regarding points which are vulnerable to flooding, falling stones, fallen trees, landslides, and other road disasters due to typhoons and torrential rain.

5.3. Road Counseling Center and emergency hot line

The "Road Counseling Center" was established in 1998 for the road managers to work together to receive inquiries and comments, thus allowing citizens a means of making inquiries and comments concerning roads by making a single call (via telephone, fax, or Internet access). (There are many road managers in Japan, such as for expressways, national routes, and prefectural roads.) The road managers aim to respond to each inquiry within a week. The road managers also strive to take speedy and appropriate actions, analyze collected inquiries systematically, and share the information among all interlinked establishments.

In addition, the Government of Japan introduced the "Road Emergency Hot Line" in 2005 using the same telephone number [#9910] on a nationwide level in cooperation with related establishments so that the citizens can have an access to necessary information that requires emergent responses such as abnormal situation of roads.

6. FUTURE ISSUES

6.1. Order placement

It is important to discuss how to place an order as efficient as possible. The "comprehensive evaluation bidding system" is different from the conventional bidding system determined by price only. The system comprehensively assesses the "price," "non-price elements" (such as the maintenance of initial performance and the effects of installation work on safety and the environment). Comprehensive evaluation is a process whereby various technical proposals are submitted by bidders, and the one who has acquired the highest marks in "assessment value" (assessment value = score/cost) based on a comparison of “score” (indicating various technical proposals submitted by bidders) and “cost” (such as the price of the work concerned and other costs of specific technical proposals) is awarded the bid.

In particular, the comprehensive evaluation bidding system for pavement work has adopted since 2000. Indicators used include the degree of road flatness at the time of completion, the amount of rutting after one year of service, safety measures in response to applicable regulations on the work concerned, and tire/ road noise. For example, the stipulated value for tire and road surface noise is supposed to be set at increments of 0.5 dB (LAeq), and determined by the value proposed by the constructor. For making a fair assessment, the “Performance Assessment Committee” was set up by a third party organization. Before the completion inspection is conducted by the client and contractor, the conformity assessment is decided to be made by sending committee members to the site in addition to the assessment of value in performance.

6.2. Outsourcing

Reflecting the Japanese government’s efforts to advance administrative streamlining, the number of government employees has been declining and the number of public workers engaged in road maintenance and management is also dwindling. Against such a backdrop, the government should continue to outsource maintenance and management services to private sector as much as possible, including patrolling, cleaning, weeding/pruning, snow removal, as well as inspection, design and construction of building structures. Nevertheless, decision-making on plans and emergency measures, as well as liaison and coordination with related institutions (e.g. police, local governments) should be conducted based on comprehensive judgments of road administrators. Therefore, these services and operations should be offered and conducted by road administrators instead of being outsourced.

6.3. Budget

In Japan, the budget for public works has been cut down in recent years. The budget for roads also continues to be decreasing, and budgetary outlays earmarked for road maintenance and management, in particular, was drastically curtailed. As expenses for aging-related repairs and renewal of building structures, including bridges, are also expected to significantly increase in the future as compared to recent years, it is necessary to reduce lifecycle costs by shifting from “post-event maintenance” to “preventive maintenance”, as well as making efforts to cut daily maintenance costs for cleaning, weeding, and pruning.