THAILAND

DATA COLLECTION SURVEY
ON
INFRASTRUCTURE MANAGEMENT
IN
THAILAND

FINAL REPORT

December 2014

JAPAN INTERNATIONAL COOPERATION AGENCY
（JICA）
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Summary

1. Outline of the Survey

Background

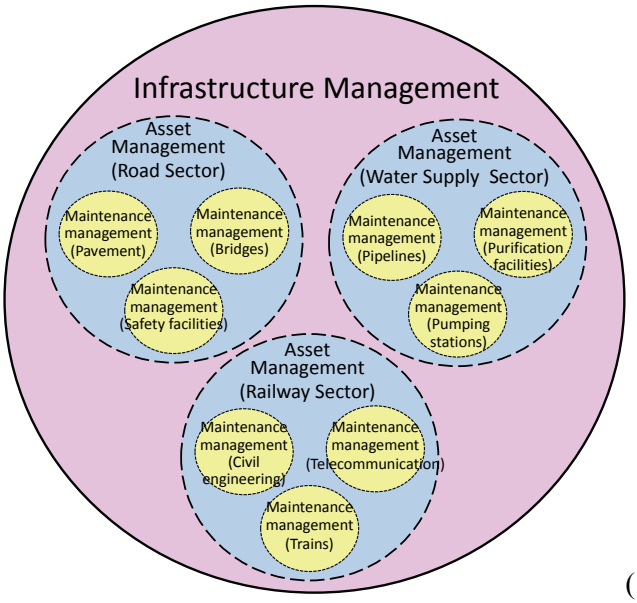
In Japan, many infrastructure facilities have already aged and many more will have aged in the near future, therefore infrastructure facility management to appropriately maintain and repair facilities, extending their life periods while giving due consideration to budgetary constraints, has recently been given deep and widespread attention.

In Thailand, aging of infrastructure facilities will become a serious concern in a decade or two. Moreover, Thailand is still promoting new infrastructure construction to keep up its economic competence with the world, which means Thailand may need to take care of both aging infrastructure facilities and new construction simultaneously.

Definition of Infrastructure Management

In this study 'Infrastructure Management' is defined as methods and methodologies to comprehensively plan, manage and operate civil infrastructure systems. Sometimes the term 'asset management' is used in similar situations. This term means economically and technically rational maintenance plans for each facility and equipment and methodologies for their implementation.

Relationship between infrastructure management, asset management, and engineering maintenance management for individual facilities is illustrated in the following figure.



( ): examples

Figure: Infrastructure Management System

Objectives

1) Introduce the idea of infrastructure facility management, which can extend life periods of infrastructure facilities by managing their routine preventive care and maintenance.

2) Introduce Japanese technologies and skills for infrastructure facility management.

3) Examine possibilities of Japan's support using Official Development Assistance and/or application of technologies and expertise from Japanese companies.

Work Period

This survey started in June 2014 and was completed in November 2014. The team executed two surveys in Thailand during this period.

2. Efforts for Infrastructure Management in Japan

In Japan, the authorities competent in the target sectors in this survey are the Ministry of Land, Infrastructure, Transport and Tourism for the road, railway and sewerage sectors, the Ministry of Health, Labor and Welfare for the waterworks sector and the Agency for Natural Resources and Energy, an extra-ministerial bureau of the Ministry of Economy, Trade and Industry for the electricity sector.

As the implementing organizations in the railway and electricity sectors are private companies, each of them is taking its own measures against deterioration of infrastructure. The roles of the competent authorities in these sectors are limited to preparation of laws and standards and supervision of the service providers.

Since introduction and development of asset management forms the foundations for infrastructure management, efforts for asset management were explained first.

In the waterworks sector, in June 2004, the Ministry of Health, Labor and Welfare (MHLW) developed the Water Supply Vision, which collectively indicates policy priorities concerning the water supply system in the future, and in July 2008 the introduction of the asset management method was added as a priority issue. Following the publication of the New Water Supply Vision, the MHLW has recommended water service providers and prefectural governments to prepare specific plans since March 2014 to clearly define their scopes of works and encourage them to take measures compliant with the new vision. The similar efforts have been executed in the sewerage sector as well.

The Minister of Land, Infrastructure, Transportation and Tourism (MLIT) began to take practical measures to facilitate extension of life of infrastructure facilities as measures against its deterioration in 2006. While the ministry was taking such measures, the ceiling boards in the Sasago Tunnel collapsed in December 2012. This accident led to spread of the awareness of the necessity of measures against the deterioration of infrastructure in the Japanese society and of the necessity of implementation of comprehensive countermeasures. In November 2013, the Minister of Land, Infrastructure, Transportation and Tourism set up the "Basic Plan to Extend Life of Infrastructure Facilities" to develop measures to control the aging of the infrastructures of the government as a whole.

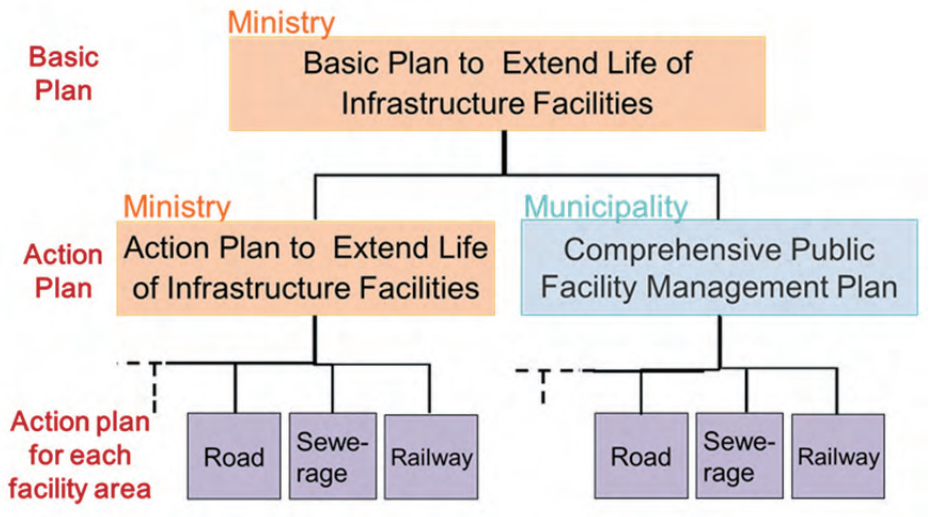


Figure: System of Basic Plan to Extend Life of Infrastructure Facilities

In order to extend the life of all infrastructure facilities across the country, this basic plan presents directives for authorities responsible for the infrastructure to implement collective and planned infrastructure management under the initiative of the MLIT. MLIT compiled the measures to be taken for seven years up to 2020 in an Action Plan. Local governments have begun the preparation of comprehensive public facility management plans.

As an example of a local government, the Fuchu city presented a policy for the infrastructure management in future based on the result of the study in The Fuchu City Infrastructure Management Plan, which was published in January 2013. In the plan, the city estimates the cost-reduction realized by implementing all the measures in the plan at 12%.

New technologies in Japan include: a camera system for inspection used where visual inspections are not possible, materials to improve durability of road pavements and their ability to disperse water, and repair methods for pipeline without having to disrupt water supply.

As for international trends, the ISO55000 series are international standards that provide guidelines for the implementation of asset management by organizations that own and manage assets in compliance with the stipulated requirements. This series came into force in January 2014.

3. Compare Infrastructure Management Approaches in Developed Countries and Assess Comparative Advantages of the Japanese Approaches

In the U.S.A., since “Crumbling America” representing the situation in the 1980’s, they have started to introduce asset management for infrastructure facilities by strengthening financial capacities and institutional systems. There are no laws or regulations that make asset management or infrastructure management a requirement. The U.S.A. has a federal system, meaning that the federal government concentrates on improvement of financial sources, institutional systems, development of databases for maintenance, investment optimization systems and so on; meanwhile each state is responsible for implementation of PDCA and so on.

There are different competent authorities for each sector, unlike Japan where MLIT is competent in more than 10 sectors. Therefore, federal and state governments do not develop a cross sectoral holistic policies or plans, nor do they enforce the implementation of such plans.

In Europe, private sector participation has been encouraged since long ago and the central governments execute the promotion and supervision of private sector participation by using institutional arrangements. Central governments often adopt the concession contract for the work which can be expected to be able to recoup costs through tolls/fees, and also PFI by paying a contractor a fee calculated by shadow toll fee system.

Regarding individual technologies, Japan has a comparative advantageous over the U.S.A. and U.K. in terms of skills for safe work on roads, which are often narrow and leading to intricate alleyways, and in terms of durable materials in a climate with large annual temperature variations and many natural disasters such as typhoons and earthquakes.

Therefore, the advantages of Japan over the Western countries are found in the national-level planning of comprehensive infrastructure management, systems and methods for providing assistance to infrastructure administrators in planning, initiatives of municipalities in the waterworks and sewerage, technologies for working in narrow and intricate roads, and material technologies in consideration of earthquake resistance and disaster prevention functions.

4. Current Status of Infrastructure Management in Thailand

In the transport and communications sector, investment in new communications infrastructure is apparent in recent years, while some of transportation infrastructure is getting older. The situation is similar in the railway sector, where 67% of railways of State Railway of Thailand are more than 30 years old. For example, aging of bridges is evident: among the bridges managed by Department of Highways, there are now 338 bridges which are more than 50 years old, or 2% of the total, and this figure will be 1,818 or 12% in another 10 years.

On the other hand, Thailand is planning to develop new infrastructure facilities in view of the formation of ASEAN Economic Community in 2015. In 2013, the government announced a large-scale infrastructure development plan up to 2020 whose total cost amounts to more than 2 trillion baht.

In Thailand, the ratio of senior citizens 65 years of age or older exceeded 7% in 2007, which means the arrival of an “aging society,” and will reach 14% in 2027 when Thailand will become a “super-aging society”. Therefore, it will inevitably be difficult in the future to acquire fund sources for infrastructure improvement.

In Thailand, the demand for construction will continue even after the start of a phase of maintenance and replacement of infrastructure facilities. Thailand will need to implement both of them at the same time, therefore it has to devise ways to further improve the efficiency of constructing and maintaining infrastructure facilities.

The statuses of sectors are recognized as follows by NESDB, which is influential on infrastructure management through assessment of each organization’s plan and policy:

- For the road sector, maintenance will be emphasized as more priority is placed on railways.
- For the railway sector, priority will be placed on new investment to enhance the railway network.
- The waterworks sector has no problem in Metropolitan Water Authority (MWA) and Provincial Water Authority (PWA) coverage areas with good conditions. However, PWA has large water supply areas with regional differences so that an adequate level of service has not reached remote, sparsely populated areas.
- The sewerage sector has a problem of not being able to charge for the services.
- The power sector has a good financial state and is free of maintenance problems.

5. Case Study on Infrastructure Management in Priority Sectors

Holistic infrastructure management across these sectors should be based on national government's plans leading to specific actions. The role of national governments in Thailand, however, is to make policies and it is implementing organizations that make plans based on the policies. As such, the planning and budgeting organizations are not aware of nor ready for their responsibility in infrastructure management. It is difficult to develop measures whose effect can be confirmed within the scope of this study. Therefore, the Study Team selected priority sectors which are ready for asset management and developed measures for target organizations which could cooperate with this study. This process also intended to promote better understanding of infrastructure management

The waterworks sector and the road sector were selected as priority sectors based on the assessment result of each sector because the infrastructure management in these sectors in particular is becoming very important. MWA for the waterworks sector and EXAT for the road sector were selected as target organizations for case studies because both the management priority in both organizations is shifting from the new construction to the maintenance and the basic organizational system to implement infrastructure management has been mostly arranged. In order to present effective examples to clearly show to each infrastructure management organization the countermeasures within the capacity of this case study, the case study focuses on long-term perspectives on a few important issues to examine countermeasures, taking various circumstances and conditions for the organization into account. In addition, an examination on the effects of revising road design standards is executed because such a revision was very effective in Japan. These three case studies with different patterns were executed to examine countermeasures.

1) Case to Examine Countermeasures to Improve Efficiency of Water Supply Business

This case study focuses on the Metropolitan Water Authority and the feasibility of it utilizing Life-Cycle Cost (LCC) analysis for selecting new pipe types for replacement. The study also investigates the most cost effective combination of pipe types in terms of reduction of non-revenue water ratio and water production costs. The study compares two scenarios of possible countermeasure, and found that the maintenance cost can be reduced by more than 51 bill baht over the next 50 years.

Table: Cost Benefit Ratio and O & M Cost Ratio for Scenarios

Unit: Mill baht/50 years

Scenario	Accumulated operation and maintenance (O& M) costs			Difference from BS	Cost savings from BS (%)	Accumulated O &M costs/Revenue (%)
	Pipe	Pump	Total			
Baseline Scenario (BS)	188,105	73,803	261,908	－	－	20.8%
Scenario 1	142,763	67,612	210,375	－51,533	20.0%	19.2%
Scenario 2	140,994	66,266	207,260	－54,648	20.9%	18.9%

Note: The accumulated revenue over 50 years is estimated as 1,097,144 million baht.

2) Case to Examine the Countermeasures to Cope With the Deterioration of Concrete Structures Due to Aging

This case study focuses RC slab of elevated road of Expressway Authority of Thailand (EXAT) to minimize the required maintenance budget, which is expected to greatly increase in future due to aging of concrete structures. It examines alternative measures using LCC analysis to identify the optimum maintenance method. The study compares the total maintenance costs for 100 years, and found that it is 75 million baht by corrective maintenance and 34 mill baht by preventive maintenance, and thus the preventive maintenance reduces the total cost by 55%.

Table: Result of Case Study

	Accumulated maintenance cost for 100 years (bill baht)		Cost difference
	Corrective maintenance scenario	Preventive maintenance scenario	
Case 1	75	45	40%
Case 2		34	55%

3) Case to Examine the Impact on LCC of Road Pavement by Doubling the Design Useful Years

In Japan, the revision of road pavement design standard in 2001 was one of the factors that helped promote the uptake of long life road pavements to reduce LCC. This case Study examines the impact on LCC of road pavements if such a road pavement design standard revision is undertaken in Thailand. It compares the LCC of road based on the present design standard with 15 year service life and LCC of road based on the 30 year service life design standard. The case Study found that LCC of road pavement can be reduced by 32% based on 100 years.

6. Technical Transfer

A workshop and a seminar were held during the survey period.

Workshop

For the purpose of explaining study objectives and introducing the approaches toward infrastructure management in Japan, a workshop was held on July 16th with the attendance of invitees from target organizations. There were 59 participants from 16 target organizations and one university, and this implied the high need for technical improvement of infrastructure management.

The answers to the questionnaires revealed that the workshop enhanced the awareness of infrastructure management with a focus on preventive maintenance and that there were needs among the participants for Japanese technology and knowledge for all the aspects of infrastructure management.

Seminar

For the purpose of explaining the results of the study and suggestions regarding infrastructure management, a seminar was held on October 21st with the attendance of invitees from target organizations. There were 60 participants from 17 target organizations and one university.

The Study Team presented the infrastructure management situations and three case studies to show the effect of life extension measures using LCC in water and road sectors. There was a presentation from a professor in Chulalongkorn University about ISO55000.

As the summary of this seminar, we pointed out keys to implementing infrastructure management found through this study. The questionnaire asked how important the participants consider each key message. Participants understood the importance of all messages, especially importance of infrastructure management and use of LCC for procurement were understood well.

Participants from implementation organizations recognize laws and rules, policy, and budget as obstacles. Other issues mentioned are that it is difficult to convince budget bureau and executives and especially because they do not have proven performance to convince, and that structural separation between planning and maintenance makes it difficult to share information.

7. Findings from the Survey

(1) Financial source

- SEPO is active to introduce the private fund such as PPP scheme and infrastructure fund for the development and operation of infrastructure which the profit can be expected.
- Securing funding is essential to continue steady maintenance of existing infrastructure facilities. It is an effective way to create taxes and subsidies preferentially allocated for maintenance activities in Thailand.

(2) Management policy and needs

1) Creation of Framework for Infrastructure Management

In Thailand there is a continuing demand for new infrastructure construction and infrastructure facilities are increasing and aging at the same time. Under such a circumstance, how to support budget for new investment and maintenance at the same time is a pressing issue for the Thai government. The following are suggested as solutions.

1) For new construction, consider measures to minimize LCC from design, procurement through to the end of use.
2) For maintenance of existing infrastructure facilities, consider LCC and implement measures against aging and for life extension

To promote proactive engagement in this policy to implementing organizations, it is effective that national competent authorities set a holistic policy for implementing organizations at national and local levels to consider all infrastructure facilities including both new and existing infrastructure facilities.

2) Approaches to State Owned Enterprises

In order to urge state owned enterprises to promote asset management, SEPO which is responsible for supervising all state enterprises in Thailand should emphasize infrastructure management in a Statement of Directions.

(3) Management plan and measures

1) Integrated management is essential for successful infrastructure management and organization structures enabling cross-sectional and comprehensive consideration and decision making works well.
2) Reduction of LCC by life extension is an important method and it is effective to proactively promote research on life extension technology and data accumulation on a trial basis.
3) Understanding of the current situation of RC structures is urgent, therefore, inspection work and the preparation of inspection database of all facilities should be completed as soon as possible.
4) The case study showed the advantages of consideration of LCC in selection of several technologies and materials and of planning a long-term strategy based on cost estimation for longer than the service lives of materials and equipment. In addition, it is effective to proactively find and use new and better materials.

(4) Organization structure and skills

1) The revision of design standards of pavement should be actively examined.
2) DOH and DRR offer staff training on maintenance including practical works and LCC methods. It is useful and should be continued.

3) Procurement costs can be saved drastically if PWA headquarters establish joint procurement systems for all 234 branches.

(5) Support from Japan

1) An effective technical training for Thailand should cover practical skills of inspection and maintenance, analysis such as LCC and projection of deterioration curve, and infrastructure management method.

2) Because the implementation level of inspection and maintenance in Thailand is assessed as being quite high, the technologies in Japan which can meet the needs are only very advanced ones.

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Figures

Tables

Abbreviations

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADB	Asian Development Bank
AEC	ASEAN Economic Community
AIT	Asian Institute of Technology
AM	Asset Management
AMS	Asset Management System
ANRE	Agency of Natural Resources and Energy (Japan)
ASCE	American Society of Civil Engineers
BMA	Bangkok Metropolitan Administration
BMMS	Bridge Maintenance and Management System
BMS	Bridge Management System
BMTA	Bangkok Mass Transit Authority
BOB	Bureau of the Budget
BOT	Build, Operate and Transfer
BSI	British Standard Institution
CFRP	Carbon Fiber Reinforced Plastics
CRD	Central Road Database
DBFO	Design, Build, Finance and Operate
DBO	Design, Build and Operate
DEDE	Department of Alternative Energy Development and Efficiency
DfT	Department for Transport
DIS	Draft International Standard
DMA	District Management Area
DOE	Department of Energy
DOH	Department of Highways
DPT	Department of Public Works and Town & Country Planning
DRR	Department of Rural Roads
DSD	Drainage and Sewage Department
EGAT	Electricity Generating Authority of Thailand
EPA	Environmental Protection Agency
ERC	Energy Regulation Commission
ERO	Electric Reliability Organization
EXAT	Expressway Authority of Thailand

FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FPO	Fiscal Policy Office
F/S	Feasibility Study
GASB	Governmental Accounting Standards Board
GIS	Geographic Information System
HA	Highways Agency
HDM	Highway Design Manual
HERS-ST	Highway Economic Requirements System-State Version
HPMS	Highway Performance Monitoring System
IAM	Institute of Asset Management
ICE	Institute of Civil Engineers
IPE	Independent Power Plant
IRI	International Roughness Index
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
LCC	Life Cycle Cost
MEA	Metropolitan Electricity Authority
METI	Ministry of Economy, Trade and Industry
MHLW	Ministry of Health, Labour and Welfare (Japan)
MIC	Ministry of Internal Affairs and Communications (Japan)
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
MNRE	Ministry of Natural Resources and Environment
MOE	Ministry of Energy
MOI	Ministry of Interior
MOF	Ministry of Finance
MOT	Ministry of Transport
MRTA	Mass Rapid Transit Authority
MWA	Metropolitan Waterworks Authority
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NESDB	National Economic and Social Development Board
NETIS	New Technology Information System
NIP	National Infrastructure Plan
ODA	Official Development Assistance
Ofgem	Office of Gas and Electricity Markets

Ofwat	Water Services Regulation Authority
OGC	Office of Government Commerce
O&M	Operation and Transfer
ORR	Office of Rail Regulation
PBMC	Performance-Based Maintenance Contracting
PC	Pre-stressed Concrete
PDCA	Plan Do Check Action
PDMO	Public Debt Management Office
PEA	Provincial Electricity Authority
PFI	Private Finance Initiative
PMMS	Pavement Maintenance and Management System
PMS	Pavement Management System
PPP	Public Private Partnership
PSO	Public Service Obligation
PVC	polyvinyl chloride
PWA	Provincial Waterworks Authority
RMMS	Routine Pavement Maintenance and Management System
SAP	Session Announcement Protocol
SCADA	Supervisory Control And Data Acquisition
SEPO	State Enterprise Policy Office
SOE	State Owned Enterprise
SRT	State Railway of Thailand
TAM	Transportation Asset Management Guide
TPMS	Thailand Pavement Management System
VMS	Variable Message Sign
WMA	Wastewater Management Authority

1 Outline of the Survey

1.1 Background

In Japan, infrastructure facilities such as roads, bridges and water supply and sewerage systems were constructed during the country's rapid economic growth in the 1960's. Service life of such infrastructure facilities is on average several decades, and many facilities have and will have aged by the 2010's. Therefore, in Japan, infrastructure facility management to appropriately maintain and repair facilities, extending their life periods while giving due consideration to budgetary constraints, has recently been given deep and widespread attention.

In Thailand, the heavy construction period for infrastructure facilities for the purpose of attracting foreign investment started in the 1980's. Considering the fact that its history of infrastructure development follows that of Japan by two decades, we can assume that aging of infrastructure facilities will become serious concern in Thailand in a decade or two. Moreover, Thailand is still promoting new infrastructure construction to keep up its economic competence with the world, which means Thailand may need to take care of both aging infrastructure facilities and new construction.

Given these circumstances, it is beneficial for Thailand to learn from the lessons that Japan gained through its trial and error process and apply precautionary measures before their infrastructure facilities age and cause serious problems, in order to keep their competent position in the world. To this aim, Japan International Cooperation Agency (JICA) will conduct this data collection survey study and examine the current situation of infrastructure facilities in Thailand, their maintenance, and their management especially in light of the issues surrounding aging infrastructure, in order to develop recommendations on necessary measures to be taken.

1.2 Definition of Infrastructure Management

In this study 'Infrastructure Management' is defined as methods and methodologies to comprehensively plan, manage and operate civil infrastructure systems. Sometimes the term 'asset management' is used in similar situations. This term means economically and technically rational maintenance plans for each facility and equipment and methodologies for their implementation. Asset management for each facility is based on comprehensive infrastructure management.

1.3 Objectives

JICA conducts this study with the following three objectives.

1) Introduce the idea of infrastructure facility management, which can extend life periods of infrastructure facilities by managing their routine preventive care and maintenance.
2) Introduce Japanese technologies and skills for infrastructure facility management.

3) Examine possibility of Japan's support using Official Development Assistance (ODA) and/or application of technologies and expertise from Japanese companies.

1.4 Scope

1.4.1 Target Location

City of Bangkok and neighboring municipalities

1.4.2 Target Organizations

The following organizations will be contacted to obtain necessary information.

1) Office of Prime Minister /Bureau of the Budget
2) Ministry of Finance (Public Debt Management Office, State Enterprise Policy Office)
3) Office of Prime Minister /National Economic and Social Development Board (NESDB)
4) Ministry of Interior/ Department of Public Works and Town & Country Planning (DPT)
5) Bangkok Metropolitan Administration (BMA)
6) Metropolitan Waterworks Authority (MWA)
7) Provincial Waterworks Authority (PWA)
8) Wastewater Management Authority (WMA)
9) Ministry of Transport/ Department of Highways (DOH)
10) Ministry of Transport/ Department of Rural Roads (DRR)
11) Expressway Authority of Thailand (EXAT)
12) State Railway of Thailand (SRT)
13) Mass Rapid Transit Authority (MRTA)
14) Electricity Generating Authority of Thailand (EGAT)
15) Metropolitan Electricity Authority (MEA)
16) Provincial Electricity Authority (PEA)

1.4.3 Target Facilities

Various public structures can be considered as infrastructure facilities. The target facilities and areas are selected based on information of the facilities that the target organizations are responsible for.

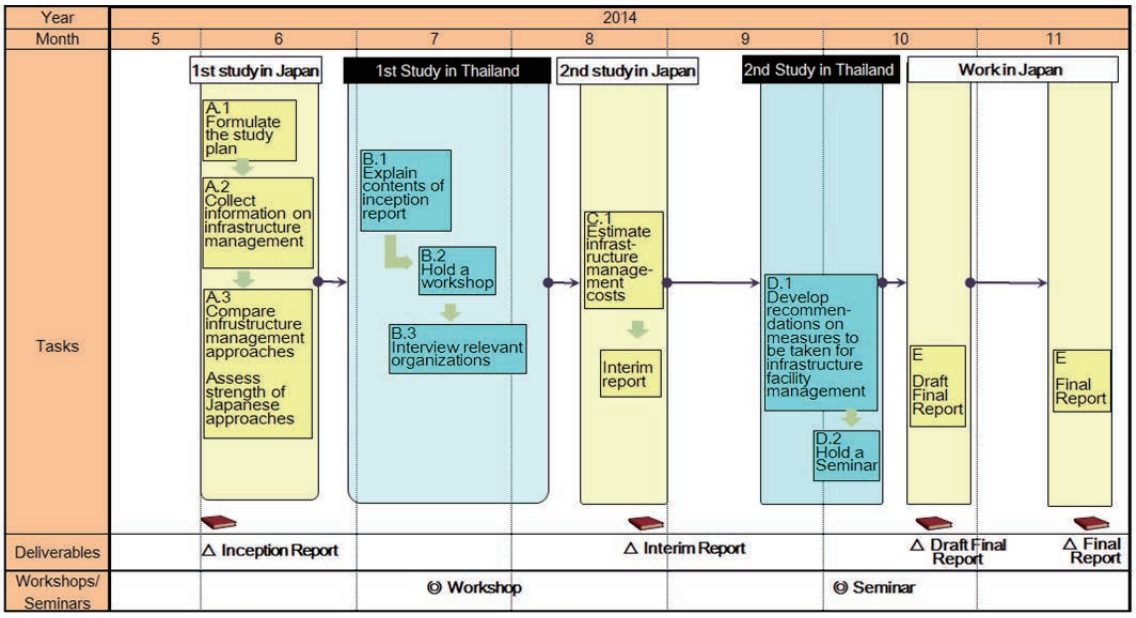
Table 1 Target Areas and Facilities

Target areas	Target facilities	Administrators		
		Ministries	Municipalities	Public corporations
Roads - Highways, - National roads, - Local roads	Pavements, bridges, tunnels	MOI/DPT MOT/DOH MOT/DRR	BMA	EXAT
Water supply	Dams, purification plants, pipelines, pumping stations	MOI/DPT		MWA, PWA
Sewerage	Pipelines, sewerage treatment plants, pumping stations	MOI/DPT	BMA	WMA
Railways - National railways - Mass Rapid Transit	Bridges, viaducts, stripline structures, fixtures and fittings	SRT		MRTA
Electricity	Powerhouse, Substation, distribution line	MOI/DOE		EGAT, MEA PEA

MOI/DPT	Ministry of Interior/ Department of Public Works and Town & Country Planning		
MOT/DOH	Ministry of Transport / Department of Highways		
MOT/DRR	Ministry of Transport / Department of Rural Roads		
EGAT	Electricity Generating Authority of Thailand		
BMA	Bangkok Metropolitan Administration		
WMA	Wastewater Management Authority	MRTA	Mass Rapid Transit Authority
MWA	Metropolitan Waterworks Authority	MEA	Metropolitan Electricity Authority
PWA	Provincial Waterworks Authority	PEA	Provincial Electricity Authority
SRT	State Railway of Thailand	EXAT	Expressway Authority of Thailand

1.5 Implementation Structure

1.5.1 Study Schedule



1.5.2 Detailed Plan of Study

A. First Study in Japan

A.1 Formulation of the study plan

The Study Team studied all available information, i.e. materials collected by the Study Team and any other projects. The Study Team will then summarize the basic policy, project methods, operation itemization and content, and study schedule.

A.2 Collection of information on infrastructure management in Japan through literature research

The Study Team collected the information on infrastructure management in Japan.

Table 2 Contents of the Initial Study

Items	Contents	Information sources in Japan	Sources of similar information in Thailand
a. Current situation of aging infrastructure facilities	Current situation of infrastructure facilities (past record-keeping, maintenance skills) Segregation of duties between national and local levels	Local governments	NESDB, BMA
	Legal systems (Regulation on use of private sector funds etc.)	Ordinance governing ministries	Bureau of the Budget, SEPO

b. National governments' approaches	National government measures and policies	MIC	NESDB
		MLIT	DPT
c. Municipalities' Approaches	Measures and policies Projects Financial plans	Infrastructure management plan	MWA, PWA, DOH, DRR, EXAT, SRT, MRTA, EGAT, MEA, PEA, BMA
d. Private sector technologies and expertise	Products and technologies, Performance Overseas businesses Overseas expansion plans	General contractors, Bridge makers, Consultants etc.	Thai Obayashi, Research institutions

MLIT Ministry of Land, Infrastructure, Transport, and Tourism
MIC Ministry of Internal Affairs and Communications

A.3 Comparison of infrastructure management approaches and assessment of strengths of Japanese approaches

The Study Team then put all information collected together and compare situations and various approaches, such as administrative structures, legal systems, policies, and private sector' technologies and expertise in each area between those applied in Japan and in other developed countries, based on a similar literature research on non-Japanese examples as described above.

B. First Study in Thailand (June 29 – August 9)

B.1 Explanation of contents of inception report

The Study Team explained the contents of the inception report, study plan, and summary of findings from the literature research on various aspects related to infrastructure facility management approaches in Japan and other developed counties.

B.2 Holding of workshop

A workshop was held with the purpose of disseminating and discussing project objectives and methods for 59 participants from the Thai side (from NESDB, SEPO, BMA, MWA, PWA, DOH, DRR, EXAT etc.). The Study Team will ask the participants for cooperation in meeting with Study Team for interviews and providing necessary information and data for assessment.

B.3 Interview of relevant organizations

In order to learn how each task in the PDCA cycle as shown in Table 3 is implemented in Thailand, the Study Team visited each organization a few times.

Table 3 Queries based on PDCA to Administrative Organizations in Thailand

PDCA	Data category	Sample interview topics
PLAN	Laws, standards, policies, and plans	・ Laws, standards, regulations, and rules governing infrastructure management ・ Infrastructure management plans in existence, including facility-specific plans ・ Infrastructure management policies, related governmental policies and direction of change (if any)
	Overall management structure	・ Whether responsibility is assigned to specific agencies/organizations for each infrastructure/facility/equipment
	Budget management	・ Maintenance budget categories
DO	Inspection system	・ Infrastructure/facility/equipment targeted by inspection-based management – locations and quantity ・ Current state of ageing of infrastructure /facility/equipment, i.e. latest results from inspections ・ Detailed inspection procedures and manuals ・ Year of construction and service life of each infrastructure/facility/equipment
	Repairs, reinforcement and upgrades	・ TOR (work description) given when hiring contractors (if applicable) ・ Capacity and skill level of agency staff and/or contractors
CHECK	Management organization's structure	・ Number of staff in each staff category, personnel cost per staff category ・ TOR (work description) of each staff category
	Recordkeeping of maintenance and management data	・ Quality standards governing recordkeeping
	Maintenance costs	・ Changes over time in maintenance costs ・ Estimates of tax revenue ・ Prospects of assistance via subsidies and foreign aid
ACT	Review and revision of infrastructure management plans	・ Whether plans were ever revised, and if so, details
	Review and revision of laws and standards governing planning	・ Whether laws and standards were ever revised, and if so, details
	Review and revision of management structure	・ Opinion of interviewee(s) on what needs to be improved and revised within current management structure

Table 4 Schedule of Visit for Interview

#	mm/dd		AM	PM
1	6/29	Su	TYO→	→BKK
2	6/30	Mo		JICA Thailand
3	7/1	Tu		Kasetsat University
4	7/2	We		Thainishimatsu Construction Co.,Ltd.
5	7/3	Th	Burapha University	Chularongkorn Univ.
6	7/4	Fr	BMA	Engineering Institute of Thailand
7	7/5	Sa		
8	7/6	Su		
9	7/7	Mo	1000 Thai obayashi	JICA Thailand Chief Rep.
10	7/8	Tu	Chulalongkorn University Prof.Wisanu Subsompon	AIT, Dr.Worsak
11	7/9	We	MWA	JICA Thailand
12	7/10	Th	DOH	EXAT
13	7/11	Fr	Thai National Holiday	
14	7/12	Sa		
15	7/13	Su		
16	7/14	Mo	Thai National Holiday	
17	7/15	Tu		SRT
18	7/16	We	**1000 Workshop**	
19	7/17	Th		NESDB, MWA
20	7/18	Fr	DRR, Kansai Koji Survey Co.Ltd.	EGAT, PWA
21	7/19	Sa		
22	7/20	Su		
23	7/21	Mo	AIT Prof.Yamamoto	
24	7/22	Tu	DOH bridge	PEA
25	7/23	We	MRTA, DPT	
26	7/24	Th	DPT	MWA, SRT, SEPO
27	7/25	Fr		PWA
28	7/26	Sa		
29	7/27	Su		
30	7/28	Mo		
31	7/29	Tu	BMA Public Works/Sewerage	PWA (Budget), SRT, JICA
32	7/30	We	JICA MRI, NTTdata, PEA	MEA
33	7/31	Th	Public Debt Management Office	
34	8/1	Fr	DRR (Budget)	
35	8/2	Sa		
36	8/3	Su		
37	8/4	Mo	SEPO	
38	8/5	Tu	Tokyo Metropolitan Expressway	
39	8/6	We	BMA Public Works, Budget	BMA Drainage
40	8/7	Th	DOH Branch 11	MWA Branch, JICA
41	8/8	Fr	BMA Budget, DRR Branch	BKK→
42	8/9	Sa	→TYO	

C. Second Study in Japan

C.1 Estimation of infrastructure management costs

The Study Team selected water supply and traffic and transportation as high priority areas because their focus is shifting from new construction to maintenance and repair. Three case studies are developed to examine measures to minimize life cycle cost (LCC) and extend life of infrastructure facilities and to estimate the impact of infrastructure management.

1) Comparison of the operation and maintenance cost based on the current pipe replacement plan and the suggested scenarios to select pipes for replacement to minimize LCC.

2) Comparison of LCCs for corrective maintenance and preventive maintenance for repair of road concrete structures

3) Comparison of LCCs if road pavement based on the current design standard and the scenario to double the design year.

D. Second Study in Thailand (September 23 – October 23)

D.1 Development of recommendations on measures to be taken for infrastructure facility management

The Study Team will grasp the expressed and potential needs of the relevant administrative organizations in charge of planning and implementation of infrastructure facility management in the priority areas, and develop practical measures and step by step plans that takes into consideration the issues and barriers to be solved. The study schedule will be developed based on the results of the previous study phases.

Table 5 Possible Recommendations of Measures to be Taken (Tentative)

Perspective	Possible recommendations (Tentative)
Financial sourcing	・Find financial sources such as tax revenue, reserve fund, subsidies, financial aid from foreign source ・Find ways of private sector involvement such as PPP and PFI
Management policy and needs	・Select priority facilities based on practical considerations and required investment
Management plan and measures	・Utilize database and IT technologies in management ・Review current tasks and workflow ・Involve citizens for daily care ・Review the total cost in life cycle for developing measures to reduce the total cost
Organization structure and skills	・Make plans for training in Japan and Thailand ・Review the level of administration
Support from Japan	・Introduce new service and technologies by private companies ・Apply the cost reduction activities applied in Japan ・Utilize JICA's ODA scheme

The impact of infrastructure management is calculated based on discussions with the target organizations about presumptions and measures proposed in the case studies. The study schedule is shown below.

Table 6 2nd Study Schedule

#	mm/dd		AM	PM
1	9/23	Tu	TYO	→BKK
2	9/24	We		
3	9/25	Th		
4	9/26	Fr		DOH
5	9/27	Sa		
6	9/28	Su		
7	9/29	Mo	MWA	
8	9/30	Tu		
9	10/1	We		
10	10/2	Th	MRTA	
11	10/3	Fr		DOH
12	10/4	Sa		
13	10/5	Su		
14	10/6	Mo	BMA (PW & SEWERAGE)	JICA Courtesy Call
15	10/7	Tu		SEPO
16	10/8	We	Assistant Governor, Planning Dept. Budget	EXAT
17	10/9	Th	EGAT	MEA, PWA
18	10/10	Fr	PEA Director, Maintenance	DTC
19	10/11	Sa		
20	10/12	Su		
21	10/13	Mo	PDMO	
22	10/14	Tu	BB Deputy Director	BMA Sewerage
23	10/15	We	WMA, DOH	SRT, EXAT
24	10/16	Th	NESDB Advisor on Policy and Planning,	Dr.Worsak AIT, DOH
25	10/17	Fr	JICA TV conference, SEPO	Interpreter
26	10/18	Sa		
27	10/19	Su		
28	10/20	Mo		
29	10/21	Tu	**1000-1230 Seminar**	JICA
30	10/22	We		BKK→
31	10/23	Th	→TYO	

D.2 Hold a seminar

A seminar will be held to report the study results, to obtain reactions from the various stakeholders and to discuss the feasibility of recommended measures and plans for improving the management of infrastructure facilities.

E. Final Report

The results of the study and suggestions in the priority areas will be integrated into a final report.

1.6 Study Team Members

The Study Team is composed of five members who are working in the following capacities.

Capacity	Name
Team leader	Akira DOI
Deputy team leader & financial planning expert	Junko TOMITA
Infrastructure management planning expert	Hideo SATO
Water supply planning expert	Kenji SHINODA
Traffic and transportation planning expert	Makoto ASHINO

2 Efforts for Infrastructure Management in Japan

2.1 Efforts of Central Government

The target sectors of this survey are the road, railway, sewerage, waterworks and electricity sectors. In Japan, the authorities competent in these sectors are the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (for the road, railway and sewerage sectors), the Ministry of Health, Labour and Welfare (MHLW) (for the waterworks sector) and the Agency for Natural Resources and Energy, an extra-ministerial bureau of the Ministry of Economy, Trade and Industry (for the electricity sector).

As the implementing organizations in the railway and electricity sectors are private companies, each of them is taking its own measures against deterioration of infrastructure. The roles of the competent authorities in these sectors are limited to preparation of laws and standards and supervision of the service providers.

In the waterworks sector, MHLW has prepared long-term guidelines for local governments which provide water supply services. In the guidelines, the ministry has urged them to have goals to be achieved in the future and use the asset management method to improve the capacity of water supply facilities to the level at which they can supply safe water in an easily accessible way and ensure stable supply of water at the time of disaster under a situation where large-scale replacement of facilities are needed. A similar approach was adopted later in the sewerage sector. MLIT prepared plans to extend the life of all the infrastructure facilities under its jurisdiction in 2013.

In this chapter, the current state of infrastructure facilities is explained at first and, then, the measures taken against their deterioration are described in chronological order.

2.1.1 Background for the Policy for the Infrastructure Development

(1) Current State of Infrastructure Facilities

Many of the existing infrastructure facilities in Japan were constructed in the period of rapid economic growth in the 1960's and the 1970's. Seventy percent of the existing bridges in Japan were constructed in these two decades.

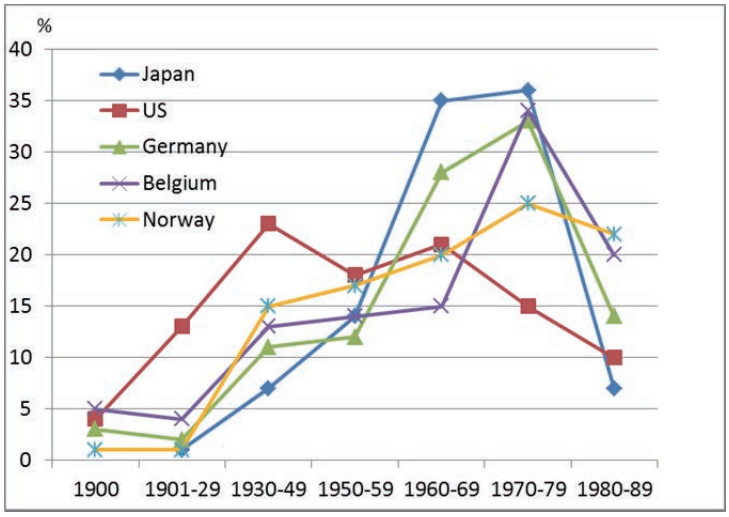


Figure 1 Proportion of Bridges by Decade of Construction in OECD Member Countries

Source: Asset Management in Construction

As a natural consequence, a large number of bridges are expected to become deteriorated over time. In fact, deterioration of bridges is already a problem. While the proportion of bridges which had been used for 50 years and longer was 6% in 1991, it had doubled to 12% by 2011. The figure is expected to reach 60% in 2051.

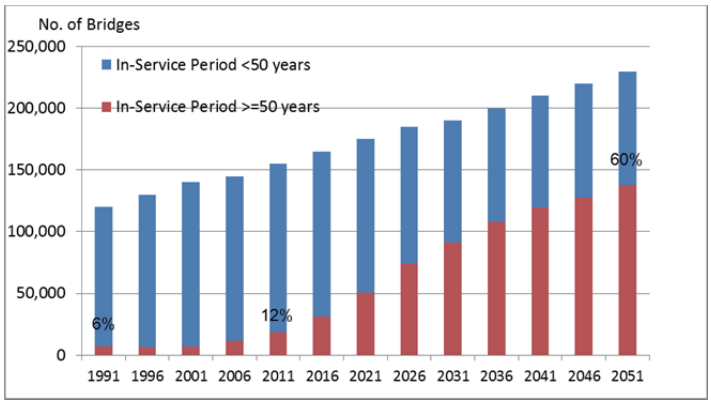


Figure 2 Change in the Number of Road Bridges (15 m or longer) Used for More or Less than 50 Years in Japan (1991-2051)

Source: Social Capital Asset Management

In the waterworks sector, deterioration of water supply pipes is progressing as the total length and the proportion of those pipes installed at least 40 years ago have both been on a steady increase.

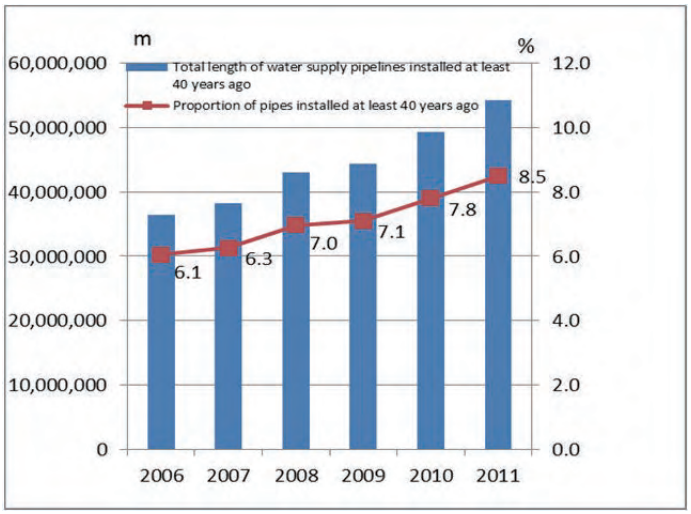


Figure 3 Changes in the Total Length of Water Supply Pipelines and the Proportion of Pipes Installed at Least 40 Years Ago

Source: Water Supply Hot News, Vol. 383 (2014)

In fact, the deterioration of infrastructure facilities has already caused many accidents. For example, old bridges have collapsed because of the loss of the bearing capacity of their foundations and degradation of underground pipes has been causing pipes to burst. There was a railway accident in Hokkaido in 2011 in which failure to identify a train wheel requiring repair caused the derailment of an express train. There was also a shocking road accident in the Sasago Tunnel in December 2012 in which the ceiling boards of the tunnel, which was constructed in December 1977, 35 years before the accident, collapsed and killed nine people. This accident has made the general public aware of the current state of the deteriorating infrastructure facilities and the necessity for urgent countermeasures.

Figure 4 Accidents Caused by Deterioration of a Bridge (above left), a Railway (above right), a Tunnel (below left) and a Water Supply Pipe (below right)

(2) Forecast of the Cost and Prospect for the Financial Resources for the Replacement of Infrastructure in Future

According to long-term projections of Japanese finances, it is anticipated that expenditures relating to healthcare and welfare will increase in accordance with the progress of aging and revenues will decrease due to the decline of population. Consequently, it is expected that top priority will be given to measures to cope with the declining birthrate and aging population and costs of such measures will rise accordingly, and inevitably, the proportion of investment allocated to maintain the current infrastructure will decrease.

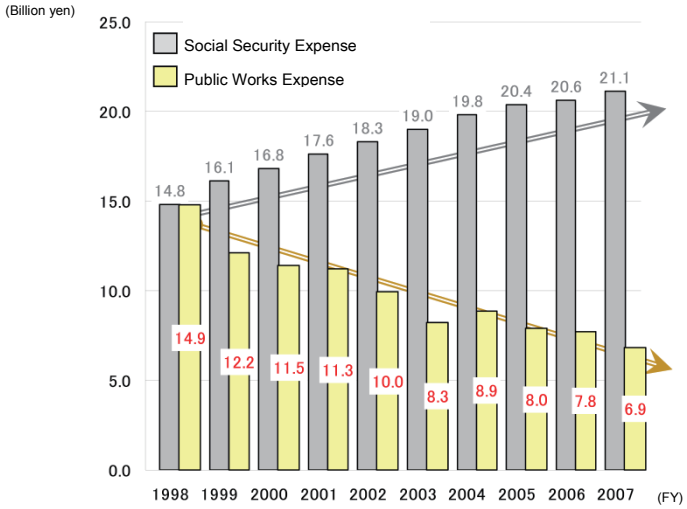


Figure 5 Trends of Social Security Expenses and Public Works Expenses

Source: Japan Federation of Construction Contractors Website

In the case of Japan, as the infrastructure construction has followed a pyramid-like pattern, there is concern that the future trend of costs required for replacement will also be pyramid-like, which means that the cost may rise sharply at a certain point in time. However, it will be almost impossible to bear the cost at the peak.

(3) Basic Policy for the Infrastructure Development

Under such circumstances, the number of infrastructure facilities to be replaced shall have to be reduced to an appropriate level according to the availability of financial resources at that point in time. Such reduction shall require administrators of the facilities to conduct a study on the possibility of terminating their use or downsizing their capacity with the evaluation of the necessity of each facility and to prepare measures for repairing and replacing the facility in stages over a long period of time, instead of as a large-scale repair work.

As such, efforts have been made to extend the life of the infrastructure. More specifically, the central government has been working to promote comprehensive and systematic management of the infrastructure facilities, reduction of maintenance cost and leveling of cost required during the replacement boom.

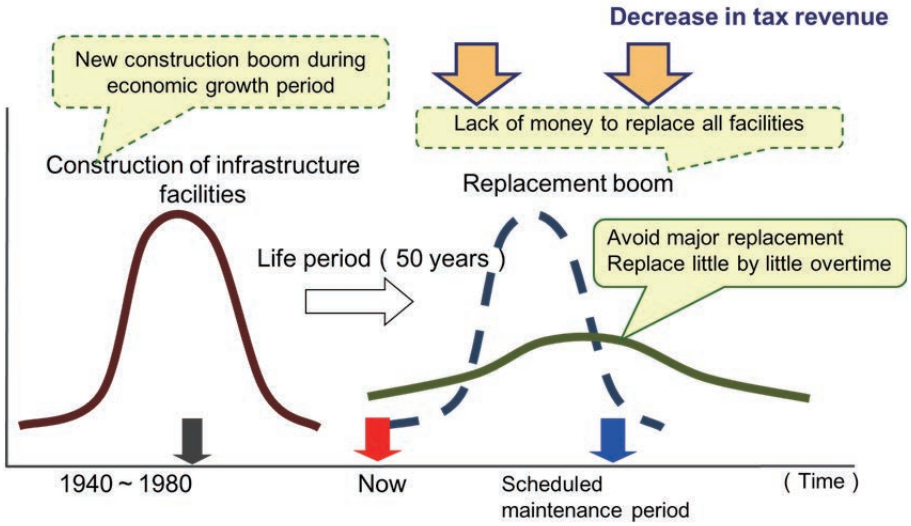


Figure 6 Image of Maintenance Cost Equalization

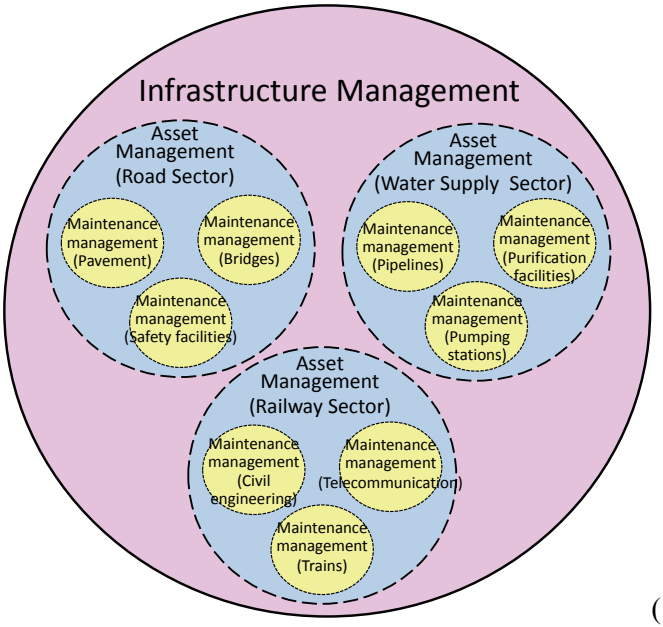
Conventionally, replacement of infrastructure facilities was carried out mainly based on the concept of corrective maintenance, that is, to take action only after an accident or a functional failure has occurred. However, since occurrence of an accident or a breakdown will make a great impact on daily life and social activities, it is important to carry out preventive maintenance to prevent the occurrence of such incidents. For example, the "Guideline for Maintenance and Operation in Sewerage Systems" promotes preventive maintenance, as it can reduce the incidence of breakdown and closure to about 1/3, failures caused by manhole cover to about 1/3 to 1/7, and accidents involving ground subsidence to about 1/3.[1] Since it is easy to estimate the cost of such systematic maintenance and, thus, plan the budget required for it, it will be necessary to include the planning of such budget in the plan.

[1] Japan Sewage Works Association

2.1.2 Introduction of Infrastructure Management

In this way, fewer babies are born and the population ages and starts to decrease, the tax revenues are also decreasing, which makes it difficult to secure budget for new construction and maintenance of infrastructure facilities. At the same time, as composition and distribution of population and the social needs change, some existing infrastructure facilities such as elementary schools become no longer needed and the need for new infrastructure facilities arises. Such needs differ according to situation and environment of municipalities. Therefore, with limited financial resources, infrastructure management measures to holistically manage various infrastructure facilities arise for national government and municipalities to maintain necessary facilities in a good condition.

Infrastructure management requires policy making and planning to balance all infrastructure facilities in an optimal way. Implementation of infrastructure management includes asset management of a sector and traditional maintenance of facilities. This system is illustrated in Figure 7.



( ) example

Figure 7 Infrastructure Management System

Infrastructure management was developed as a result of transition from engineering maintenance management of individual facilities, then asset management to infrastructure management. In asset management organizations competent in one sector such as water supply and electricity recognize all facilities producing profit as assets and take good care of them to keep their value efficiently with a long-term perspective. Asset management started to be featured by Japan Society of Civil Engineers in about 2000 and is now widely used among implementing organizations. This section describes the transition from introduction of asset management to infrastructure management in a chronological order, from asset management of

water supply sector, sewerage sector, and infrastructure management of Ministry of Land, Infrastructure, Transportation and Tourism.

2.1.3 Efforts on Waterworks System

(1) Water Supply Vision

With the arrival of the 21st century, the need for large-scale replacement of water supply facilities is peaking with the progressing deterioration of those constructed rapidly and on a large scale in Japan's period of rapid economic growth. The systematic replacement of the water supply facilities is beginning to be recognized as the most important and urgent issue to be addressed by all the water service providers in order to hand over these valuable assets to the next generation in a sound state. Therefore, in June 2004, the Ministry of Health, Labour and Welfare (MHLW) developed the "Water Supply Vision", which collectively indicates policy priorities concerning the water supply system in the future as well as specific policies, measures and roadmap to tackle them.

The basic concept of this vision is a "Water supply system that strives to be a leading player in the world". The vision outlines five principles: security (guarantee of the supply of safe and palatable water), stability (sufficient measures against disaster), sustainability (reinforcement of the foundation for the operation of water services), environment (upgrading of measures for environmental protection and energy saving) and globalization (contribution to the world through international cooperation), as long-term policy objectives and defines "systematic development and replacement of facilities while maintaining the fiscal balance in the medium- to long-term" as one of the policy objectives in the reinforcement of the foundation for the operation of water services.

(2) Regional Waterworks Vision

After the publication of the Water Supply Vision, MHLW issued a notice entitled "The Guidelines for the Preparation of Regional Waterworks Vision" in October 2005. In the notice, the ministry recommended water service providers and prefectural governments to analyze the current state of their water services, evaluate their prospects in ten years' time, draw images of the ideal water services in future and prepare measures to achieve the ideal in the form of Regional Waterworks Visions.

(3) Guidelines on Asset Management in Water Utility

Although the Water Vision has a provision that water service providers should take measures to replace their facilities and secure funds for the replacement, they were unable to fulfill the provision. In order to improve the situation, the Water Supply Vision was revised and the introduction of the asset management method was added as a priority issue to the revised vision,

which was published in July 2008. This addition was based on the recognition that implementation of asset management, a system for efficient and effective management and operation of water supply facilities throughout their entire life cycle with a long-term perspective, by each water service provider was essential for realization of sustainable waterworks services with systematic replacement and earthquake-proofing of the facilities on the basis of a medium- to long-term forecast of fiscal balance.

Unlike other public infrastructure, water supply infrastructure has no alternatives. As such, great impact will be made on society in the event of water leakage or other accidents. Also, according to the beneficiary-to-pay principle, fees can be collected from users, which means that financial resources for the implementation of asset management can be secured.

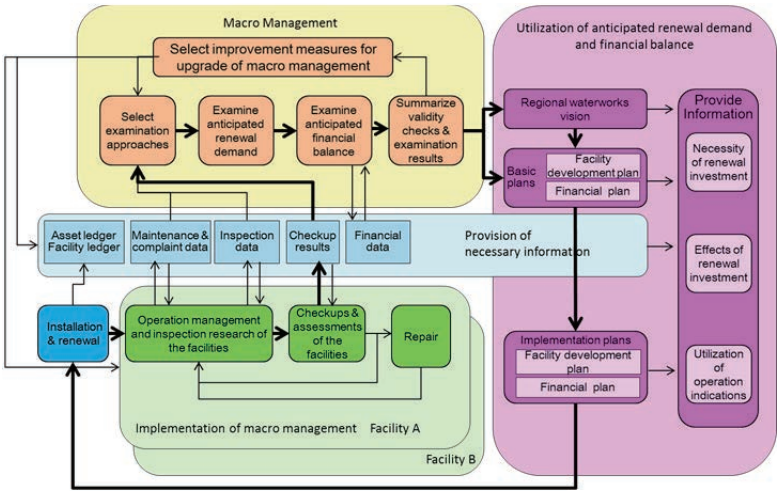


Figure 8 Asset Management Practice Cycle[2]

MHLW issued "The Guidelines for Asset Management in Water Utility" in July 2008 for the implementation of the asset management. The guidelines recommend all water service providers to implement the asset management with full understanding of its importance and request each of them to prepare a medium- to long-term plan for facility replacement with financial backing and prefectural governments to play an active role in dissemination and promotion of the asset management to water service providers and provide them with guidance and advice on its implementation.

The guidelines provide the points mentioned below as those requiring attention in the preparation of the replacement plans for the achievement of "defining ideal waterworks services in future and incorporating the problems in and measures for the realization of the ideal in a Regional Waterworks Vision" and "raising awareness of stakeholders on the necessity of the replacement and earthquake-proofing projects with publicity activities for sharing information

[2] Source: Guidelines on Asset Management in Water Utility Outline

with them."[3]

- Priority on the implementation

The guidelines provide a simple method which enables the asset management just by entering such data as quantities of facilities in a prepared form. This method allows a study on macro-management while asset data are being compiled. The accuracy of the management is to be improved by analyzing the results in stages while implementing asset management.

- Importance of an organization-wide approach

Activities are to be implemented in a controlled way under the leadership of waterworks technical administrators while the knowledge of the problems and countermeasures are shared throughout the entire organization.

- Establishment of a long-term perspective

The period of the analysis is to be at least 30 years in principle and can be more than 40 years. The result of the analysis is to be used for setting an objective to be achieved in ten years' time with the backcasting[4]. The set objective and measures to achieve it are to be incorporated in a Regional Waterworks Vision to establish an organic link between the vision and the asset management.

- Integration of technical bases and financial backing

A replacement and earthquake-proofing plan is to be prepared with technical bases and financial backing. The prepared plan is to be used as information to obtain understanding of the project of the stakeholders in such activities as explanation of the necessity of the investment in the facility replacement and effects of the investment.

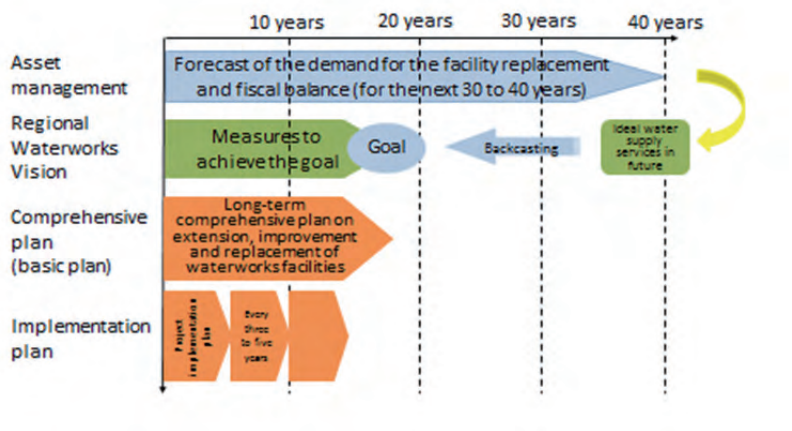


Figure 9 Feedback to the Reinforcement of the Foundation of Operation and the Regional Waterworks Vision

Source: "The Guidelines for Asset Management in Water Utility", MHLW

[3] "Guidelines on Asset Management in Water Utility" MHLW Website

[4] A method to identify a way to achieve an objective without being affected by presumed social problems

By having each water utility practice asset management, albeit in a simplified manner, it aims to manage and operate waterworks assets from medium- to long-term perspectives and to continuously improve the level of asset management. At the same time, it also aims at enabling steady investment in the replacement of waterworks facilities by creation of replacement demand projection with secure financial resources.

(4) New Water Supply Vision

Since the preparation of the "Water Supply Vision," the environment affecting the water sector has changed significantly. For example, the population of Japan has been on the decline since it peaked in 2010 and it has become certain that the population will continue to decrease in future. The Great East Japan Earthquake caused damage to water supply facilities in a wide area. Because of the significant changes, the Water Supply Vision was reviewed comprehensively and the New Water Supply Vision was published in March 2013. The new vision mentions the shift from measures for the extension of water supply services to those based on the assumption that the water demand shall decrease in future and puts emphasis on measures for disaster and crisis management. The New Water Supply Vision clearly describes ideal water supply services 50 years and 100 years from now with a clear vision of the society in the future and provides issues to be addressed and measures to be taken immediately to realize the ideal service.

(5) Water Service Visions and Prefectural Waterworks Visions

Following the publication of the New Water Supply Vision, MLHW has recommended water service providers and prefectural governments to prepare Water Service Visions and Prefectural Waterworks Visions, respectively, since March 2014 to clearly define the scopes of works of them and encourage them to take measures compliant with the new vision. A "Prefectural Waterworks Vision" is a comprehensive vision for wide-area waterworks services to be prepared through appropriate review by a prefectural government of its Master Plan for Development of Waterworks with "Water Service Visions" prepared by water service providers taken into consideration.

The new vision assumes the five subjects mentioned below as the basic subjects to be mentioned in Water Service Visions. It provides that implementation of "asset management" is essential in the implementation of the policy.

(i) Evaluation of the state of the current water services and identification of problems in them
(ii) Environment for the provision of water services in future
(iii) Setting of ideal regional water services and objectives
(iv) Measures to facilitate the achievement of the objectives
(v) Analysis method and follow-up activities

With this recommendation, the Regional Waterworks Vision provided in the notice issued in

2005 was replaced by the above-mentioned Water Service Visions and Prefectural Waterworks Visions. Since then, the term has been used to refer to both of the two new visions.

As of October 2014, 793 and 53 Water Service Visions had been prepared by water service providers and water supply providers, respectively. These visions cover 91% and 95% of the total populations served by water service providers and water supply providers, respectively. Ten Prefectural Waterworks Visions had been prepared by the administrative departments supervising waterworks of prefectural governments by October 2014[5].

2.1.4 Efforts on Sewerage System

(1) Sewerage Vision 2100

Sewerage system development approached its peak 15 to 20 years later than water supply system development. Also, as the legal service life of sewerage pipeline facilities is designated as 50 years, which is longer than that of water pipeline facilities (40 years), it is expected that large-scale replacement demands will arise around 2025.

However, road subsidence of varying scales caused by aging pipeline facilities, etc. frequently occurs every year. About 3,900 cases of road subsidence occurred in fiscal 2012.

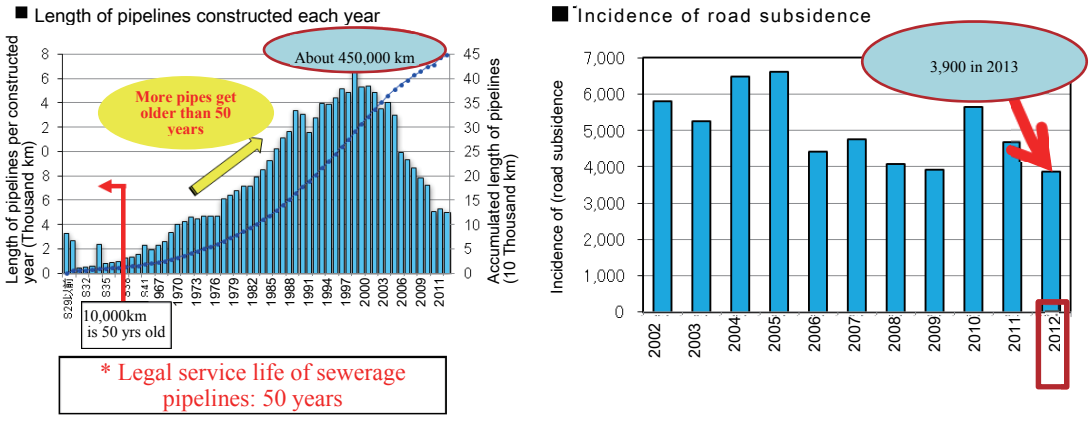


Figure 10 Trends of Length of Pipelines Constructed Each Year and Incidence of Road Subsidence

Source: MLIT Website "Sewerage System – Planned Reconstruction and Maintenance"

Under such circumstances, the "Sewerage Vision 2100" was published in September 2005 in a way similar to the "Water Supply Visions." In the "Sewerage Vision 2100," MLIT provides guidelines for the development and maintenance of sewerage services with the vision for the future 100 years from now taken into consideration and practical measures to realize the vision. With "path of recycling" as the basic concept, this vision declares that transition from the 20th

[5] Guidelines for the preparation of "Water Service Vision," MHLW Website

century-type sewerage system focused on diffusion and expansion to the 21st century-type sewerage system creating sound water cycle and resource cycle should be aimed at in order to establish sustainable recycling-oriented society. Also, the vision lists "path of water", "path of resources" and "facility regeneration" as basic approaches to realize the "path of recycling", and with respect to "facility regeneration", it states that sewerage systems that meet new social needs (sustainable sewerage system) should be realized by sustaining efforts for the securement of safety and advancement of functions by making an effective use of existing facilities through asset management, etc.[6]

(2) New Sewerage Vision

Eight years have passed since the preparation of the Sewerage Vision 2100. In this eight-year period, factors such as the Great East Japan Earthquake, tight financial conditions and a declining population have changed the socio-economic conditions in Japan and abroad, times have changed completely from the era of promotion of development to that of maintenance and restrictions on the service provision including deterioration of facilities and operating systems have increased, while new technologies have been developed for the diversification of the methods of service provision including PPP/PFI and rapid development of ICT.

Against this background, MLIT prepared the "New Sewerage Vision" in July 2013 and mentioned the missions of the sewerage services, a long-term vision and a medium-term plan for the achievement of the vision in the new vision. The ministry presented the objectives to be achieved in the next ten or so years and practical measures to achieve them in the medium-term plan. The "New Sewerage Vision" has two key concepts; "maintenance" and "evolution" of "sewerage system as the path of recycling". With respect to "maintenance", this vision includes the establishment of sustainable and integrated management of people, things and money (asset management) as an item for promotion, and it calls for drastic reexamination of conventional legal and budgetary systems, regulations, standards and operational systems centered on the promotion of construction and development as well as transition to asset management that aims to optimize facility management through integrated management of management resources, namely, people, things and money in order to establish the project management system that is suited to the times.

[6] MLIT Website

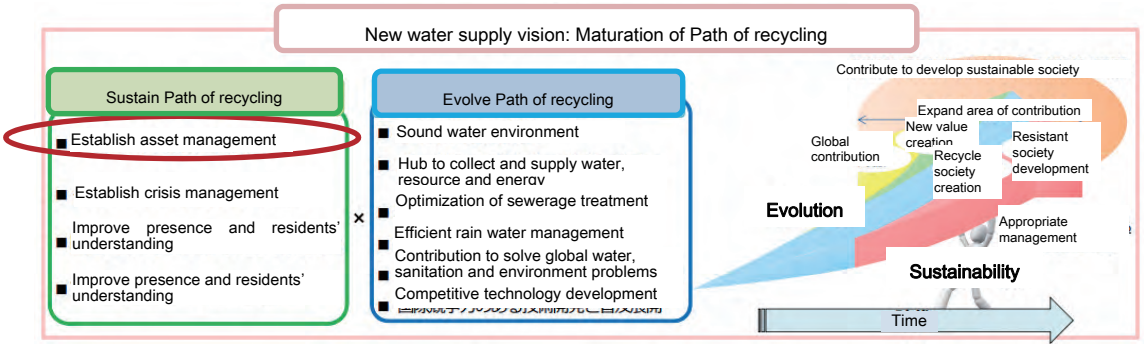


Figure 11 Composition of New Sewerage Vision

Source: New Sewerage Vision (Outline)

2.1.5 Efforts for Railway Operators by Ministry of Land, Infrastructure and Transportation (MLIT)

MLIT began to take practical measures to facilitate extension of life of infrastructure facilities as measures against its deterioration in 2006. While the ministry was taking such measures, the ceiling boards in the Sasago Tunnel collapsed in December 2012. This accident led to spread of the awareness of the necessity of measures against the deterioration of infrastructure in Japanese society and of the necessity of implementing comprehensive countermeasures. Facilities whose life is to be extended include those for which organizations and systems for their operation have been established by MLIT and managed either directly by MLIT such as national roads or by local governments such as prefectural roads. Therefore, MLIT requested the Ministry of Internal Affairs and Communications (MIC) to urge local governments to implement measures to extend the life of facilities as their competent authority, while MLIT was taking the measures mentioned above.

Table 7 Measures Relative to Infrastructure Management Taken by MLIT and MIC in Recent Years

Date	Name of Measure	Implementing body	Purpose
Dec. 20, 2006	Creation of the Program for the Development of Repair Plan for Infrastructure Life Extension	Road Bureau, MLIT	A program was set up to subsidize local governments in developing the repair plans of road bridges of no less than 15m in length, thereby extending the life of bridges managed by local governments and reducing the repair and replacement costs of bridges. It is expected that this program will help in ensuring the safety and reliability of road networks.
Dec. 2, 2012	Sasago Tunnel Ceiling Panel Collapse Accident Concrete ceiling panels fell over a section of about 130m in the Tokyo-bound Sasago Tunnel on the Chuo Expressway. Three passenger cars driving in the tunnel were crushed, resulting in the death of 9 people and major/minor injury of 2 people. With this accident as a trigger, the importance of infrastructure maintenance was re-appreciated.		
Jan. 21,	Establishment of	MLIT	An expert committee for the examination of

Date	Name of Measure	Implementing body	Purpose
2013	the Conference on Measures to Control the Aging of Social Capital		measures required for strategic maintenance and replacement of social capital and steady implementation of such measures.
June 14, 2013	Basic Policies for Economic and Fiscal Management and Reform – Ending Deflation and Revitalizing the Economy –	Cabinet Office	To facilitate the involvement of private sector and to shift the focus from "building new infrastructure" to "using existing infrastructure wisely", directives were indicated to promote the utilization of the PPP/PFI in projects that the use of private sector is expected to improve the efficiency of infrastructure management and replacement, improve the quality of services and reduce the financial burden.
Nov. 29, 2013	Basic Plan for Extending Life of Infrastructure Facilities	Liaison Conference of Relevant Ministries and Agencies Concerning the Promotion of Measures to Control the Aging of Infrastructure (Secretariat: MLIT)	Based on the recognition of the importance of focusing on "using wisely", directions for the reduction of mid- and long-term total maintenance cost, equalization of budget and ensuring the competitiveness of the maintenance industry were indicated. A roadmap up to 2030 is shown to call for the creation of "life extension plan of each individual facility", utilizing the resources of the private sector.
Apr. 22, 2014	Promotion of Comprehensive and Planned Management of Public Facilities	Ministry of Internal Affairs and Communications (MIC)	MIC has instructed local governments to develop management policies and plans for all the public facilities under their jurisdiction. This project subsidizes local governments to facilitate the planning of replacement, abolition/integration, extension of the service life of public facilities in accordance with the changes in the utilization demands in the future. This project aims to reduce and spread the financial burden of local governments, enabling them to relocate public facilities by developing such plans.
May 21, 2014	Action Plan to Extend Life of Infrastructure Facilities	MLIT	This is a concrete plan that clearly defines the directions of medium- to long-term initiatives concerning the maintenance and replacement of all infrastructures under the management or jurisdiction of MLIT. It also includes the "clarification of responsibilities" by developing laws and regulations necessary to realize the "action plan".

(1) Conference on Measures against Aging of Social Capital

This conference was set up in January 2013 as an expert committee "Conference on Measures against Aging of Social Capital" chaired by the Minister of Land, Infrastructure, Transportation and Tourism for the examination and steady implementation of measures to promote strategic maintenance and replacement of social capital.

Through the activities of this conference which has met four times to date, the "Basic Plan for Extending the Life of Infrastructure" was drafted with the Liaison Conference of Relevant Ministries and Agencies, including MLIT and the Cabinet Office, as the implementation body, aiming to achieve a smooth turnaround in approaches from the conventional symptomatic repair and replacement to preventive repair and replacement based on the life extension plan.[7]

(2) Basic Plan for Life Extension

In November 2013, MLIT set up the "Basic Plan to Extend Life of Infrastructure Facilities" to develop measures to control the aging of the infrastructures of the government as a whole. In order to extend the life of all infrastructure facilities across the country, this basic plan presents directives for authorities responsible for the infrastructure to implement collective and planned infrastructure management under the initiative of MLIT. The plan provides an ideal of establishing sustainable infrastructure management with the establishment of a maintenance cycle, reduction in the total cost and the spreading of budget and creating competitiveness in the maintenance industry as a strategy. It also provides a road map to achieve the ideal.

In the basic plan, MLIT requests itself and local governments which are responsible for infrastructure facilities to prepare overall action plans and action plans for individual facilities for the achievement of the "ideal." The basic plan stipulates that an action plan shall have clear descriptions on the eight subjects: 1) inspection and diagnosis/repair and replacement, 2) establishment of standards, 3) development and use of information infrastructure, 4) preparation of facility-specific plans, 5) development and application of new technologies, 6) budgetary management, 7) construction of systems, and 8) establishment of laws and regulations for the achievement of the ideal.

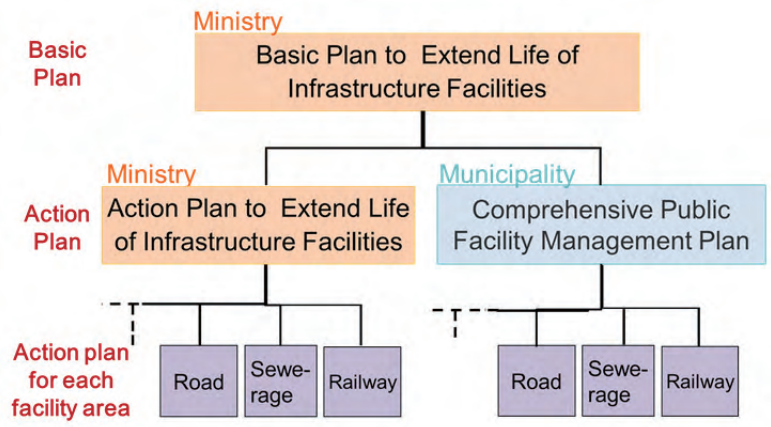


Figure 12 System of Basic Plan to Extend Life of Infrastructure Facilities Promoted by MLIT

On the other hand, municipalities have started to consider developing the Comprehensive Public Facility Management Plan for municipalities' infrastructure facilities, and plan to have them completed by 2017.

[7] MLIT Comprehensive Policies: Aging of Social Capital website

(3) Action Plan to Extend Life of Infrastructure Facilities

MLIT prepared measures which it would take both as a supervisor who is to construct systems and structures for the maintenance of infrastructure and as an administrator who is to be engaged in practical activities for the maintenance of infrastructure under its jurisdiction in the seven-year period up to 2020 in accordance with the Basic Plan for Extending Life of Infrastructure Facilities and compiled these measures in the Action Plan. MLIT also conducted a study on the strategies and activities for the maintenance of infrastructure using the results of the analysis of the current state of and problems in each of the eight subjects described in the basic policy and prepared a concrete implementation schedule in accordance with the road map in the basic plan.

Action Plan to Extend Life of Infrastructure Facilities describes activities in twelve sectors. The practical measures described in the plan for the sectors included in this survey among the 12 sectors are as follows:

a. Roads
   - Close visual inspection once in five years was required by the new Ordinance of the Ministry of Land, Infrastructure and Transport for about 700,000 bridges, 10,000 tunnels and so on. (promulgated in March and enforced in July 2014)
   - For inspection and replacement of road surfaces and light poles, it is considered to set appropriate replacement periods based on degradation over time.
   - For bridges across expressways and emergency transportation roads, inspection priorities should be set based on importance and soundness.
   - Scheduled inspection and diagnosis, repair and replacement should be kept for MLIT's bridges.
   - Local municipalities are in charge of many facilities and lack budget, personnel and skills. MLIT will provide necessary support for their inspection and diagnosis, repair and replacement.

b. Sewerage
   - MLIT will continue technical and financial support for local municipalities to ensure inspections, surveys and renovation of sewerage facilities.

c. Railways
   - MLIT will continue technical and financial assistance and provide training for railway operator to ensure maintenance of railway facilities based on technical standards given in the ministerial ordinance.

d. Expressways
   - MLIT will provide technical assistance to expressway operators so that they can ensure appropriate inspections and replacement.

(4) Comprehensive Public Facility Management Plans of Local Governments

Local governments in the entire country have begun the preparation of comprehensive public facility management plans for the next ten years in accordance with the notice of MIC, "Promotion of Comprehensive and Planned Management of Public Facilities," issued in April 2014. The details of the plans are described in the following section. The notice also provides provision of subsidies of up to 50% of the expenses for the preparation of the management plans as a financial measure for local governments and establishment of a special measure for the issuance of local government bonds for the removal of infrastructure facilities.

Meanwhile, MLIT established a committee which includes officials responsible for infrastructure management of prefectural and municipal governments in July 2014 to support preparation of plans for extending life of public structures by local governments. The committee is expected to prepare the policies for the preparation of the plans by May 2015.

(5) Facility-Specific Plan

MIC has requested local governments to prepare a "Facility-Specific Plan" as a plan for the extension of the life of each facility by fiscal 2016. The committee mentioned above is expected to establish a basic concept for the preparation of such plans and use it to prepare a reference material which all local governments can use in the preparation of such plans in accordance with the specific conditions in the areas under their jurisdiction. MLIT has announced in the action plan mentioned in (3) above that it will provide technical assistance to administrators of individual facilities in keeping appropriate maintenance records for the preparation of the facility-specific plans.

2.2 Efforts of Local Governments

In this section, examples of infrastructure management lead by local governments are described, namely, the contents of the Comprehensive Public Facility Management Plans which are required to be detailed in the plans and the cases considered by MIC as Facility-Specific Plans and cases where management of all the infrastructure facilities in a certain sector is outsourced as a whole in an attempt to reduce the cost by improving cost-efficiency.

2.2.1 Comprehensive Public Facility Management Plan

In accordance with the policies of extending life of infrastructure facilities of MLIT and MIC, local governments are preparing for the preparation of Comprehensive Public Facility Management Plans for extending life of infrastructure facilities. Some local governments had prepared plans for the repair of certain types of infrastructure facilities such as bridges for the extension of their life. Such local governments are conducting studies to elucidate the current states of the other types of infrastructure facilities (including tunnels, pavement and sewerage). The components of a Comprehensive Public Facility Management Plan are mentioned below.

1. Current condition of retained facilities

Objectively grasp and analyze the current conditions and issues of all public facilities, etc.

- Conditions of public facilities, etc.
- Future projection of population
- Estimation of medium- to long-term expenses and financial resources relative to the maintenance and replacement

2. Basic policy concerning the management of entire facility

- Range of plan: 10 years or longer
- Description of establishment of a structure to involve all personnel within the government and information sharing
- Description of the basic policy based on the analysis of current condition
- Description of the methods of evaluating the progress of the plan and publishing the results

It is considered that comprehensive and systematic management of public facilities is essential for the implementation of urban planning which is consistent with the current state of local communities and that it also contributes to the establishment of national resilience which has been promoted recently by the Cabinet Secretariat.

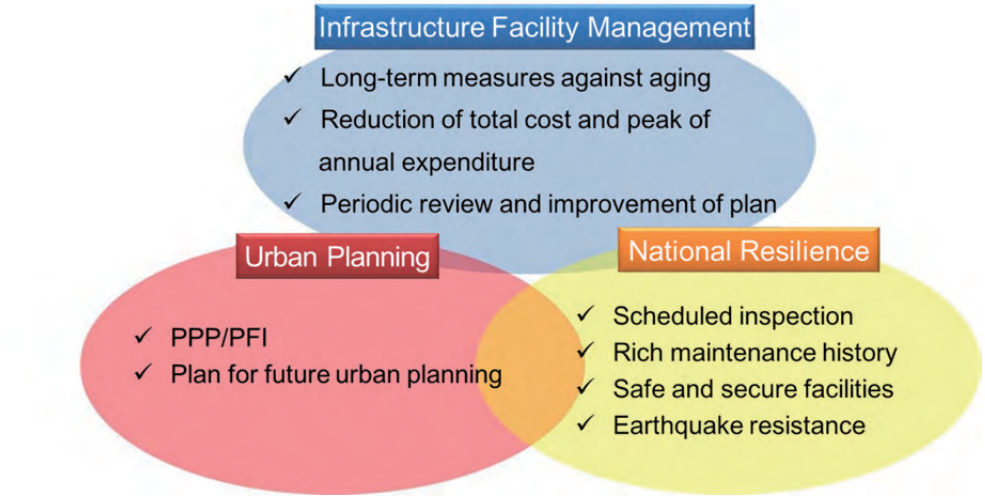


Figure 13 Image of Promotion of Measures to Control Aging Based on Comprehensive Public Facility Management Plan

In fact, approx. 15 basic policies, which were equivalent to the Comprehensive Public Facility Management Plans had been established by certain local governments before the MIC issued the notice concerned. A survey conducted by MIC in May 2014 after the issuance of the notice revealed that approx. 25% of local governments were planning to complete the preparation of the policies or plans by the end of fiscal 2014.

2.2.2 Introduction of Comprehensive Outsourcing of Management

Fuchu City in Tokyo published "The White Paper on the Infrastructure Management in Fuchu City" in October 2012. In the white paper, the city described the current state of the roads, bridges, parks, sewerage and facilities associated with them managed by the city and the cost required for continuing to maintain their capacities and functions at the current levels. After the publication of the white paper, the city conducted a study to identify problems in the current infrastructure management, to find a sustainable and feasible plan for the infrastructure management and to estimate the amount of the cost saving achieved by the adoption of the new plan. The city presented a policy for the infrastructure management in future based on the result of the study in "The Fuchu City Infrastructure Management Plan," which was published in January 2013. Fuchu Infrastructure Management Plan explains management policies based on the current situation as outlined in the White Paper. The target period is 40 years.

In the study, the cost of managing the city's infrastructure was divided into maintenance cost and repair/replacement cost and the maintenance cost required for maintaining the current levels of infrastructure[8] and the amount of budget actually spent on the maintenance of infrastructure were compared. As the comparison revealed that the city did not have financial resources to

[8] To maintain the infrastructure at the current levels does not mean to take no measures. Instead, it means to take measures to prevent deterioration and maintain the capacities and functions at the current levels.

maintain the infrastructure facilities at the current levels, the city conducted a study to establish a feasible strategy for cost-reduction such as improvement of cost-efficiency of outsourcing and life-cycle cost and to identify measures to increase revenue.

Table 8 Fuchu Infrastructure Management Plan

Items	Aims	Measures
Overall Policies	● Increased income ● Sustainable finance ● Streamlining	➢ Adequate service fees ➢ Allocation of infrastructure usage fees for maintenance ➢ Introduction of sponsorship ➢ Introduction of naming rights[9]
Maintenance costs	● Cost reduction by review of business	➢ Streamlining of operations ➢ Comprehensive outsourcing of management ➢ Increased use of IT
	● Cooperation with citizens	➢ Reporting system of troubles ➢ Introduction of infrastructure adoption systems[10]
	● Reduction of maintenance costs (-128 mil yen/year)	
Repair and replacement costs	● Streamlining through life cycle ● Examination of quality level ● Reduction of costs (-173 mil yen/year)	➢ For each: road surfaces, bridges, trees, sign posts, light poles, parks and sewerage systems
Implementation	● Reexamination of organization structure ● Financial arrangement ● Review and reexamination of the plan	

In the "Fuchu City Infrastructure Management Plan," the city estimates the cost-reduction realized by implementing all the measures in the road sector (including bridges) and the park sector mentioned in the plan at 12% (300 million yen)[11].

[9] Governments sell the right to give a name to a facility. Sponsors can expect to raise publicity through names implying the company or its product. The first case in Japan was Ajinomoto Stadium in 2002.

[10] Civil society groups and private companies can adopt a part of public facilities such as roads and parks and agree to undertake maintenance such as cleaning of the adopted facilities.

[11] The estimate does not include the cost reduction in the sewerage sector, because the city was not able to estimate the cost for maintaining the current level of sewerage services.

Table 9 Difference in Annual Infrastructure Management Cost between Planned and As-is (keeping current level)

Unit: Mill yen/year

Infrastructure type		Estimated cost for Planned (1)	Estimated cost for As-is (2)	Difference (1)-(2) =(3)	(3) / (2)	Actual expenditure in 2010
Roads	Roads, Footways, Bridges	892	1,167	-275	-23.6%	857
	Street trees	224	220	4	1.8%	134
	Signposts	4	2	2	100.0%	2
	Street lights	210	152	58	38.2%	152
	Road subtotal	1,329	1,541	-212	-13.8%	1,145
Parks		825	913	-88	-9.6%	733
Total		2,154	2,454	-300	-12.2%	1,878

Source: Fuchu City Infrastructure Management Plan

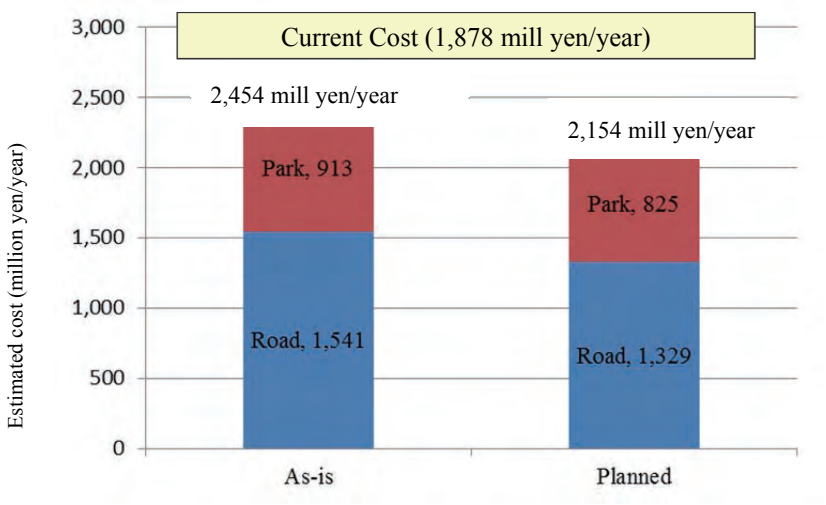


Figure 14 Difference in Annual Infrastructure Management Cost between As-is and Planned (Predicted)

2.2.3 Introduction of Comprehensive Outsourcing of Management

Comprehensive outsourcing of management is an example of infrastructure management and refers to outsourcing of infrastructure management over more than one sector, which was previously conducted by the administration, to private companies. This has been in practice since around 2006 mainly in the form of designated administrator system or comprehensive outsourcing to private entities.

In the designated administrator system, the designated administrator is obliged to receive the approval of the assembly. This system was introduced as part of the administrative reform of local governments with the amendment of the Local Autonomy Act in September 2003. Currently, it is implemented in 73,476 public facilities and about 30% of which or 24,384 facilities are run by a private company or an NPO corporation.

Comprehensive outsourcing to private entities is a method of outsourcing all operations as a package to a single entity, instead of outsourcing each operation one by one to different entities, to achieve economies of scale and improve public services.

However, with respect to roads, the administration agency is specified by law and outsourcing to an external party is prohibited. The Road Act stipulates in Article 13 (maintenance, repair and other management of national roads), Article 15 (administration of prefectural roads) and Article 16 (administration of municipal roads) that road administration shall be carried out by administrative organization and that expressways shall be managed by companies specified by the Act on Special Measures Concerning Road Construction and Improvement.

In the areas other than roads, some municipalities have started making an attempt to reduce the expenses through economies of scale and to improve public services by comprehensive outsourcing to a single business entity.

(1) Comprehensive Outsourcing Contract of Fuchu City

Fuchu City, in the Tokyo Metropolitan Area started a three-year pilot project in fiscal 2014 for comprehensive outsourcing of minor road repairs, cleaning, trimming of roadside trees, electric bulb replacement of street lights and road patrol to one business entity. The following benefits are expected of this project.

(Securing profit through economies of scale)

- Expansion of the coverage of operation items
- Expansion of the coverage of city area (division of the city area for outsourcing)

(Collaboration with residents and improvement of resident service)

- Transfer of a part of the city's responsibility to private companies or residents
- Proactive utilization of the ideas and new technologies of the residents and business entities

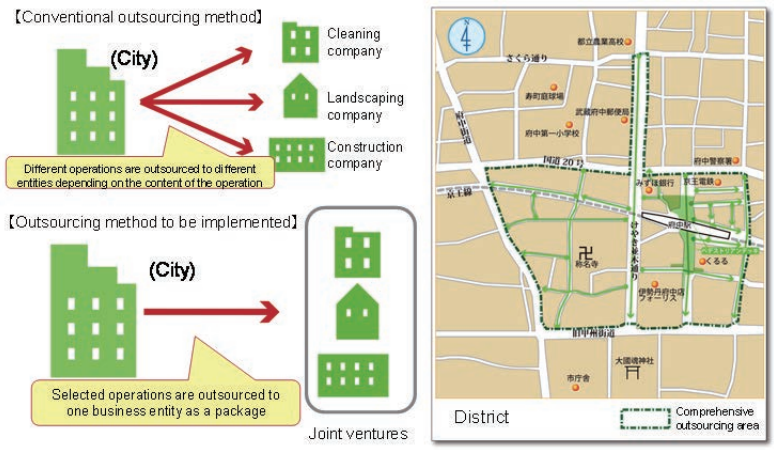


Figure 15 Description of Pilot Project Concerning Comprehensive Outsourcing

Source: Fuchu City

Fuchu City wishes to further expand this project of comprehensive outsourcing, thereby ensuring the profit of private business entities and improving the satisfaction of residents by getting them involved in the project.

(2) Comprehensive Outsourcing to Designated Administrator by Kiyosato-cho, Hokkaido

Kiyosato-cho, Hokkaido, designates a construction company in the town as a designated administrator for comprehensive outsourcing to reduce infrastructure maintenance costs.

Table 10 Comprehensive Outsourcing by Kiyosato-cho, Hokkaido

Item	Content
Designated Administrator	Kiyoken Kogyo (Construction Company)
Background	Outsourcing started in 2006. Kiyoken Kogyo was established through investment of several local construction companies.
Effect	Personnel cost for two staff was reduced.
Outsource Period	2010-2014 (5 years)
Amount	255 million yen (tax included)
Outsourced Work	Monitoring of rivers, surface levelling, mowing, road surface cleaning, surface paving, repair of slopes, snow removal. Monitoring of face paving, repair of slopes, snow removal.

(3) Comprehensive Outsourcing to Designated Administrator by Ozora-cho, Hokkaido

Ozora-cho, Hokkaido, designates a cooperative association in the town as a designated administrator for comprehensive outsourcing to reduce infrastructure maintenance costs.

Table 11 Comprehensive Outsourcing by Ozora-cho, Hokkaido

Item	Contents
Designated Administrator	Ozora Comprehensive Cooperation Association
Background	Starting with a 3–year contract (April 1, 2011-March 31, 2013), the coop has renewed the contract.
Effect	Personnel cost for two staff was reduced.
Outsource Period	2014-2016 (3 years)
Amount	390 million yen/year (tax included)
Outsourced Work	Roads, bridges and rivers

(4) Comprehensive Outsourcing of Water Supply and Sewerage Projects by Ota City

Ota City in Gunma Prefecture has been keen on outsourcing water supply and sewerage projects to external entities, and outsourced meter reading and fee collection operations in 2001 and

operation and management of water purification plant in 2002 to a third party. Moreover, in 2006, the City started comprehensive outsourcing of all operations relating to the water supply project excluding the operations concerning "policy formulation and determination", "permits, licenses and disciplinary actions" and "ensuring fairness". This comprehensive outsourcing of water supply projects, which ranges over five years, covers acceptance and inspection of construction applications, general affairs operations including corporate accounting and building management, and witnessing repair works, among others.

In Japan, technical operations concerning water supply facilities may be outsourced only to a single entity.[12] Therefore, three companies employed as outsourcees of this project, namely, Meidensha, GCC and Plumbing, Heating and Air-conditioning Constructor's Association, established a new company called "Advanced Business Service Co., Ltd." as a business entity to conduct this project.

Figure 16 Operations of Advanced Business Service Co., Ltd.

Source: Meidensha Website

The following benefits were obtained by implementing this project.

- Reduction of staff
  The staff was reduced by 33 from 52 in 2006, shortly before the start of comprehensive outsourcing, then to 19 in 2013.
- Reduction of total cost
  The cost was reduced by about 700 million yen (10%) from about 6.7 billion yen before 2006 to about 6 billion yen, which is the cost of comprehensive outsourcing from 2007 to 2011.[13]

[12] Paragraph 1, Article 7, Enforcement Order of the Water Supply Act

[13] Local Public Enterprise Division, Local Public Finance Bureau, MIC "Application Cases of Private-Sector Management Methods to Local Public Enterprises", October 2012

The succeeding five-year comprehensive outsourcing (April 2012 to March 2017) has a wider range of outsourced operations with the addition of facility maintenance operations.

(5) Comprehensive Management of Sewerage Pipeline Facilities in Kawachinagano City

In Kawachinagano City, Osaka Prefecture, out of the total sewerage pipelines of about 360km that have been constructed, as much as about 91km (about 25%) are 30 years old or older. As such, the risk of road subsidence accident caused by the aging facilities that would seriously affect the life of the residents has been increasing.

To achieve a transition from the conventional after-the-fact maintenance to preventive maintenance, in addition to the operation of handling complaints from residents, which was already outsourced, the City currently outsources patrol inspections and investigations, periodic cleaning as well as research and planning relative to life extension plan as a package.

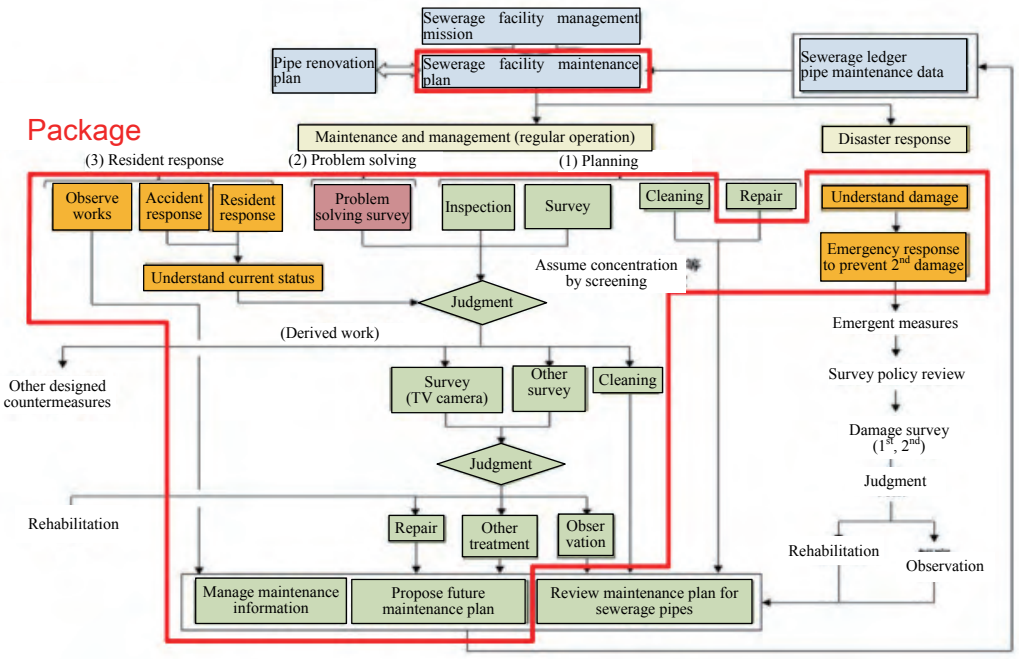


Figure 17 Operations Packaged in the Project

Source: Material of MLIT

2.3 New Technologies

2.3.1 Study Methodology

In this chapter, technologies that contribute to the extension of the life and reduction in the life-cycle cost of infrastructure are described. Many of the technologies described below were selected from the New Technology Information System (NETIS) of MLIT. NETIS is a database system, which MLIT has been developing and operating since fiscal 2001, for the purpose of sharing and disseminating the information on new technologies[14] developed by the private sector. It is a mechanism not only to promote active application of new technologies for the reduction in the cost and the improvement in quality of public works, but also to facilitate improvement of new technologies. The system has approx. 4,700 registered technologies[15], which are being updated upon application for updating from the companies.

In the following, the technologies selected using the criteria mentioned in the table below are described.

Table 12 Criteria for Selection of New Technologies

○ About "Technologies for inspection and maintenance" (i) Simple design (not occupy the installation space of equipment) (ii) Equipment size is not large (transportable by a car) (iii) The record of adoption in Japan is high (100 or more cases) (iv) Capacity to extend the life of a facility (v) Applicability in Thailand

[14] New technology means such technology that has had its feasibility verified by the methods including tests made by the private business operator who has developed it and that has been put into practical use for public works, and that its effects of use are or are expected to be higher than those of the conventional technologies in its scope of application. (Source: Operation Guide to "the New Technology Information System in Public Works", July 2006).

[15] About Revision of "the New Technology Information System (NETIS) in Public Works" – Promotion to introduce it to the field by defining the technical characteristics of new technologies – Reference Material 1, April 8, 2014, Ministry of Land, Infrastructure, Transport and Tourism

Table 13 New Technologies Used in Japan

Application Type	Technology
Road Inspection Technology	Crack Measuring System
	Concrete Soundness Diagnosis Portable Kits
	Underground Installation Length Measuring Equipment
	Structure Inspection Camera "DS Camera" System
Road Repair Technology	Water Repellent Agent
	Concrete Permeability Modifier
	Concrete Reinforcing Embrocation
	Highly Durable Epoxy Adhesive
Road Facility Replacement Technology	Continuous Bridge Surface Pavement Engineering
Road Paving Technology	Modified asphalt pavement
	Composite pavement
	Draining pavement
	SMA pavement
Sewerage Pipe Inspection Technology	Camera Survey of Inside Water Pipe
	Camera Survey of Inside Sewerage Pipe
Water Pipe Repair Technology	SPR Engineering
	NSP Pipe Support for Installing Underground Sewerage Pipe
	Seamless System Engineering
	EX Engineering
Water Pipe-Leakage Prevention Technology	NS-type ductile cast iron pipes
	Polyethylene pipes for water distribution
Subway Inspection Technology	Visualization and digitization of maintenance records

Classification: Road Inspection Technology

Name: Crack Measuring System

Explanation of the function

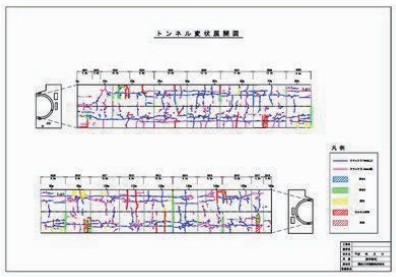
This system is a technology to measure the length, width, shape and positional coordinates of a crack caused in a concrete structure from a distant place by means of an electro-optical measuring instrument and to automatically plot the measured data by dedicated application software on an AutoCAD drawing.

Use

(1) The sectional data and linear data of a structure to be inspected are measured.

(2) The length, width, shape and positional coordinates of a crack in it are measured and the measured data are automatically plotted by the joint use of dedicated application software and commercially available AutoCAD.

Inspection Scene, Automatic Plotting Image and Development View of Analytical Results (example)



Effect

- The measurement can be made from a distant place without temporary scaffolds and mobile elevating work platform, ensuring work cost reduction.
- The measurement can be made from a safe place, ensuring the higher safety of work to be expected.
- The measured data can be automatically plotted, ensuring higher reproducibility and quality and the shorter work schedule and the higher economy of work.
- The accuracy is higher than the conventional technologies (sketch drawings).

Number of cases of application in Japan: 146 cases (as of May 2012)

Applicability in Thailand

Applicability and needs of this technology is examined in: ODA Project Formulation Survey on popularization of 3D maintenance methods for structures using Japan's high-tech survey instruments and measurement technologies, March 2014, joint venture between Kansai Construction Survey and Oriental Consultants.

Developer of the technology

Developer: Kansai Construction Survey Co., Ltd.

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=KK-080019

Classification: Road Inspection Technology

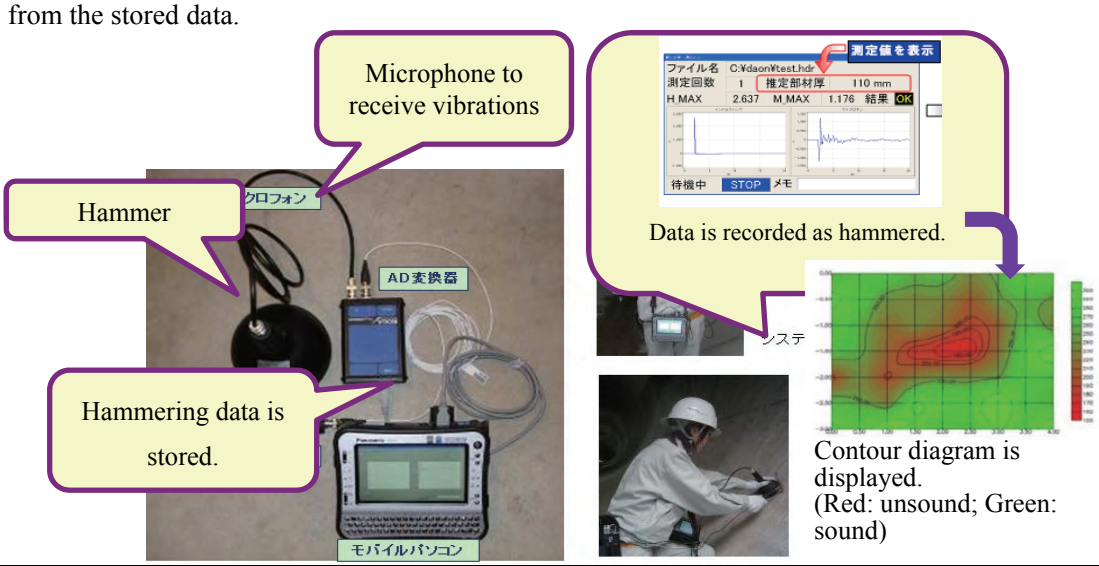
Name: Concrete Soundness Diagnosis Portable Kits

Explanation of the function

The portable kits are used for the survey technology to search any surface layer defects (including float, exfoliation and cavity) in tunnel lining concrete and RC floor slabs by the hammering method (technology to record and analyze the sound caused by hammering by means of a microphone and to evaluate their soundness).

Use

The points to be surveyed are hammered and the sound data is recorded to produce contour diagram from the stored data.



Effect

- The searching performance and accuracy is improved.
- The digital data is obtained and the inspection results can be reflected on the next inspection.
- Accurate and objective results are obtained without relying on the inspector's skills.

Number of cases of application in Japan: 44 cases (as of November 2010)

Applicability in Thailand

BMA uses an echo test to measure soundness of concrete, which is similar to this technology, therefore, applicability of this technology is assumed to be high.

Developer of the technology

Developer: Sato Kogyo Co., Ltd.

References:

1) http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=KT-100062&TabType=&nt=

2) http://www.satokogyo.co.jp/technology/detail.php?id=55&parent_id=1&category_id=8

Classification: Road Inspection Technology

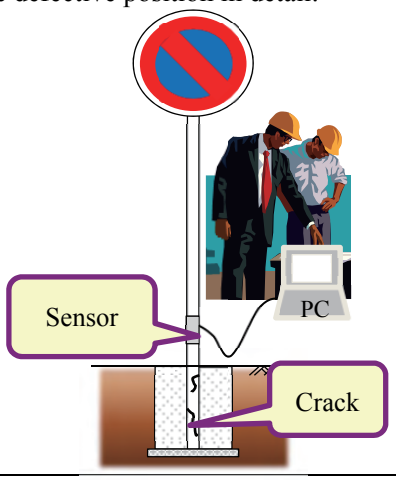
Name: Underground Installation Length Measuring Equipment

Explanation of the function

The length measuring equipment is a technology to measure the length of a steel material buried underground including H-steel, sheet pile, lock bolt, slope anchor bolt or pipe anchor by non-destructive inspection. If there is a crack or corrosion in the steel material, the measurement of the length comes to a stop at the location of the crack or corrosion. And because the measured length is shorter than the actual length, one can confirm the presence of a crack or corrosion. This technology enables the finding of any changes due to cracks or corrosion in poles of road facilities.

Use

A sensor is installed at the exposed part of a pole on the ground to record the ultrasonic data, which is analyzed to diagnose the defective position in detail.



Effect

- A crack position and corrosion can be monitored by ultrasonics without damaging a pole of road facility.
- The positioning information can be managed by a GPS terminal and a crack position can be monitored at a glance.
- As the corrosion analysis software is also provided, the corrosion in 4 levels and the corrosion condition can be displayed on a waveform capture window.
- The equipment can be carried out by one person.

Number of cases of application in Japan: 22 cases (as of September 2013)

Applicability in Thailand

BMA uses a similar technology, therefore, applicability of this technology is assumed to be high.

Developer of the technology

Developer: MK Kaihatsu Co., Ltd. / Japan Probe Co., Ltd.

References: http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=CB-110028

Classification: Road Inspection Technology

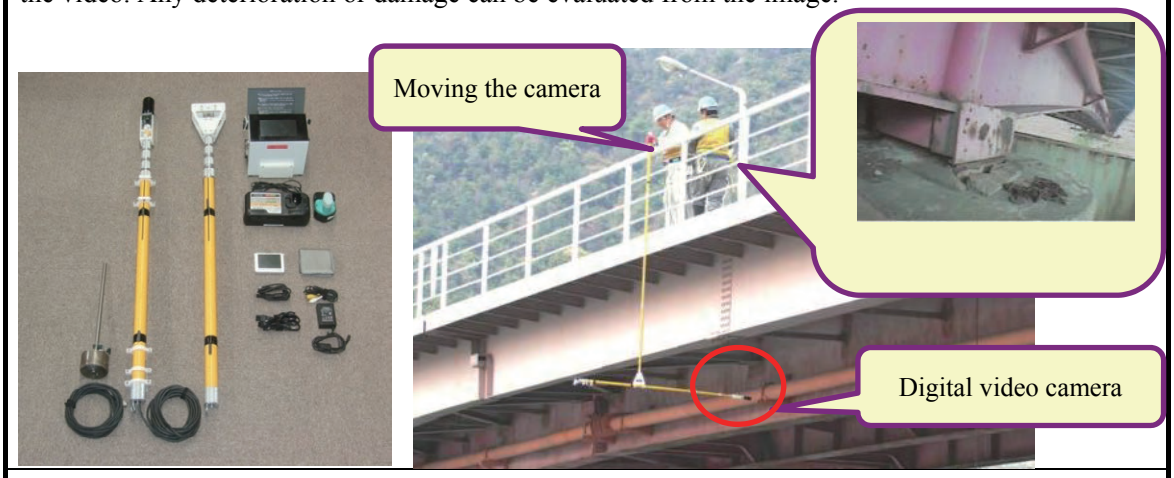
Name: Structure Inspection Camera "DS Camera" System

Explanation of the function

This system is a technology to shoot a point incapable of visual inspection by the manual operation of a digital video camera with a flexible arm.

Use

The inspection is made by a two-person team, one person moving the camera, and the other checking the video. Any deterioration or damage can be evaluated from the image.



Effect

- As the work can be done manually without mobile elevating work platform etc., the inspection process can be shorter than the conventional method.
- No large machine and temporary facility are used, ensuring the economical work.
- No traffic regulation is required.
- Safe work is ensured.
- A dark or narrow point can be inspected, ensuring a wider range of inspection.
- The inspection can be performed more quickly in the event of an emergency.

Number of cases of application in Japan: 11 cases (as of June 2010)

Applicability in Thailand

This technology was introduced in the Study's workshop this July and attracted attention from participants from the road sector, therefore it is expected that there will be demand for inspection of bridges in locations where visual inspection is difficult.

Developer of the technology

Developer: West Nippon Expressway Engineering Chugoku Co., Ltd. and Sansei Bussan Co., Ltd., and Intes

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=CG-090005&TabType=2&nt=nt

Classification: Road Repair Technology

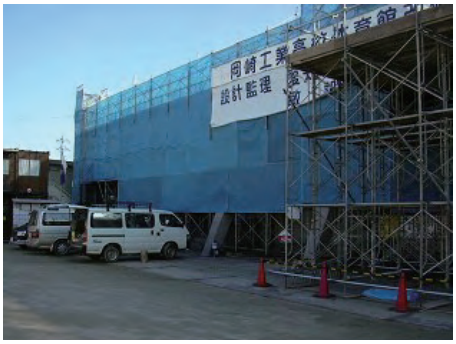
Name: Water Repellent Agent

Explanation of the function

By applying this water repellent agent, concrete and the external concrete wall is coated to prevent water from penetrating into the concrete inside.

Use

The building concrete surface is washed and coated with the agent.



Effect

The agent is not a film, but is penetrated into the inside of the concrete, ensuring a longer recoating cycle and lower maintenance costs.

The concrete neutralization is suppressed and the concrete deterioration can be delayed and the repair cost can be reduced.

Number of cases of application in Japan: 23 cases (as of September 2012)

Applicability in Thailand

This technology to easily extend the life of concrete structures is assumed to be highly applicable in Thailand.

Weather resistance test period (hours)

Developer of the technology

Developer: Silica Japan Laboratory, Token Polymer Chemical Co., Ltd., Nihon Samikon Co., Ltd., r-fourth Co., Ltd.

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=CB-070015&TabType=2&nt=nt

Classification: Road Repair Technology

Name: Concrete Permeability Modifier [RC Guardex]

Explanation of the function

The permeability modifier is the technology of modifying concrete quality by spraying and permeating the agent onto concrete to ensure the concrete waterproofing, enhance its durability, prevent its salt damage or its frost damage, enhance its strength, prevent cracks and efflorescence, and stop water leakages.

Use

The dirt on the coated concrete surface is removed and the concrete surface is coated with the diluted solution by means of a sprayer, brush or roller.

Source:
http://nakamura-web.jp/product/rc-guardex/guardex-series/bousui.html

Effect

By permeating the solution into the concrete, its bending and compressive strength as well as its waterproofness and durability are improved permanently.

The workability and durability are superior and the maintenance cost can be reduced.

Number of cases of application in Japan: 2,881 cases (as of March 2013)

Applicability in Thailand

This technology to easily extend the life of concrete structures is assumed to be highly applicable in Thailand.

Developer of the technology

Developer: Reinforced Concrete Care of Japan, Airex Inc.

References:
http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=KT-060600&TabType=2&nt=nt

Classification: Road Repair Technology

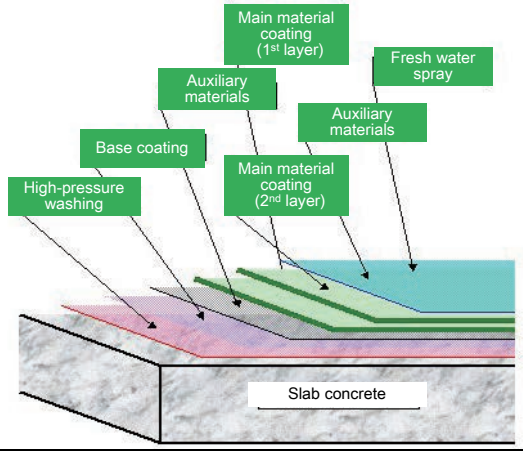
Name: Xypex Concrete Engineering

Explanation of the function

Xypex concrete engineering is a technology of forming and proliferating cement crystals on the capillary pores, aggregate transition zone or crack interface repeatedly (using chemical reaction) to densify the entire concrete body and enhance its durability.

Use

The concrete surface is cleaned by high-pressure washing and supplied with water. Then the auxiliary materials are sprayed on it and it is coated with the main material. Thereafter, it is cured and fresh water is sprayed on it for 3 days.



Effect

The technology can form a surface modifying zone to prevent any concrete deteriorating factors from penetrating into the concrete and it is effective for waterproofing and water stopping, self-recovery of cracks, suppression of progressive neutralization, and initial defect recovery.

Number of cases of application in Japan: 2,284 cases (as of January 2011)

Applicability in Thailand

This technology to easily extend the life of concrete structures is assumed to be highly applicable in Thailand.

Developer of the technology

Developer: Japan Xypex Co., Ltd.

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=QS-000011&TabType=2&nt=nt

Classification: Road Repair Technology

Name: Highly Durable Epoxy Adhesive (Applying to register in NETIS)

Explanation of the function

Highly durable epoxy adhesive is for connecting concrete structures when placing fresh concrete. Traditionally, concrete is placed on an old floor slab when repairing bridges to recover the load bearing ability. However, the joint area of old and new concrete is too weak to secure enough durability and water resistance. This adhesive can improve durability and water resistance of the joint area.

Use

This adhesive is applied on the old concrete surface and at least five minutes later fresh concrete is placed.


Scene of Placing on Concrete Slab of an Elevated Bridge

Effect

When placing concrete on the existing concrete structure, this adhesive makes up for weaknesses in the joint area and improves durability and water resistance by bonding firmly and leads to extend the soundness of asphalt pavers placed on the RC floor slabs and floor slabs.

Number of cases of application in Japan: 129 cases (as of September 2014)

Applicability in Thailand

In the near future needs for major repairs of RC floor slabs of elevated bridges will increase. This easy method to extend RC floor slabs in placing fresh concrete on existing concrete structures is assumed to be highly applicable in Thailand.

Developer of the technology

Developer: Kajima Road Co., Ltd.

References: http://www.kajimaroad.co.jp/tech_data/t014-00074.html

Classification: Road Facility Replacement Technology

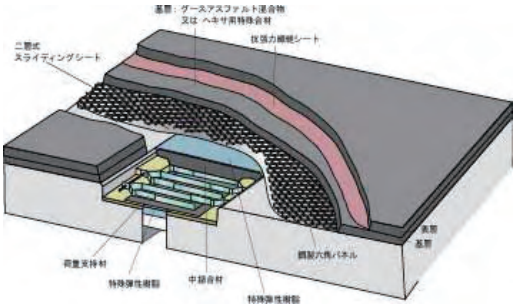
Name: Continuous Bridge Surface Pavement Engineering (Hexa Lock Engineering)

Explanation of the function

This technology uses flexible dispersion type embedded joints which are applicable to long-span bridges with a flexible girder of 120m and joint gaps of 400mm or less. The bridge surface is continuously paved with the same materials to realize a jointless road bridge.

Use

The load supporting materials are installed and coated with special elastic resin, on which the Hexa Lock structure is installed and paved.



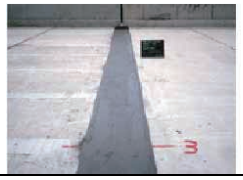
Hexa Lock Structure

[Load supporting work]

Before work

(1) Load supporting materials are installed

(2) Special elastic resin coating



[Hexa Lock work]

(3) 2 layer sliding sheet is installed.

(4) Steel hexagon panel is installed.

(5) Base layer: Special asphalt mixture for Hexa.

Effect

If the surface layer is damaged, only the surface layer can be cut out and overlaid. The workability is enhanced and the operation and maintenance is easy because no flexible joints are used.

The bridge abutments and piers can be protected against damage by shocks due to level differences at the boundary between the bridge surface pavement and the flexible joints.

Number of cases of application in Japan: 1,074 cases (as of November 2013)

Applicability in Thailand

Traditional expansion joints are used in Thailand, and damage around joints is prominent. Jointless structures not only make for smoother driving but also eliminate necessity of maintenance, which can contribute to reducing damage on elevated structures. Therefore applicability in Thailand is assumed to be high.

Developer of the technology

Developer: Japan Cons-Tech Co., Ltd.

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=CG-980017&TabType=2&nt=nt

Classification: Road Paving Technology

Name: Modified Asphalt Pavement

Explanation of the function

Modified asphalt is an asphalt mixture with improved durability manufactured with addition of a modifier to or modification treatment of the straight asphalt mixture. Its durability is derived from good flow resistance, abrasion resistance, aggregate scattering resistance and flexibility. It is mainly used as a material for the surface and binder courses.

Use

The method of paving road with modified asphalt is the same as that used when paving with regular asphalt.

There are several types of modified asphalt including modified asphalt Type-I, Type-II and Type-III prepared by mixing rubber and/or thermoplastic elastomer individually or in combination with the straight asphalt, modified asphalt type-H used in porous asphalt mixture, semi-blown asphalt with improved thermo-sensitivity provided by the blowing process, epoxy asphalt in which epoxy resin is used as a modifier and hard asphalt used in mastic asphalt mixture.

Effect

The use of modified asphalt is effective in preventing rutting on the road surface where high durability is required such as the surface of heavily trafficked roads and bridges.

Number of cases of application in Japan: Many

As the performances required for road surface differ between regions and between locations because of the difference in the meteorological conditions and traffic volume, the variety of modified asphalt available in Japan is unparalleled in the world and many original technologies for the modification have been developed in Japan.

Applicability in Thailand

Modified asphalt has been used on the surface of some roads in Thailand. Its applicability in Thailand is expected to be high because there are many overloaded vehicles and many busy roads in Thailand.

Developer of the technology

Developer: The Japan Asphalt Association

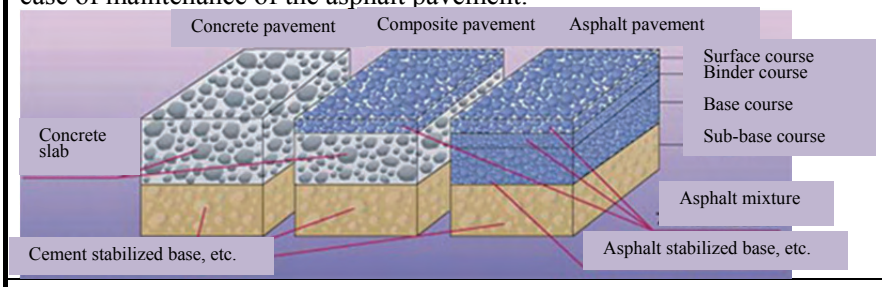
References: http://www.askyo.jp/knowledge/05-1.html#top

Classification: Road Paving Technology

Name: Composite Pavement

Explanation of the function

The composite pavement is pavement consisting of asphalt surface course laid over a concrete slab. It has the characteristics of both high durability of the concrete pavement and comfort of driving and ease of maintenance of the asphalt pavement.



Use

Concrete slabs are cast on subgrade and asphalt pavement is installed on the slab.

Effect

Rutting affects not only the surface course but also the courses below it on a road used heavily by large vehicles. As the composite pavement has rutting resistance and high durability, it does not require frequent repairs. Therefore, LCC reduction is expected from its use.

Number of cases of application in Japan: Many

The composite pavement was used recently in the construction of the Shin-Tomei Expressway. The use of continuous reinforced-concrete slabs in the construction eliminated joints between slabs, which improved the comfort of driving further.

Applicability in Thailand

It is expected that the composite pavement is not applicable in the plains where ground is often soft and that its applicability is high in areas other than plains where ground is firm.

Developer of the technology

Developer: Japan Road Contractors Association

References: http://www.dohkenkyo.net/pavement/meisyo/conpo.html

Classification: Road Paving Technology

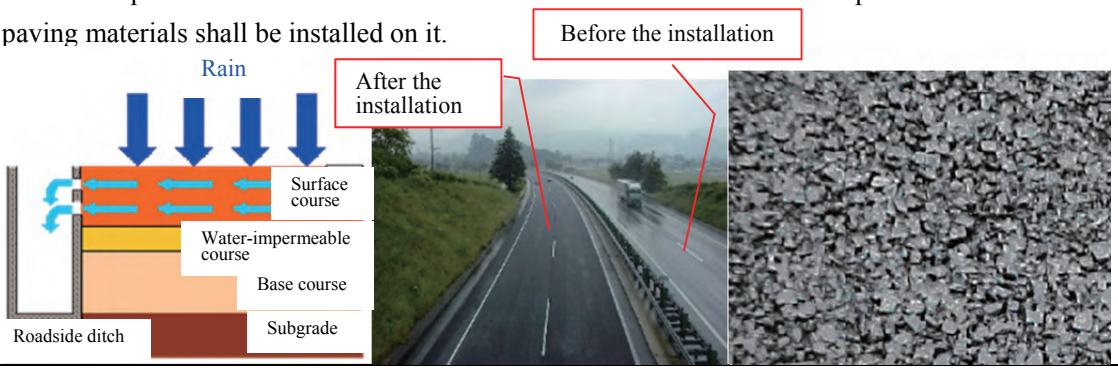
Name: Draining Pavement

Explanation of the function

The draining pavement consists of a surface course of porous asphalt and a water-impermeable course beneath it. This structure allows rainwater to permeate in the asphalt surface and the permeated water to be drained off into drainage facilities at roadsides.

Use

A water impermeable course shall be laid on the base course and coarse asphalt and water-draining paving materials shall be installed on it.



Effect

- The use of the draining pavement on road surface will reduce the number and sizes of puddles formed on it on rainy days. Vehicles traveling on such a road will create less water splash and spray, which will improve the visibility on the road. Hydroplaning is also less likely to occur on vehicles travelling on such a road. In these ways, the use of the draining pavement is expected to help reduce road accidents on rainy days.
- The porousness of the draining pavement is expected reduce noise as part of the noise created by friction between the road surface and tires will be dispersed in the pores in the pavement.

Number of cases of application in Japan: Many

The draining pavement has been widely used in Japan for the reduction in accidents on rainy days and noise reduction.

Applicability in Thailand

The applicability of the draining pavement is considered to be high for the reduction of accidents on rainy days, which occur frequently in Thailand.

Developer of the technology

Developer: Japan Road Contractors Association

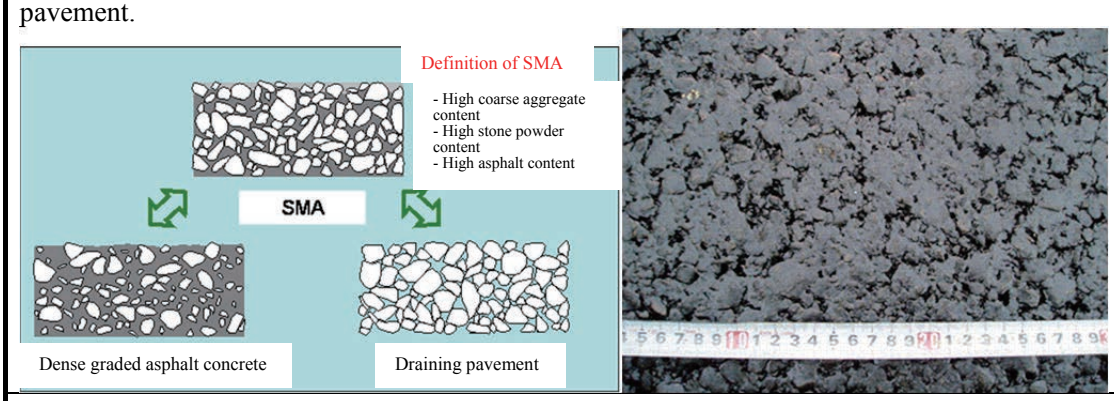
References: http://www.dohkenkyo.net/pavement/meisyo/conpo.html

Classification: Road Paving Technology

Name: SMA Pavement

Explanation of the function

The SMA pavement has a high rough aggregate content (70 – 80%). The space between rough aggregate particles is filled with asphalt-mortar. The asphalt mortar filling, the engagement between rough aggregate particles and the use of reinforcing fiber and modified asphalt provides flow resistance, abrasion resistance, water-tightness, skid resistance and fatigue fracture resistance to the pavement.



Use

While the SMA pavement is manufactured and installed in a way similar to the straight asphalt, the temperature of the mixture shall have to be controlled precisely and the mixture shall be compacted thoroughly.

Effect

It is expected to be useful as a measure against rutting where high durability is required for the pavement such as busy roads and bridges.

Number of cases of application in Japan: Many

Applicability in Thailand

The SMA pavement has been used on the surface of some roads in Thailand. Its applicability in Thailand is expected to be high because there are many overloaded vehicles and many busy roads in Thailand.

Developer of the technology

Developer: Japan Road Contractors Association

References: http://www.dohkenkyo.net/pavement/meisyo/conpo.html

Classification: Water Pipe Inspection Technology

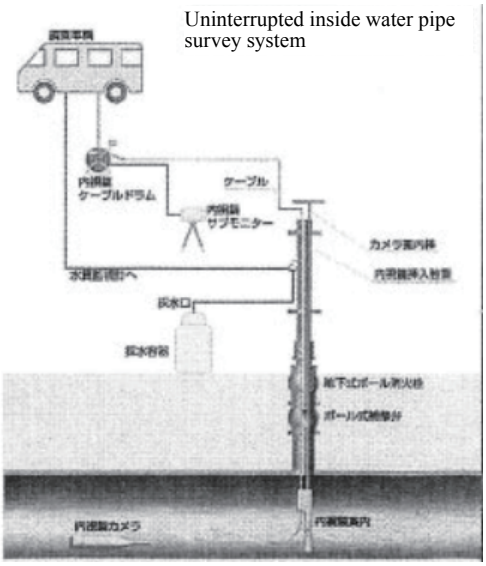
Name: Camera Survey of Inside Water Pipe

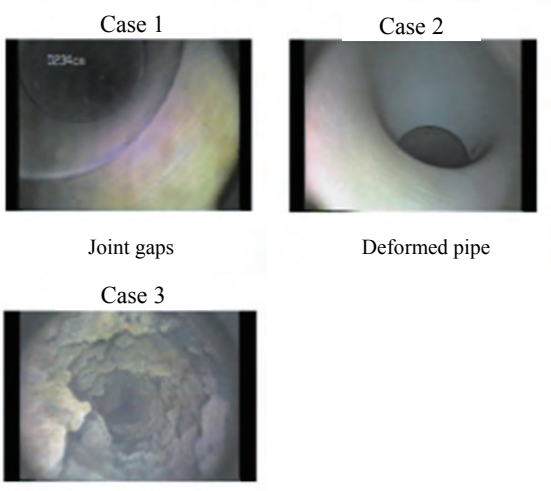
Explanation of the function

This is a technology for conducting inspection of the insides of water pipelines which are difficult to be inspected with the naked eye for safe supply of piped water and efficient replacement of deteriorated pipelines.

Use

A pipe inspection camera is inserted from a fire hydrant to survey any incrustations, joint gaps, paint stripping, mixed foreign objects inside a water pipe.





Source: JWECA Website

Effect

The conditions inside pipes can be observed in detail from the ground level.

Number of cases of application in Japan: More than 4,000 cases (as of March 2013 [Source JWECA Website])

Applicability in Thailand

This technology does not require heavy machinery and is not affected by climatic and geological conditions. Assuming that structure of fire hydrants and air valves where the camera is inserted is the same as Japan, this technology can be highly applicable.

Developer of the technology

References: http://www.jweca.org/

Classification: Sewerage Pipe Inspection Technology

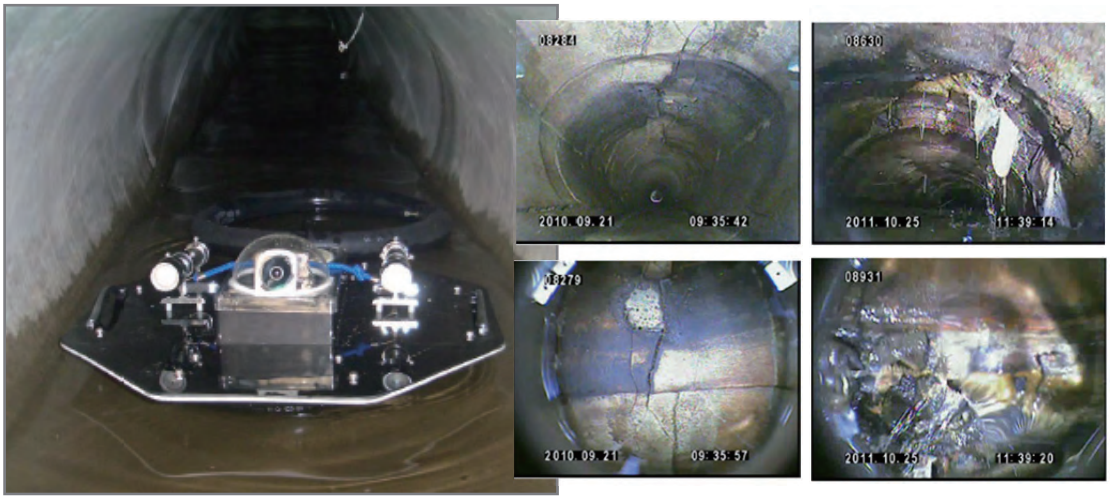
Name: Camera Survey of Inside Sewerage Pipe

Explanation of the function

While a person can enter a large diameter pipe (φ800 mm or more) and inspect its inside with the naked eye, the inside of small and medium-sized pipes cannot be inspected in the same way because it is difficult to enter such pipes. This technology is used for the inspection of the inside of such pipes.

Use

A self-propelling robot equipped with a video camera is placed inside a pipe from a manhole. The robot takes video images of the inside of the pipes while moving through the pipes.



Self-traveling Robot with TV Camera and Camera Survey Videos of Inside Sewerage Pipe

Effect

This technology allows acquisition of precise and detailed information of the inside of sewerage pipes which a person cannot enter, such as cracks on interior wall, exfoliation of the surface of the interior wall, degradation and damage on the pipes caused by intruding roots of trees.

Number of cases of application in Japan: Many

Lot of cases are reported across the country, including in ordinance-designated cities such as Tokyo and Yokohama

Applicability in Thailand

Like camera survey of inside water pipe, this technology is not affected by climatic and geological conditions and can be conducted using only a self-traveling robot with a TV camera. Therefore, this technology is assumed to be highly applicable

Developer of the technology

At least ten companies are providing services using similar technologies in Japan.

Classification: Sewerage Pipe Repair Technology

Name: SPR Engineering

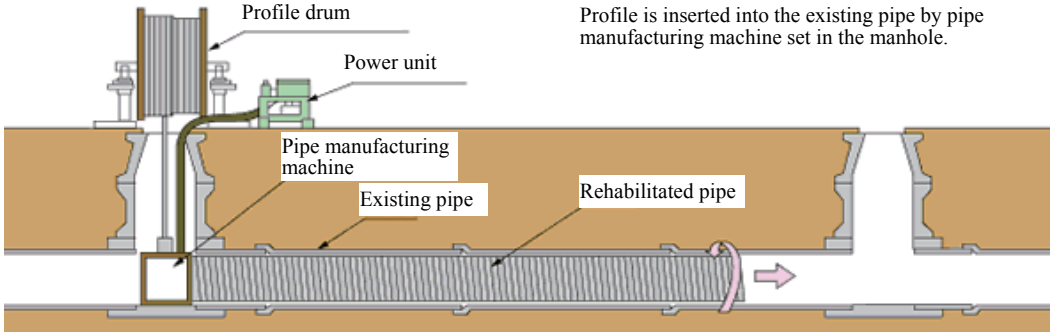
Explanation of the function

This is a method to form a strong composite pipe in a deteriorated pipe conduit embedded underground and to renew the pipe conduit. In using this technology, the repair can be carried out without doing excavation work and in the water supplying state.

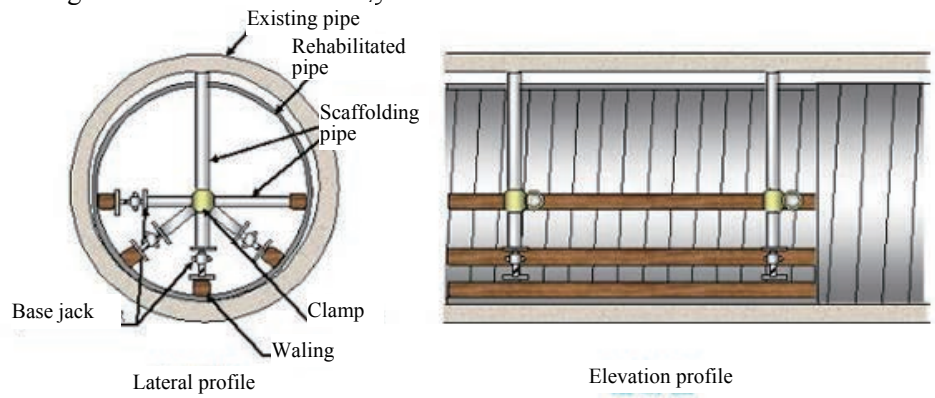
Use

There are 3 steps in the construction method of this technology: (i) the pipe manufacturing work, (ii) the floatation prevention and timbering work and (iii) the backfilling work.

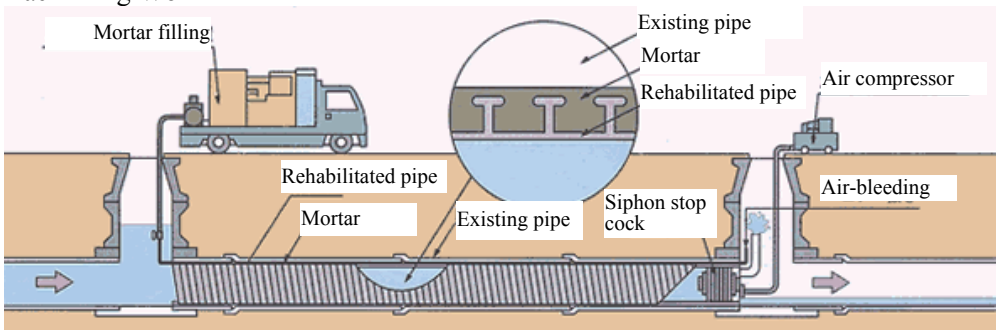
Pipe Manufacturing Work



Floating Prevention and Timbering Work



Backfilling Work



Source: Sekisui Chemical Co., Ltd. Website

Effect

- No excavation is made, giving little influence on the surrounding environment including traffic regulation.
- Quality stability is high because the hard polyvinyl chloride (PVC) pipes are used as the inner materials and no hardening is needed at construction sites.
- The long-time performance (corrosion resistance and wear resistance) is excellent and vibration resistance is also ensured.
- The short work period and the high economy are ensured (with cost reduction of approx. 50% compared with the conventional technology).

Number of cases of application in Japan: 1,879 cases (as of September 2013)

Applicability in Thailand

This technology has a track record of over 700 km and accounts for about 30% in value terms of the pipe replacement market in Japan. It is also popular overseas and is about to become a standard in Germany and the US.

In Thailand, especially in Bangkok, pipe replacement under congested roads is difficult, as in Japan, therefore this technology is assumed to be highly applicable.

Developer of the technology

Developer: Tokyo Metropolitan Sewerage Service Corporation, Sekisui Chemical Co., Ltd. and Adachi Construction & Industry Co., Ltd.

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=KT-990074&TabType=2&nt=nt

Classification: Sewerage Pipe Repair Technology

Name: Seamless System Engineering

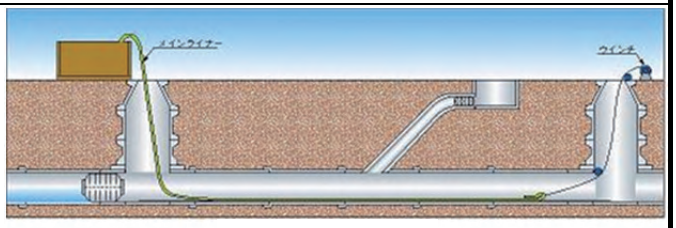
Explanation of the function

This technology is the pipe conduit replacement method in which the construction is made from an existing manhole without excavation.

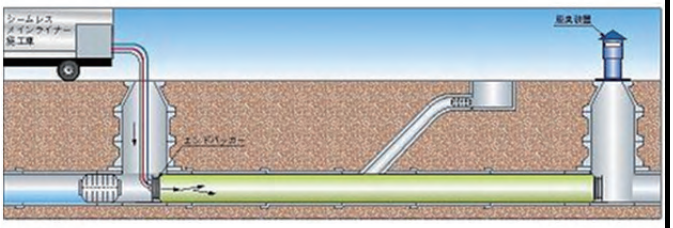
Use

The conventional technology had to excavate the entire pipe laying range to relay pipes. This engineering method allows the replacement materials having the same or higher performance as the new pipes to be lined in the existing pipe conduit for pipe conduit repair and rebuilding. The fitting pipes and the junctions between those fitting pipes and the main piping are also renewed with the same materials, allowing the main piping and the fitting pipes to be integrated seamlessly.

The construction work images of lead-in work, diameter expansion work and photo-hardening work which are the characteristic construction steps are shown in the figure.



Lead-in work



Diameter expansion work

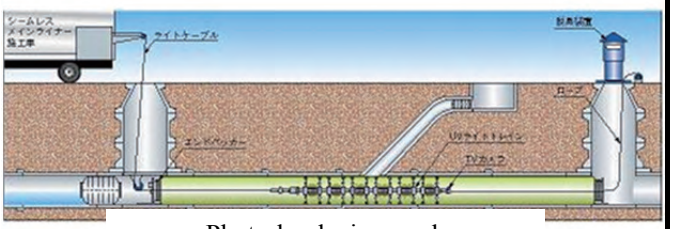


Photo-hardening work

Effect

- There is little influence on traffic regulation and surrounding environment because no excavation is made.
- The work hours are shortened and the cost is reduced.
- The CO_2 emission is so low as to have little influence on the surrounding environment.

Number of cases of application in Japan: 1,104 cases (as of January 2010)

Applicability in Thailand

In Thailand, especially in Bangkok, excavation for pipe replacement under congested roads is difficult, therefore this technology is assumed to be highly applicable.

Developer of the technology

Developer: Toa Grout Kogyo Co., Ltd., Obayashi Road Corporation, and SGC Inc.

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=KT-040074&TabType=2&nt=nt

Classification: Sewerage Pipe Repair Technology

Name: EX Engineering

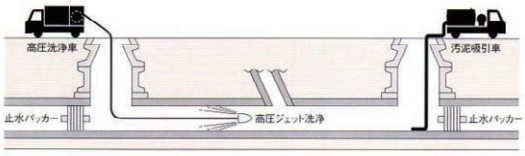
Explanation of the function

This technology is a pipe conduit replacement method to rebuild or repair the existing deteriorated or damaged pipes without excavation. It uses hard polyvinyl chloride resin as material. By the replacement of existing pipe conduits using this technology, the cost reduction and higher safety are expected in comparison with the excavation method.

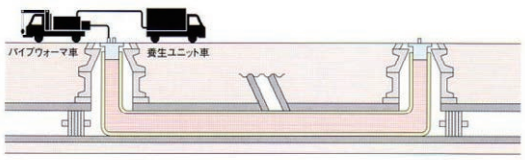
Use

The construction method is largely divided into the following Steps 1 to 4.

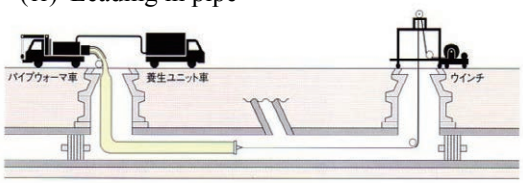
(i) Pipe conduit washing



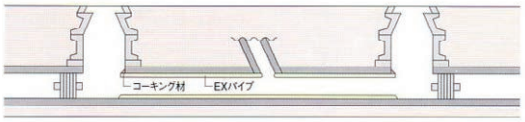
(iii) Pipe heating, diameter expansion and cooling



(ii) Leading in pipe



(iv) Completion



Effect

- There is little influence on traffic regulation and surrounding environment because no excavation is made.
- The work hours are shortened and the cost is reduced.
- The rebuilt or repaired pipe conduit is integrated, forming continuous jointless pipes, which can maintain the flow-down function even if ground movements is caused by an earthquake.

Number of cases of application in Japan: 954 cases (as of May 2012)

Applicability in Thailand

In Thailand, especially in Bangkok, excavation for pipe replacement under congested roads is difficult, therefore this technology is assumed to be highly applicable.

Developer of the technology

Developer: Osaka Bosui Construction Co., Ltd., Kubota-C.I. Co., Ltd.

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=CB-080008&TabType=2&nt=nt

Classification: Water Pipe-Leakage Prevention Technology

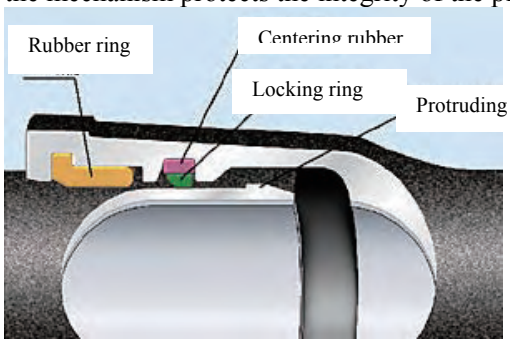
Name: NS-type Ductile Cast Iron Pipes

Explanation of the function

An NS-type ductile cast iron pipe is a highly elastic and highly flexible pipe with push-on connectors on both ends. When extreme force is applied to a pipeline made of NS-type pipes, the male connector and the female connector of adjacent pipes are interlocked to keep them connected and maintain water-tightness of the pipes.

Use

Installation of a pipeline can be completed by inserting the male connectors of pipes into the female connectors of adjacent pipes. When external force is applied to a pipeline, it behaves like a chain buried underground by extending, contracting and bending its joints using their large elasticity and, when a joint is extended to the limit, the protruding part of male connecter and the locking ring of the female connectors of adjacent pipes become interlocked to activate the locking mechanism and the mechanism protects the integrity of the pipeline.



Effect

Water leakages from an underground water pipeline can be prevented by constructing a pipeline with NS-type ductile cast iron pipes which have the locking mechanism at locations where unequal settling of the ground is expected to occur, *e.g.* locations with soft ground and boundaries of structures, and those where significant ground deformation is expected to be caused by earthquakes.

Number of cases of application in Japan: 87.4% of straight ductile cast iron pipes used in Japan are earthquake-resistant ones including NS-type ductile cast iron pipes.

Applicability in Thailand

A characteristic of this technology is that water leakages from pipelines constructed with this technology occur very rarely even when ground deformation has moved the pipelines because the locking mechanism makes loosening of pipe joints by ground deformation unlikely. Because the ground is soft and subsidence causes loosening of pipe joints and water leakages from pipelines in Bangkok, this technology is considered to have high applicability in Thailand for the prevention of these problems.

Developer of the technology

Japan Ductile Iron Pipe Association, Nippon Chutetsukan K. K.

References: http://www.jdpa.gr.jp/

http://www.nichu.co.jp/product/dac01.html

Classification: Water Pipe-Leakage Prevention Technology

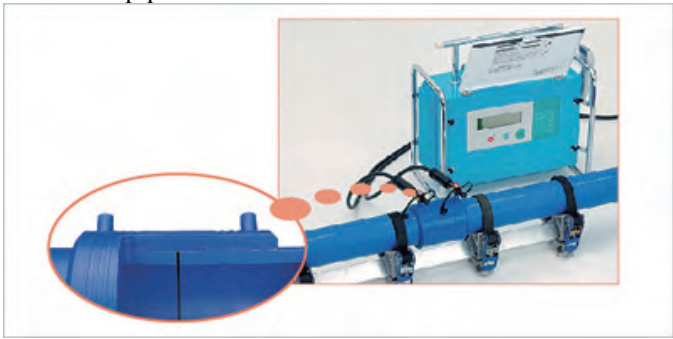
Name: Polyethylene pipes for water distribution

Explanation of the function

Polyethylene pipes for distribution of piped water show excellent earthquake-resistance by absorbing the impact of ground deformation with the characteristics of the material being light and hygienic and having excellent flexibility and corrosion resistance and the structural integration of pipes and joints with electrical heat fusion.

Use

After inserting a pipe in a joint in which heating wire is embedded, electricity is applied to the wire from a controller to heat the wire and the resin in the joint and pipe are melted with the heat generated by the wire and fused together. As the structurally integrated joint parts have the strength equivalent to or greater than the pipe parts, a highly reliable pipeline can be constructed with these pipes.



Effect

Water leakages from an underground water pipeline can be prevented by constructing pipelines with polyethylene pipes on which joints have been integrated with fusion at locations where unequal settling of the ground is expected to occur, *e.g.* locations with soft ground and boundaries of structure, and those where significant ground deformation is expected to be caused by earthquakes.

Number of cases of application in Japan: The total length of the polyethylene pipelines was 2,614 km in 2010.

Applicability in Thailand

Because the ground is soft and subsidence causes loosening of pipe joints and water leakages from pipelines in Bangkok, this technology is considered to have high applicability in Thailand for the prevention of these problems.

Developer of the technology

Japan Polyethylene Piping System and Integrated Technology Association for Water Supply (POLITEC), Kubota-C.I. Co., Ltd.

References: http://www.politec.gr.jp/index.html

http://www.kubota-ci.co.jp/products/water/polyethylene.html

Classification: Subway Inspection Technology

Name: Visualization and Digitization of Maintenance Records

Explanation of the function

Deterioration status is identified by taking images from a vehicle equipped with a measurement device running in the tunnel.

Use

It is possible to take images from a vehicle equipped with a camera running in the tunnel and make a continuous image from them, which is used to identify defects including cracking or water leakage.

The system features functions to store and search inspection results and repair history, which contributes to make the data such as location and size of deformations more accurate and objective and easy to update and search. Furthermore, the system is connected to GIS so that it is possible to search and browse a variety of maintenance data, construction/ inspection history, accidents and disaster records, and user feedback information.

Effect

The inspection is conducted safely and accurately in a short time.

Data is easily managed and possible to be used for various analysis.

Vehicle equipped with a camera device

Source: Japan Subway Association

Number of cases of application in Japan: Tokyo Metro Inc. utilizes this technology.

Applicability in Thailand

Subway system in Thailand is so new and short that the need for this technology is not acknowledged yet, however in future needs may arise.

Developer of the technology

References: http://www.jametro.or.jp/upload/subway/YLUQLjQXNEJA.pdf

2.4 Commitments by Academic Societies and Industry

2.4.1 Japan Society of Civil Engineers

The Japan Society of Civil Engineers (JSCE) is making its organizational activities under the governmental guidelines including those issued by Ministry of Land, Infrastructure, Transport and Tourism, though there are some leading discussions. The main activities of JSCE will be introduced below.

(1) Task Force for Study of Social Infrastructure Maintenance and Replacement

The JSCE set up "the Task Force for Study of Social Infrastructure Maintenance and Replacement" (hereinafter "Social Infrastructure TF") for the problems of infrastructure aging in January 2013 and 8 meetings have been held as of June 2013.

The Social Infrastructure TF is making the study including practical views in reference to the investigation, deliberations, etc. by "the Social Infrastructure Maintenance Strategy Subcommittee of the Panel on Infrastructure Development and the Technical Group, Technical Committee of the Council of Transport Policy, etc."

(2) Setup of Special Committee for Investigation of Priority Subjects on Social Infrastructure Maintenance and Replacement (August 2013)

This special committee was set up in August 2013 to promote the strategy of the JSCE activities, especially the cross-field activities at the initiative of Social Infrastructure TF and in participation by various committees including the study and research departments within the JSCE. Three meetings of the Committee have been held as of April 2014.

(3) Information Dissemination by JSCE Magazine

The monthly JSCE Magazine has issued the special edition on infrastructure management every one or two years since the February 2000 issue until now; meaning it initiated action earlier than the government. Since around 2003, the magazine has paid attention to the relation with finance and started to use the concept of asset management from around 2004 and the concept of preventive maintenance was added in 2010.

Table 14 Special Issues on Infrastructure Management in JSCE Magazine

(February 2000 to July 2014)

JSCE Issue	Special Feature
February 2000	Outline of a plan to consider the maintenance and replacement of social infrastructure
December 2001	Present and future social infrastructure maintenance
January 2003	Thinking of the balance of public investment and finance, and the future public works
December 2003	Social infrastructure development and financial source – Financial management by local governments
August 2004	On introduction of asset management to social infrastructure
January 2006	Management of social infrastructure development – Dawn of policy management
December 2007	Replacement of social infrastructure
October 2009	Extension of life periods of urban civil engineering structures
December 2010	Future prospect for asset management and inspection/testing technology – Looking for introduction of preventive maintenance
November 2012	Thinking about social infrastructure development – Original and creative ideas on financial sources and schemes –
July 2013	What is the essential problem of social infrastructure maintenance? –How to gain the understanding of citizens –
July 2014	10 years after introduction of asset management – What are the future prospects, achievements and problems?

Source: JSCE Magazine Website: Contents of back numbers

2.4.2 Power Industry

As the electric power companies are private companies, central government-led activities on the infrastructure management seen in the management of infrastructure facilities directly managed by government organizations are not observed in the electricity sector. Instead, each company is addressing the need for strategic implementation of inspection, maintenance and replacement of the existing facilities in order to meet the demand for cost-reduction requested by end users. Therefore, their interest in the advancement of facility diagnosis technology and asset management methods incorporating economic indices is high. They are accumulating inspection and diagnosis data and they are beginning to use some of those data for the preparation of maintenance and replacement plans.

As the aging of power distribution facilities constructed around the same period is in progress, there will inevitably be a period in which those facilities will have to be replaced at a time. Therefore, the power companies are spreading the time of replacement by not only delaying the time of replacement of certain facilities which have been found able to be used beyond the

expected replacement time in the diagnosis of individual facilities, but also replacing facilities essential for the entire grid when the number of facilities to be replaced is small even before the expiry of their life, using the concepts of the cost equalization at the level of individual facilities and at the level of the entire grid.

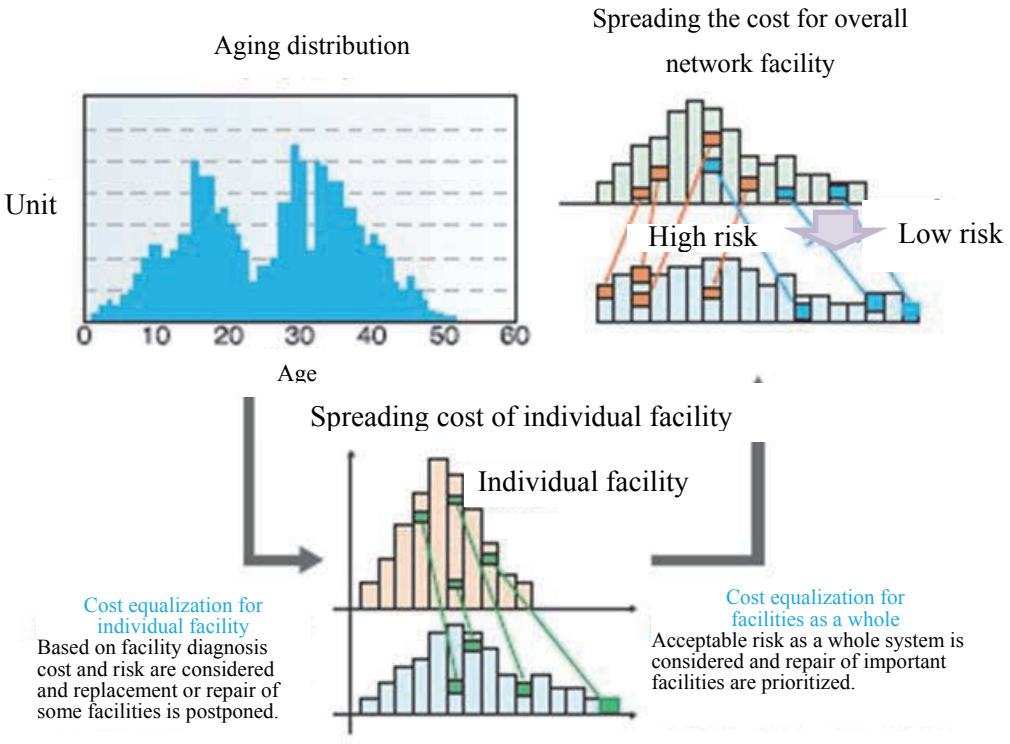


Figure 18 Power Distribution Facilities Cost Equalization Concept

Source: Central Research Institute of Electric Power Industry, Japan

In addition, the power companies are developing and using asset management tools to support studies on the equalization of the risk associated with the arrival of the time of such mass replacement of electric power distribution facilities and the cost for the replacement and establishment of standards for the maintenance of old equipment.

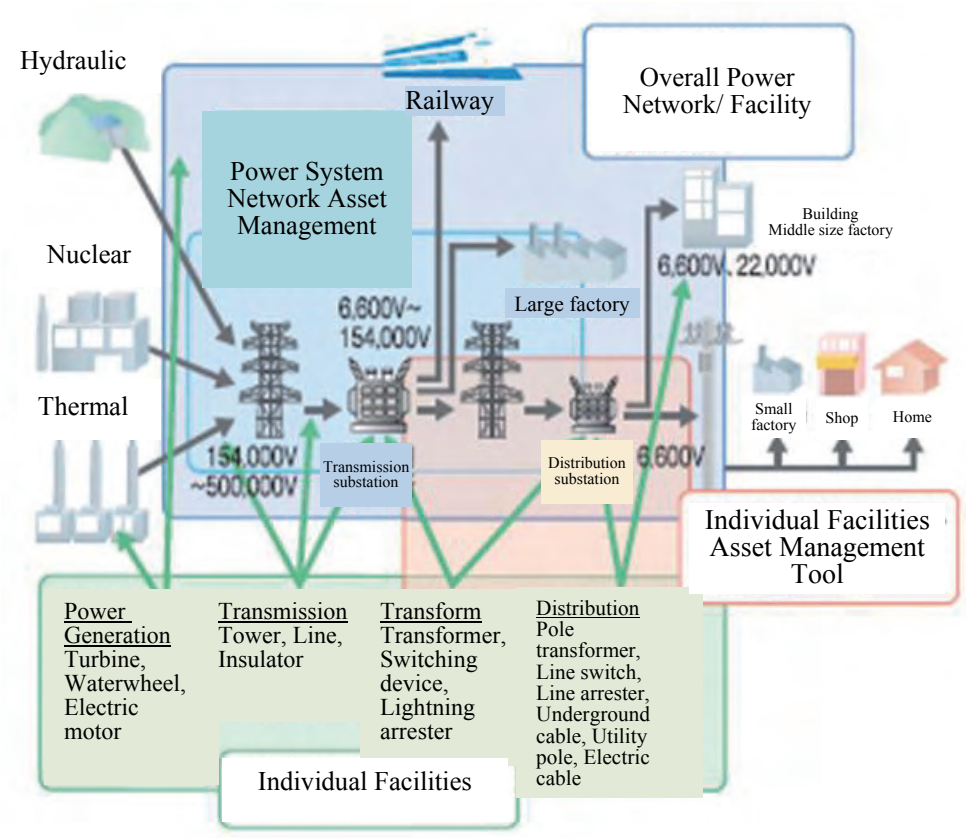


Figure 19 Power Industry Asset Management Activities

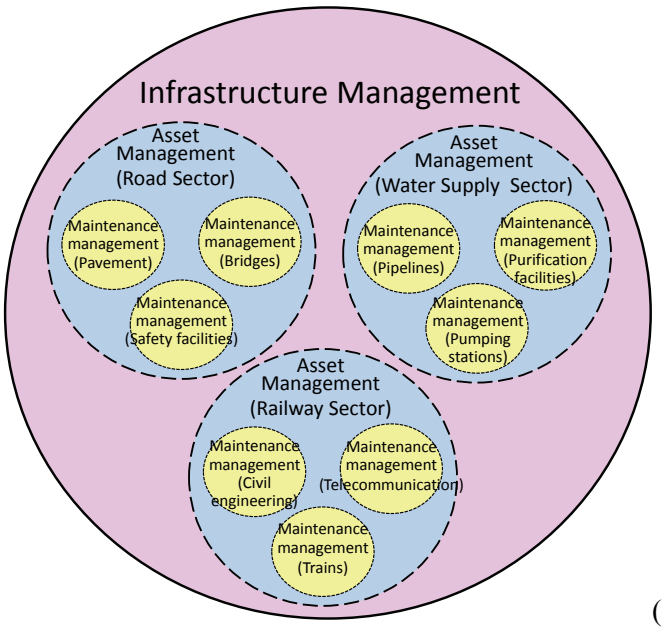
Source: Central Research Institute of Electric Power Industry, Japan

2.5 Trend in the Methods for Infrastructure Facility Management

The development of the methods for the management of infrastructure facilities in Japan is explained in the following in the four stages mentioned below for the sake of convenience:

(i) Engineering maintenance management
(ii) Asset management
(iii) Establishment of ISO series for asset management
(iv) Infrastructure management

Figure 7 is shown again to illustrate the relationship between engineering maintenance management, asset management and infrastructure management.



( ) example

2.5.1 Engineering Maintenance Management

In the first stage, the minimum maintenance work required for the maintenance of the function of infrastructure facilities was conducted. Later, with the increase in the number of the facilities, the demand for the improvement of the efficiency of the maintenance work emerged and, as a consequence, a management system was developed by systematizing the engineering methods for the maintenance work.

A general engineering maintenance management cycle for civil engineering structures is illustrated in Figure 19. Information obtained by the inspection becomes the foundation for further steps such as developing medium- to long-term maintenance plans and planning budgets for maintenance. In this planning process, the repair time, repair method for damages are examined by predicting the degradation of the structure based on the present condition and type of damage obtained by inspections. However, due to the fact that many uncertainties are

included in the prediction of the degradation, it is essential to improve the management quality over correcting the maintenance plan by monitoring whether there is deviation in the estimated values and actual degradation.

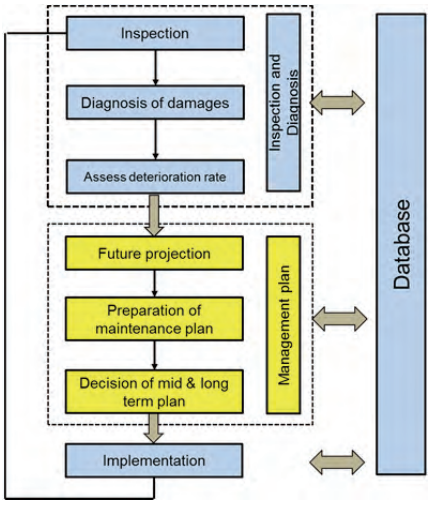


Figure 20 Engineering Management Cycle

Source: Striving to Introduce Asset Management, JSCE

The introduction of the engineering maintenance management began in the 1980's in Japan. It is widely used in Japan at present.

2.5.2 Asset Management

Asset management is considered as a generic term to describe the concept, methodology and framework of considering infrastructure facilities as assets and preparing medium to long-term plans for efficient and effective maintenance and management of the assets from the engineering and economic viewpoints. However, as the asset management is still in the process of being developed, its definition has not been established and the term is actually used to refer to various things.

The management from the engineering viewpoint is the conventional engineering maintenance management. The newly added management from the economic viewpoint consists mainly of the elements mentioned below.

- To use life cycle cost as the cost
- To use tax revenue efficiently on social capital
- To be able to provide information on the condition of social capital

Management cycle based on an engineering point of view plus the economic point of view, which is described in the following figure, should be rotated as per the PDCA (Plan, Do, Check, Action) cycle.

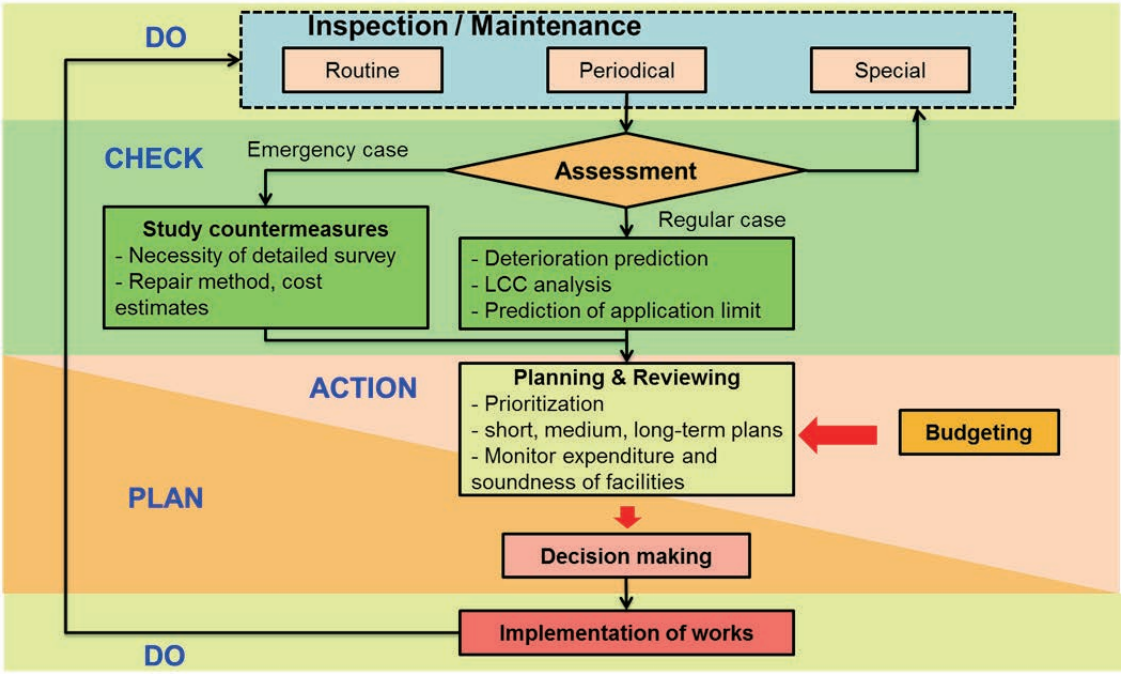


Figure 21 Engineering and Economic Management Cycle

The life cycle cost (LCC) of the structure is regarded as including all costs during the entire period, such as beginning with the plan and design, through construction, operation, repair, until the dismantlement and final disposal. Generally, LCC includes the following costs.

- Initial investment for construction such as plan, design and construction
- Maintenance cost such as inspection, maintenance and replacement
- Dismantling, processing and final disposal
- Risks such as fire, accidents and natural disasters
- Social costs such as traffic closures, water and power outages, noise, and vibrations.

Calculating the LCC in the structure design can change the conventional judgment based on the initial construction costs to the new judgment based on the cost including not only the initial investment but also all of the long-term maintenance costs.

It is very difficult to select an optimum maintenance plan because there are countless maintenance scenarios such as when and what repair and reinforcement works should be executed. However, to calculate the LCC can identify the financially favorable scenario.

- As it is difficult to conduct inspection, development of more efficient and accurate inspection technologies is required.
- As an extremely large number of factors are involved in the projection of deterioration, it is very difficult to predict the deterioration of individual structures

accurately.

Various technology development activities and studies are being conducted actively to solve the above-mentioned problems in Japan.

2.5.3 Establishment of ISO standards for Asset Management

As management systems are required to ensure that the cycle of Asset Management of PDCA is working, such systems are being developed.

(1) ISO55000 Series

The ISO55000 series which came into force in January 2014 are the international standards derived from the ISO9001 quality management system and prepared based on the PAS55 (published specification on asset management) established by BSI (British Standards Institution). They provide the guidelines for the implementation of asset management by an organization which owns and manages assets in compliance with the requirements, such as planning, operation, evaluation and improvement of performance, and in accordance with the international standards.

The ISO9001 provides the "Total Quality Management (TQM)" to be executed by all departments of the organization in the "PDCA cycle" which was taken up from the traditional business management. However, the ISO9001 does not cover the risk concept. Therefore, the new management system was developed by adopting the risk management concept in the present business management for the organizational management to respond to changes.[16]

Asset can be all infrastructure facilities in water supply and sewerage, energy, railway, and road sectors and so on. The ISO55001 provides the minimum requirements for the effective operation of asset management.

The ISO55000 Series stipulates the necessary mechanisms to enable an organization to identify the current situation of infrastructure facilities including aging, to analyze impact on potential accidents, to make plans for efficient operation and management, and to revise them based on verification. Figure 21 shows the relationships between components in the asset management and the requirements in each component. To acquire the certification, the application for any partial certification is not admitted, but all the 170 items must be satisfied.

[16] Committee for Study of the Guidelines for Application of ISO55001 (Ministry of Land, Infrastructure, Transport and Tourism) [Supplement for Explanatory Meeting] Edited from the Users' Guide to Application of ISO55001 to the sewerage field (Draft revised edition)

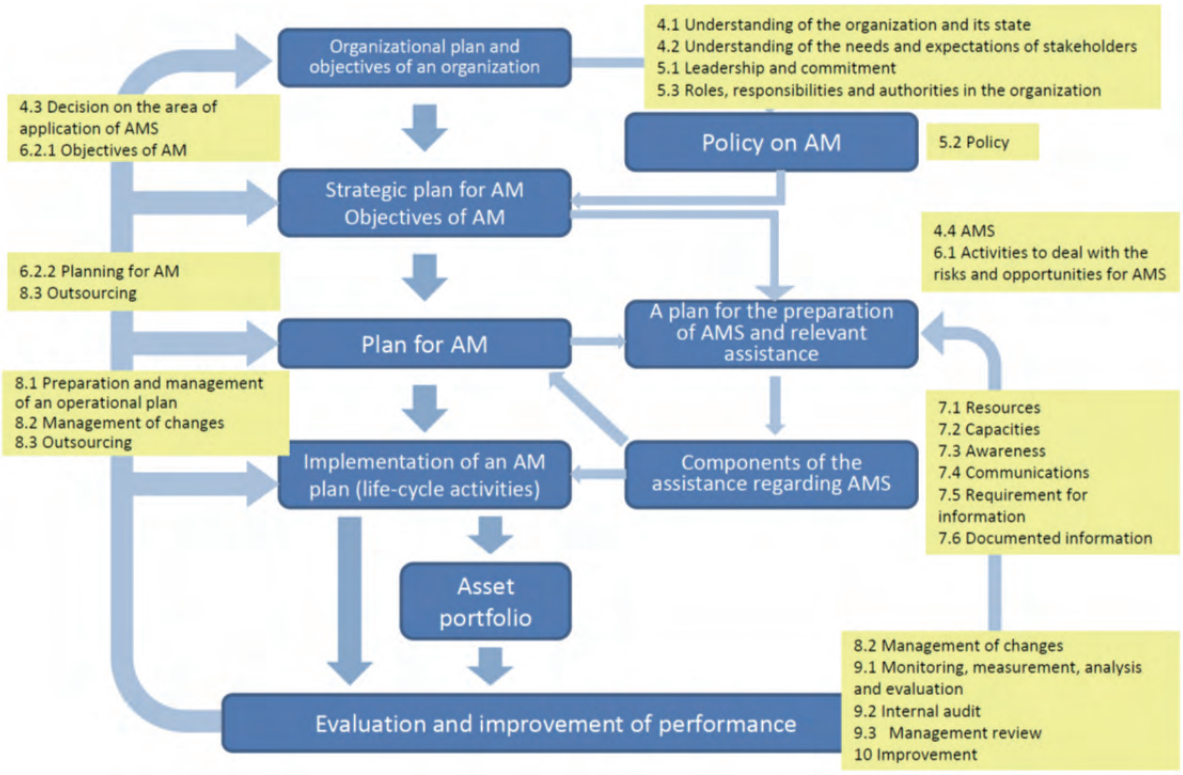


Figure 22 Relationships between Components of the Asset Management System and the Requirements in Each Component

Source: "Training Course on ISO5500X - 2013," Kyoto Business Research Center

The ISO operating entity is composed of 24 Participating Counties and 15 Observing Countries (as of 2014) as follows.

- Participating Countries

Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Colombia, Costa Rica, Cuba, Ecuador, Finland, France, Germany, India, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Norway, Peru, Portugal, Russian Federation, South Africa, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States

- Observing Countries

Armenia, Austria, Czech Republic, Denmark, Estonia, Hong Kong, Hungary, Iceland, Iraq, Israel, Malaysia, Morocco, New Zealand, Slovakia, Thailand

The ISO was originally established as a set of civil standards and each organization is free to adopt it. However, the standards to guarantee and certify the level of organizational management which is needed in the relevant fields have conventionally been derived from the internationally common standards for industrial products, but they are increasing at present. Also, the administrative organizations to deal with the ISO standards applicable to the public sector are also increasing after the WTO was established.

(2) ISO TC224 WG6: International Standard for Waterworks and Sewerage Services

The ISO TC224 is the 224th technical committee (TC) established in International Organization for Standardization (ISO) in 2002 to study international standardization related to waterworks and sewerage services. The TC held its final meeting in the Seventh General Assembly in Tokyo in November 2007. The three new ISO24500 series standards, ISO24510 (Evaluation and Improvement of Services), ISO24511 (Sewerage Service Management) and ISO24512 (Drinking Water Service Management), were approved and came into effect in December 2007.

In 2007, the Working Group WG6 was additionally set up to discuss the asset management of waterworks and sewerage services. The Task Group (TG) was set up within WG6 to prepare the international standard, "the Guidelines for the Infrastructure Asset Management (IAM) of the waterworks and sewerage system", but the work of preparing the Guidelines by WG6 was suspended once because the ISO/PC251 was set up in 2011 to start the development of the asset management standard (ISO55000 series).

At present, the Guidelines for Asset Management including the excellent cases in various countries (4 types of water distributing pipeline, water service facility, sewerage pipeline, and sewerage facility) are under preparation in accordance with the provisions of the ISO55000 series. The Guidelines specify the collection and collecting procedure of asset registers and status data, the operation and maintenance, the replacement plans and enforcement thereof, documentation and review of efficiency.

2.5.4 Infrastructure Management

In countries in which the population ages and starts to decrease, the tax revenues are also decreasing, which makes it difficult to secure budget for new construction and maintenance of infrastructure facilities. At the same time, as the social needs change, some existing infrastructure facilities become no longer needed and the need for new infrastructure facilities arises. Under the circumstances with limited financial resources, infrastructure management measures to holistically manage various infrastructure facilities arise to maintain necessary facilities in a good condition.

Infrastructure management is a concept to select necessary infrastructure facilities from a long-term and holistic perspective and to keep the quality of them and service level provided by them with limited financial resources. Specific measures taken differ depending on environment of implementing organizations and condition of facilities.

As a specific step in Japan, comprehensive outsourcing of infrastructure management started in 2006, and Fuchu City signed a comprehensive outsourcing contract in 2012.

3 Compare Infrastructure Management Approaches in Developed Countries and Assess Comparative Advantages of the Japanese Approaches

3.1 Current Situation of Aging Infrastructure Facilities in the U.S.A. and Europe

3.1.1 Current Situation of the Aging of Infrastructure Facilities in the U.S.A.

As shown in Figure 1 in Chapter 2.1.1(1), the construction of infrastructure facilities was promoted by the New Deal program in the 1930's in the U.S.A. and continued for a long time into the 1970's. Since the construction of urban waterworks systems began in the latter half of the 19th Century, there are many water supply pipeline facilities which have been in use for more than 100 years in the U.S.A. Many infrastructure facilities in the U.S.A. therefore began to show apparent signs of aging earlier than in Japan. The term "Crumbling America"[17] was used to refer to the situation in the 1980's whereby the deterioration of infrastructure facilities was brought to public attention by numerous accidents such as the collapse of Silver Bridge, which killed 46 people, and the U.S. Federal Government started to focus on maintenance.

(1) Problems due to deterioration

Problems due to deterioration are affecting the social life and life itself of the people in various sectors and here are some examples resulting in bridge collapses, road cave-ins, and water leakages due to ruptured water pipes.

1) Collapse of the Silver Bridge over the Ohio River

The Silver Bridge over the Ohio River connecting West Virginia and Ohio collapsed on December 15, 1967 and 46 people were killed. This hanging bridge was built in 1928 and the suspender cables were too old to tolerate the weight of many cars in a traffic jam due to Christmas shopping and finally broke.

[17] Why America's Bridges Are Crumbling, Kenneth F. Dunker and Basile G. Rabbat, Scientific American, March 1993

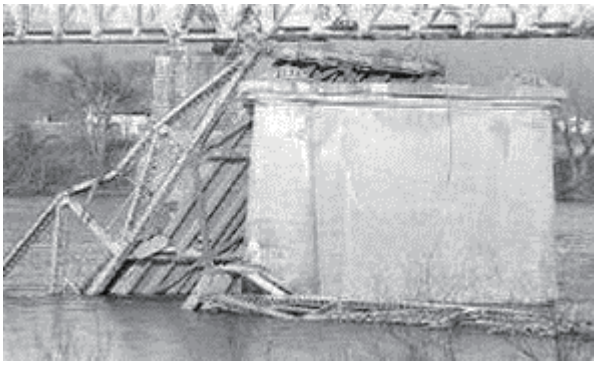


Figure 23 Scenes of the Collapse of the Silver Bridge

Source：Charlestone Daily Mail

2) Collapse of the Lakeview Drive Bridge in Pennsylvania

The middle part of the beam of the Lakeview Drive Bridge (a concrete overpass) collapsed and fell onto Interstate 70 in Pennsylvania in 2005. Ten people were injured in the accident. The collapse is suspected to have been caused by a combination of factors including damage to the bottom of the beam caused by the trucks crashing into it and concrete deterioration caused by salt damage. Although structural defects were found on the bridge in the regular inspection conducted in the previous year, safety measures such as road closure had not been taken.

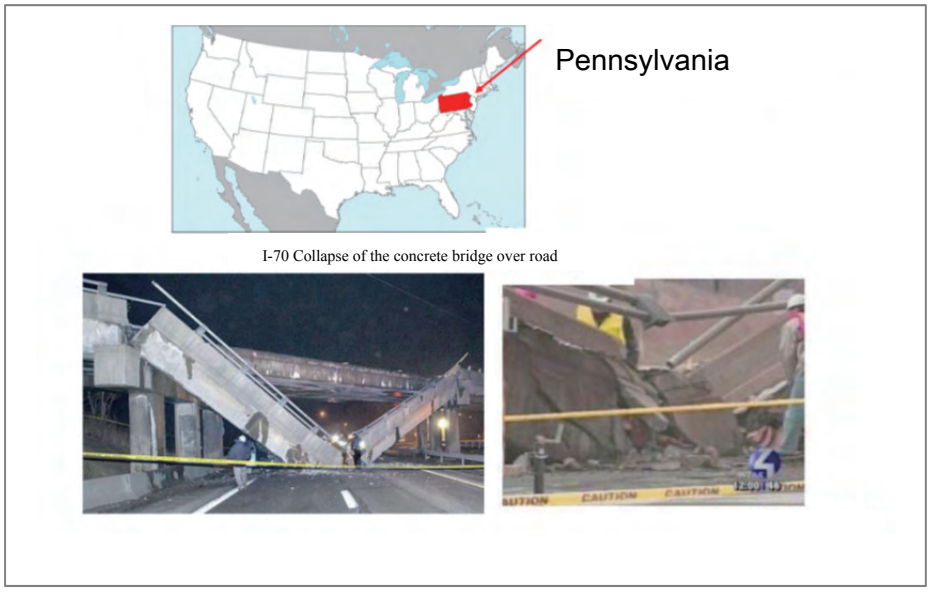


Figure 24 Scenes of the Collapse of the Lakeview Drive Bridge

3) Collapse of a Highway Bridge in Minneapolis, Minnesota

The Mississippi River Bridge on Interstate 35W over the Mississippi River between St. Paul and Minneapolis, Minnesota, collapsed on August 1, 2007. More than 60 vehicles were involved and nine people were killed, four went missing and more than 100 were injured in the accident.

Deterioration of the structural members and insufficient maintenance/repair are the suspected causes of the accident.

Figure 25 Scene of the Collapse of the Highway Bridge in Minneapolis

4) Water Mains Break in New York City

A water main burst in the center of Manhattan in New York City on February 2, 2013. The break caused serious damage including disruption of the road traffic with inundation and suspension of the subway services due to the water flowing into the stations and onto the tracks. The broken main was installed below Fifth Avenue, in the center of New York City, in 1915.
Then, another water main broke at around 1:40 a.m. on January 15, 2014 and a large area of the road above it caved in near Union Square, also located in Manhattan. The broken main was installed in 1877. It took approx. five hours to stop the flow of water from the water mains.[18] Because of this accident, subway services had to be suspended temporarily and the routes of bus services had to be changed near the site of the accident.

Figure 26 Road Caved in due to the Water Main Break (January 15, 2014)[19]

[18] New York Daily News
[19] http://www.tv-asahi.co.jp/ann/news/web/html/230202007.html ©CABLE NEWS NETWORK 2013

5) Northeast Blackout of 2003

The Northeast Blackout that occurred in August 2003 in six states in the northeastern U.S.A. and two states in southwestern Canada was the largest power outage in the American market, reaching the outage scale of 61.8 million kW and affecting about 50 to 51 million people. It took two days for power recovery and more than one week for complete recovery in all the areas. One of the causes of the blackout was the insufficient capacity and deterioration of power distribution facilities due to the long-term stagnation of investment in them because of emphasis on profit resulting from deregulation of the power supply industry for flexible selection of suppliers and uncertainness of institutional design[20]. After this accident, the Energy Policy Act (EPAct) was enacted in 2005 to maintain and enhance reliability in power supply, resulting in the establishment of the Electric Reliability Organization (ERO) and the provision of incentives for transmission investments.

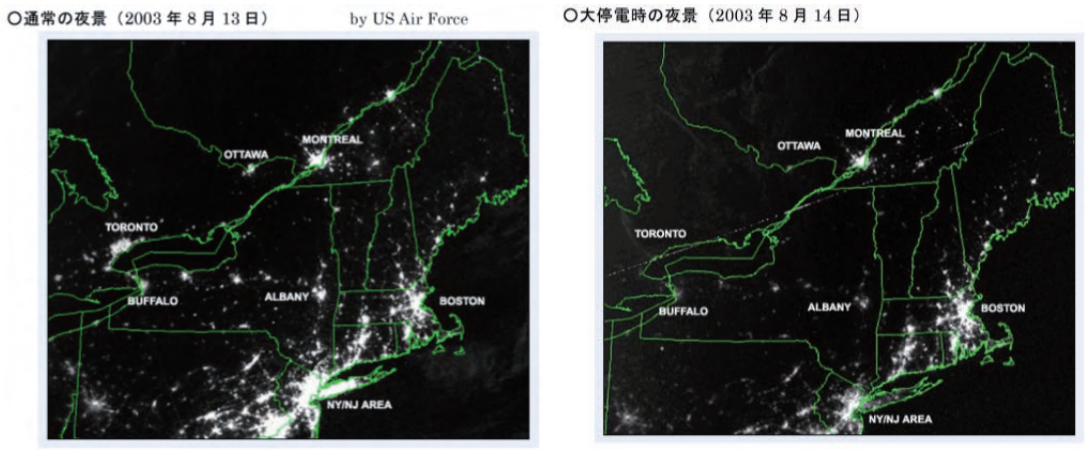


Figure 27 Night view during the Northeast Blackout of 2003 (Left: Normal, Right: Blackout)

Source: One Speculation on the Northeast Blackout of 2003, Development Bank of Japan

(2) Status Quo of Deterioration of Infrastructure Facilities

The American Society of Civil Engineers (ASCE) has published a comprehensive evaluation of major infrastructure facilities every four years since 1998 to identify the nationwide status quo of infrastructure facilities. At present, there are 16 target areas in which eight evaluation indicators are rated in five grades, A through F. Figure 23 shows the transition of these evaluation items, evaluations of target areas in this study, and average evaluations of all the infrastructure facilities.[21] This evaluation result shows that the average rating of all the infrastructure facilities has remained at D, a dangerous state, since 1998, which results from a delay in operation and maintenance and a shortage of investment. In particular, roads and waterworks and sewerage have remained in a critical state since 1998.

[20] One Speculation on the Northeast Blackout of 2003, Los Angeles Office, Development Bank of Japan, October 2003

[21] Report Card for America's Infrastructure

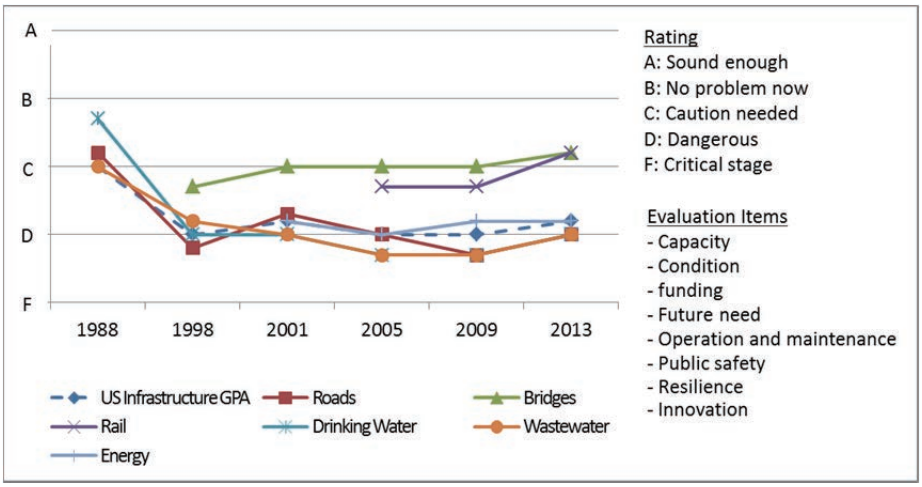


Figure 28 Transition of Infrastructure Evaluations by ASCE

Source: Report Card for America's Infrastructure 2013

In fact, ASCE summarized future prospects and budgets of maintenance and replacement costs, which demonstrate that only about half of the budgets required for maintenance are secured for roads and waterworks and sewerage. Nevertheless, the investment in waterworks and sewerage infrastructure facilities has increased at an average annual rate of 6.5%.[22]

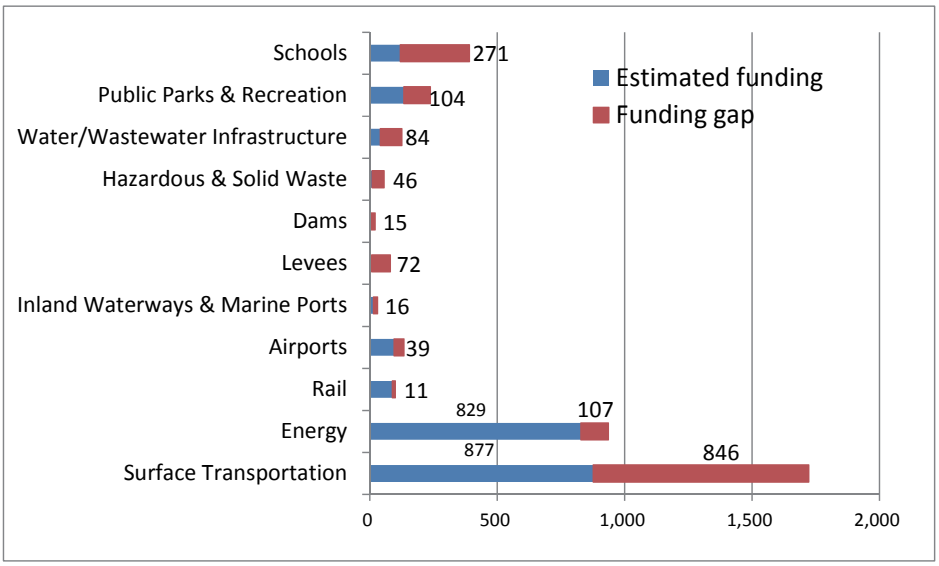


Figure 29 Gap between Future Prospects and Budgets for Maintenance and Replacement in U.S.A.

Source: 2013 Report Card for America's Infrastructure

[22] A report released by the United States Conference of Mayors (2013)

More than 600,000 bridges existing nationwide were built 42 years ago on average. One-ninth of them, or one-third in terms of the area, were found to have structural problems. In other words, the repair of large bridges is long overdue.[23]

Water leakages occur at 240,000 locations a year[24] in the entire U.S.A. It is estimated that two trillion gallons (approx. 750,000 m^3) of treated water worth US$ 2.6 billion is lost through water leakages every year.

In the late 1990's, the electric power industry was deregulated to enable flexible selection of power suppliers, resulting in a decrease of infrastructure investment. The industry still depends on the power system constructed in the 1880's, causing blackouts due to the deterioration of facilities.

3.1.2 Current Situation of the Aging of Infrastructure Facilities in Europe

Since the appearance of automobiles at the end of the 19th Century, roads have been constructed as a means of land transportation in the U.K. Many highways (motorways) have been constructed since the end of World War II as a foundation of economic development. In order to finance road construction, the Government of the U.K. began to create the source of revenue for road construction in such forms as taxes on automobiles and their fuel as early as in the 1900's. However, the infrastructure began to show apparent signs of the aging in the late 1980's and the early 1990's when the financial deficit of the government increased.

The Ynys-y-Gwas Bridge, whose construction was completed in 1952, collapsed in 1985. Breaks of pre-stressing steel bars caused by insufficient grouting are the suspected cause of the collapse. Since this accident, construction of bridges with the post-tensioning method with grouting has been banned in the U.K.

Figure 30 Collapse of a Bridge Caused by Breaks of Pre-stressing Steel Bars[25]

[23] 2013 Report Card for America's Infrastructure (March 2013)
[24] JWRC Hot News, No. 229-2 (September 17, 2012)
[25] http://www.youtube.com/watch?v=PUg_EqQN6Gg&translated=1

In the U.K. many water pipelines installed in the latter half of the 19th Century, including the waterworks of Glasgow whose operation began in the 1850's and, thus, which are called the origin of the modern waterworks, are still in use. They are in an advanced stage of aging and water leakage from those old pipelines is a serious problem.

As for countries besides U.K., as shown in Figure 1 in Chapter 2.1.1(1), the construction of bridges started in the 1930's, which is earlier than Japan, in Belgium, Germany, and Norway, the peak of construction was later than Japan, which peaked in 1970's. The construction was concentrated but the peak was not as high as that of Japan.

According to the survey between 1998 and 2000, approximately 30% of the bridges were defective and the major cause was corrosion of reinforcement bars and other steel materials.

Table 15 Major Defects of Bridges in OECD Countries

Country	No. of bridges	Bridges on national highways	% of defective bridges	Main defect
France	233,500	21,500	39%	Reinforcement corrosion Unappropriate surface compaction PC corrosion Unappropriate waterproof treatment Misestimation of temprature stress Alkali-aggregate reaction
Germany	80,000	34,800	37%	Reinforcement corrosion Shoddy design and workmanship Poor shoe, joint or drainage Overloaded vehicle Crackup Fire or flood
Norway	21,500	9,173	26%	Reinforcement corrosion Freeze and meltdown Alkali-aggregate reaction Deteriorating paint Shoddy workmanship and contraction of concrete Use of seawater for concrete placement Unstable foundation and scour
UK	155,000	10,987	30%	Reinforcement corrosion PC corrosion Unappropriate waterproof treatment Misestimation of temprature stress Alkali-aggregate reaction Neutralization

Source: Construction Asset Management

Maintenance costs in OECD countries were about 1% of maintenance and replacement costs in 2001.

Table 16 Maintenance Costs in OECD Countries

Unit: mill Euro

Country	Bridges	Annual maintenance cost (1)	Annual maintenance and replacement cost (2)	(1) / (2) (%)
Belgium	5,000	10	3,800	0.3
Finnland	15,000	30	2,900	1.0
Francce (Highway)	22,000	50	10,800	0.5
France (Expressway)	6,000	23	4,100	0.6
Germany (Highway)	34,600	318	30,000	1.0
UK (Highway)	9,500	225	22,500	1.0
Ireland (Highway)	1,800	2.5	450	0.6
Norway	17,000	37	6,000	0.6
Spain (Highway)	13,000	13	4,100	0.3
Sweden (Highway)	15,000	92	5,300	1.7

Source: Construction Asset Management

Against such a background, the Institute of Civil Engineers (ICE) has been summarizing the circumstances of nationwide infrastructure facilities since 2000 and rating five evaluation indicators in five grades in six target areas[26]. Figure 31 shows the transition of average evaluations in the target areas of this study and the general evaluation. In this figure, the average of all the infrastructure facilities is changing between Caution Needed and Dangerous. The waterworks and sewerage are free of problems at present. In 1989, the governmental corporation for waterworks and sewerage was incorporated to form a private water company. The water company set about the replacement of treatment facilities and piping equipment, which continued to be postponed in the days of governmental corporation, and compliance with the new environmental standards. The company is now able to improve the cost structure and secure the funding for investment in replacement of facilities and improvement of water and service quality.[27]

The major roads were improved to a problem-free state by 2010 owing to preventive maintenance. If the budget is cut in the future, however, corrective maintenance will be employed again, deteriorating the road states and making the repair cost comparatively high in the long run. In contrast, local roads have deteriorated to a dangerous level. Due to lack of funding, maintenance has not been conducted in many places. Furthermore, the integration and multi-functionalization of administrative organizations are making it difficult to maintain the

[26] The six target areas are 1) Energy, 2) Major traffic networks (railways, highways, airports, and harbors), 3) Local traffic networks (local roads and local public transportation), 4) Waterworks and sewerage, 5) Flood prevention and seashores, and 6) Waste disposal and resource management.

[27] CLAIR (Council of Local Authorities for International Relations) Forum, January 2012

specialized skills for management.[28]

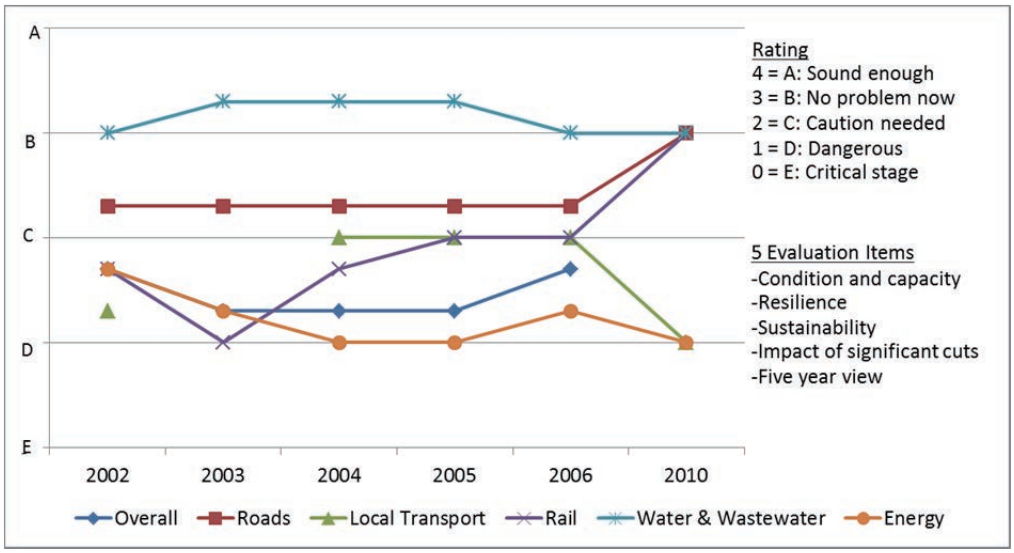


Figure 31 Overall Evaluation of Infrastructure Facilities in the U.K.

Source: The State of the Nation Infrastructure 2010

The budget for maintenance and replacement in the U.K. as of 2009 is estimated to be about 1.8 billion pounds out of the total infrastructure spending of 12 billion pounds.[29]

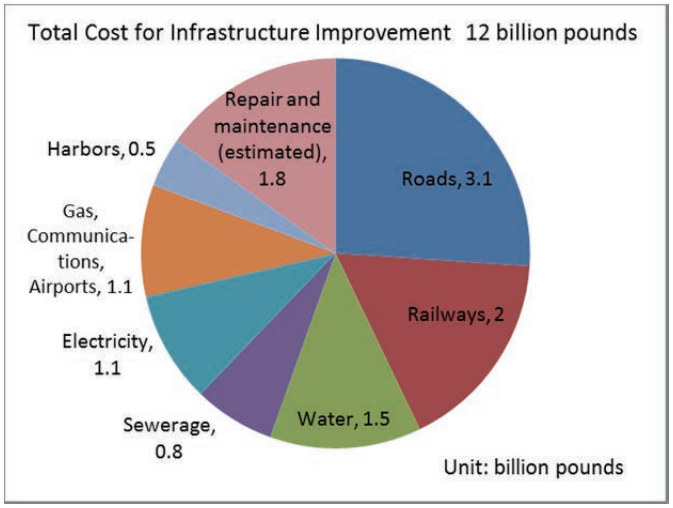


Figure 32 Cost for Infrastructure Improvement in the U.K.

Source: The Office for National Statistics

[28] The State of the Nation Infrastructure 2010 (The Institute of Civil Engineers)
[29] The Office for National Statistics

3.2 Approaches Taken by the Governments in the U.S.A. and Europe

3.2.1 Approaches Taken by the U.S. Government

In the U.S.A, state governments have independent rights to decide practical matters including infrastructure development from planning to maintenance, while the federal government is mainly in charge of providing subsidies and research activities. For example, 62% of the budget related to roads is used by the states, 36% by the local governments and only 2% by the federal government.

There are different competent authorities for each sector unlike in Japan MLIT is competent in more than 10 sectors. The competent authorities and implementing organizations for infrastructure facilities in the U.S.A. are as follows:

- The implementing organizations for roads are the national and local governments and the competent authorities are the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO).
- The implementing organizations for waterworks and sewerage are local governments and the competent authority is the Environmental Protection Agency (EPA).
- The implementing organizations for railroads are private companies and the control association of railroad operators is the Association of American Railroads (AAR).
- The implementing organizations for electric power are private companies, which are supervised by the Federal Energy Regulatory Commission (FERC).

There are no regulations imposed on asset management or infrastructure management.

Regarding waterworks, the federal government is assisting local governments by providing training and introducing best practices. However, there is growing privatization and outsourcing of railroads, electric power supply and waterworks services because they can be provided with the fares and fees received from users. Therefore, the public administration is assuming the role of providing supervision only. On the other hand, the operation of toll-free roads is directly managed by the national and local governments. Since there is no incentive for improving infrastructure facilities because it does not increase the profit directly, the public administration must take the lead in implementing the maintenance and replacement.

(1) Approaches Taken in Road Sector

The asset management by the public administration is the most advanced in the road sector.

The Federal government makes a comprehensive transportation funding and policy act called the Surface Transportation Assistance Act.[30] A major specific revenue source for development of roads is Federal Highway Trust Fund from the user taxes such as gas tax and vehicle tonnage tax, a new use of subsidies from funds earmarked for road improvement, and expanded the use

[30] Originally it was only for roads and called as Federal-Aid Highway Act.

that was previously limited to replacement to include large-scale repairs[31]. Federal-Aid roads were decided to be free in the Federal-Aid Highway Act of 1916. The Surface Transportation Assistance Act of 1982 added four cents to the cost of fuel dedicated to restore interstate highways and bridges and a 1987 revision of the act enabled federal aid of up to 35% for toll roads. Later on, as shown in Figure 33 gas tax is further raised in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the following Transportation Equity Act for the 21st Century (TEA-21) to enhance financial source for development of roads. The usage was first limited to new construction and replacement, but later enhanced to large maintenance.

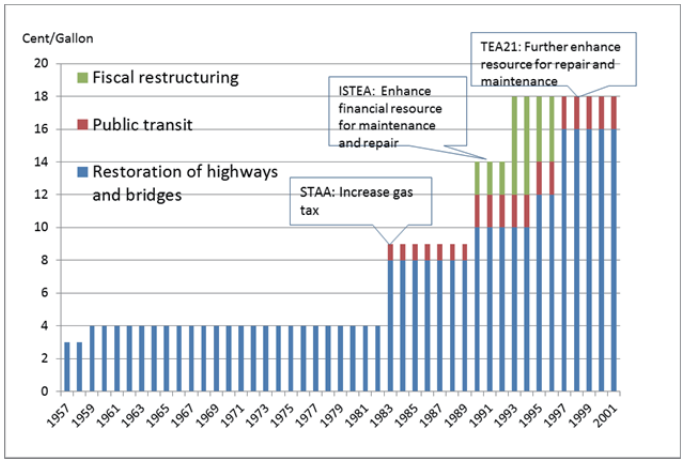


Figure 33 Change in Gas Tax and Its Usage in the U.S.A

Source: Road Bureau, MLIT

As a result budget derived from the TEA is increasing.

Table 17 Recent Surface Transportation Assistance Act and Budget

	ISTEA	TEA21	SAFETEA-LU
Year	1992－1997	1998-2003	2004-2009
Budget (bill dollars)	155.3	218.0	286.4

Source : Japan Expressway Holding and Debt Repayment Agency (2009)

In order to break away from the "Crumbling America," the Federal Government planned replacement and repair of bridges and spent the budget focusing on large replacement projects of defective bridges. For example, in the City of New York, the total repair cost of the Williams Bridge between 1981 and 2002 was as much as 97 billion dollars.

[31] Asset Management Practices by Local Governments in Overseas and Supportive Activities by Central Government, 39th Collection of Papers for Research Presentation for Infrastructure Planning and Management, June 2009

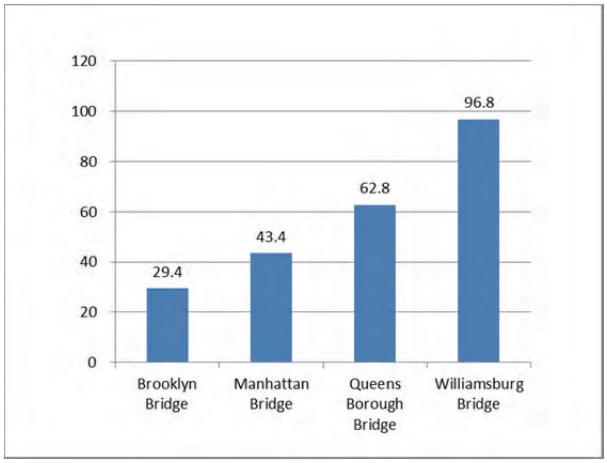


Figure 34 Repair Costs of Major Bridges in City of NY (1981-2002)

This facilitated the planned spending of maintenance budget and work for extending the road life, allowing the Government to reduce the number of defective bridges.

For the technical side, the Federal Act in 1971 had the local authorities inspect bridges strictly and established the National Bridge Inspection Standards (NBIS). NBIS require each state to prepare and maintain the National Bridge Inventory (NBI) and report the result of the inspection to FHWA. The FHWA also provided assistance to development of various types of general-purpose software such as BBI, PONTIS, bridge inspection database software, and tried to encourage use of such software and distributed them to states and other local authorities, and established a qualification system and the Bridge Inspection Refresher Training in accordance with NBIS.

States develop a pavement management system (PMS) used for maintenance of pavement independently and try to encourage its use.[32]

Furthermore, the concept of New Public Management (NPM) derived in late 1980's to utilize private sectors' management principle and methods in public administration to activate efficiency began to be used in road maintenance and that triggered the shift to asset management.[33]

In 1995 FHWA established Office of Asset Management to promote asset management through examination, system development and to encourage its expanded use.

[32] Infrastructure facility management overseas, Pacific Consultants, Defense facilities technology quarterly, January 2004

[33] Road Asset Management Handbook

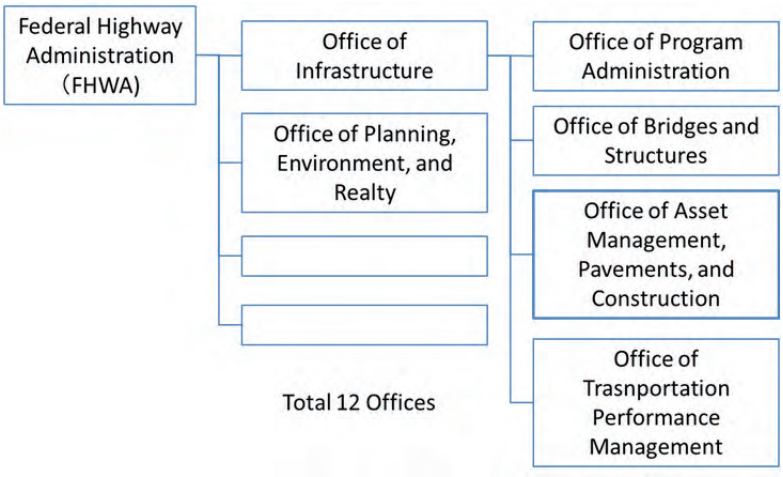


Figure 35 FHWA Organization Chart

* Renamed the Office of Asset Management, Pavements, and Construction

Source: FHWA (Effective February 2014)

Followed by NBI, PONTIS, FHWA developed Life-Cycle Cost Analysis: LCCA) in 1998. In 1999, the Highway Economic Requirements System-State Version (HERS-ST), a road management system that optimizes the investment in improvement of roads through cost-effective analysis, started to be introduced to states and local governments on a trial basis. Regarding the major road segments in the U.S., this system forecasts defects in pavement, etc. in the next 20 years, and calculates the investment costs for improvement and benefits from improvement to derive a proper budget scale.[34] The analysis is based on the information accumulated in the FHWA's database, Highway Performance Monitoring System (HPMS), and the data is updated every year by the administrators of state highways.[35]

The Governmental Accounting Standards Board (GASB) prepared the GASB34 (GASB Statement No.34) in 1999 and introduced the concepts of asset values and depreciation in the accounting of infrastructure facilities. However, "modified approach" to whereby and repair costs of infrastructure facilities without depreciation costs are accounted for, was accepted if the quality of the O & M services is sufficiently maintained. This stimulated interest in appropriate maintenance and activated system and database development for analysis.

In addition, the American Association of State Highway and Transportation Officials (AASHTO) established the "Transportation Asset Management Guide" (TAM Guide) in 2002 and "TAM Guide: A Focus on Implementation," in 2011. This 2011 version explains each step in the asset management from planning to implementation with a focus on implementation.

[34] FHWA Website

[35] Introduction to Road Management System in the U.S.A., Pacific Consultants

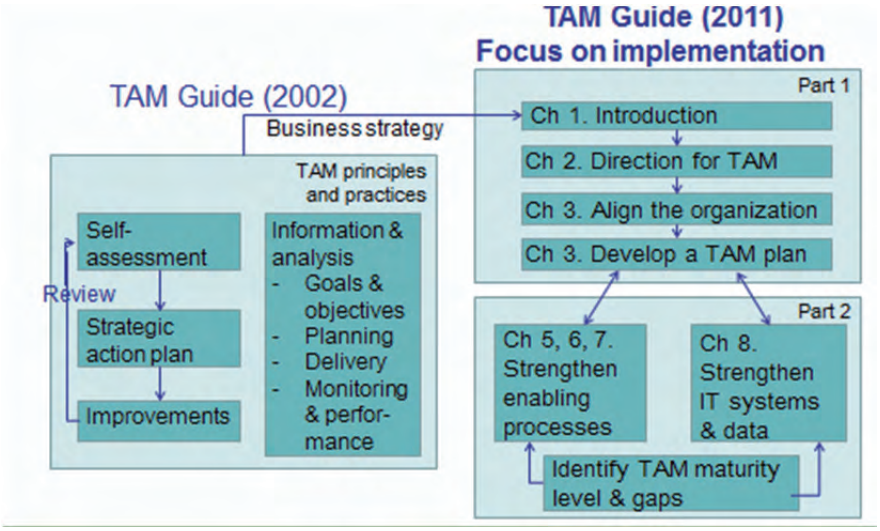


Figure 36 Road Map of Transportation Asset Management Guide: A Focus on Implementation[36]

(2) Ways of raising funds

There are the following ways of raising funds for public investment applicable to infrastructure management.[37]

1) Revenue bond

Revenue bond is a municipal debt on which the payment of interest and principal depends on revenues from the particular asset that the bond issue is used to finance. Examples of such projects are toll roads and bridges, sewer developments, and airport expansions. Generally speaking, a revenue bond is riskier than other municipal bonds because debt default risk is on the bondholders. It is not considered as debt in the general account.

2) Tax-exempt bond fund

Tax-exempt bond is by a local or state government. These municipal bonds are usually used to raise capital for improvements in infrastructure or other aspects of the municipality. They are exempt from federal income taxes and sometimes from state and local taxes as well. Public companies can use this scheme to raise funds for public projects if they meet the regulations.

[36] AASHTO Transportation Asset Management Guide – a Focus on Implementation, Jan 2011

[37] Joint research to introduce PPP for maintenance and repair of public infrastructure facilities, Yokohama City and Mizuho Securities Co., Ltd., April 2011

3.2.2 Approaches Taken by the Governments in Europe

Privatization is in a more advanced stage in Europe than in Japan or the U.S. Approx. 90% and 80% of the waterworks systems are operated by private companies in the U.K. and France, respectively.

National governments in Europe assist private participation through revision of laws. For example, in 1955, Italy established a framework for long-term concession of toll roads to contract out by Asienda Naxionale Autonoma delle Strada (ANAS).[38] In 1970 France established laws to eliminate restrictions on qualification of concession companies for construction and operation of toll roads. Concession companies can raise funds without government guarantees and are allowed to undertake a wider range of works, which resulted in establishment of four private concession companies.

In the 1970's and 1980's, the U.K. was called the "sick man of Europe"[39] and it needed alleviation of the financial burden urgently. The U.K. Government promoted the privatization of government-run companies as a measure to reduce the cost of operating public works through the transformation of the "big government" to a "limited government."

The U.K. government privatized waterworks and sewerage in 1989, electric power in 1990, and railroads in 1997. For these areas, there are three regulatory agencies that promote competition by private companies and supervise and regulate them from the viewpoint of consumer protection: the Water Services Regulation Authority (Ofwat), the Office of Gas and Electricity Markets (Ofgem), and the Office of Rail Regulation (ORR). Furthermore, the major road networks are in the charge of the Highways Agency (HA) of the Department of Transport (DfT).

In the 1990's, the PFI and PPP methods were introduced to the infrastructure management for the first time in the world. Then, a series of laws were enacted to eliminate obstacles to the use of PFI contracts.

[38] Survey on toll road systems in Europe, Japan Expressway Holding and Debt Repayment Agency, 2008

[39] While the economy stagnated, the gracious social security systems and the policies such as nationalization of key industries made the people dependent of the gracious welfare systems, lose motivation to work and critical to vested interests.

Table 18 Chronological Table of the Adoption of PFI by the U.K. Government

	Measure
From 1979	Privatization of the state-owned enterprises (in the railway, airline, petroleum, pharmaceutical, communication, steel and automobile industries, waterworks, etc.)
1991	**New Roads and Street Works Act 1991** A law on concession
From 1992	Adoption of PFI
1993 – 1997	Establishment of the Private Finance Panel in HM Treasury as an organization to promote PFI
1994	**Deregulation and Contracting Out Act 1994** For the removal of legal obstacles to introduction of contract-based provision of public functions
From 1997	Adoption of PPP
1997	**Local Government (Contracts) Act 1997** To guarantee the legality of PFI contracts Endowment of the authority to conclude contracts with financial institutions and to conclude contracts including loans to the beneficiaries of the contracts from financial institutions to local authorities in order to remove the fear of the financial institutions on concluding contracts with local authorities
Sep. 1997	Establishment of HM Treasury Task Force as an organization to promote PFI
Sep. 1999	Dissolution of the PFI Task Force and establishment of the Office of Government Commerce (OGC)
1999	Preparation of the guidelines for the standardization of PFI contracts

Involvement of the private sector in infrastructure management has been promoted since 2000 in accordance with the Asset Management Strategy. Since 2010, the U.K. government has been focusing on infrastructure improvement by allocating the limited funding efficiently on the initiative of the HM Treasury to change the system in a way to ensure the implementation of infrastructure improvement.

Table 19 Infrastructure Improvement Initiatives in the U.K.

	Measure
2000 – present	**The State of the Nation Infrastructure**, Institution of Civil Engineers (ICE) For explicit description of the measures to be taken to improve the conditions of the land infrastructure, the organizations evaluate the infrastructure facilities and discuss the required measures every year to summarize them in the State of the Nation (SoN).
Published in 2004 Revised in 2008	**PAS55**[40] Standards for Asset Management in the U.K. published by the British Standards Institute (BSI) and prepared jointly by the Institute of Asset Management (IAM) and 49 organizations of 15 industries in 10 countries. Showing a management method for maximizing the asset value of tangible assets throughout their service life and spreading to various countries in the world as standards applicable to any type of physical asset, developed into ISO55000 described in 2.4.1.
2008	**Planning Act** Creation of a new approval system in pursuit of acceleration and transparency of procedures for large infrastructure projects. Eight approval systems in six areas (railways, harbors, roads, airports, waterworks, and wastes) have been integrated into one.
2009	**Infrastructure UK (I-UK)** Establishment of the government's infrastructure-related platform. Review of planning, prioritization, funding, and procurement in all the infrastructure areas from a long-term view to increase the investment in replacement and maintenance of existing infrastructure facilities that are important as the basis for economic development.
2010	**Strategy for National Infrastructure**, HM Treasury Investment strategies for 2010 through 2014 in five areas (energy, transportation, waterworks, wastes, and communications) that contribute directly to economic development.
Updated every year since 2010	**National Infrastructure Plan (NIP) 2010, 2011, 2012, 2013,** HM Treasury To adopt a cross-sectional strategic approach in planning, funding, and implementation, HM Treasury establishes the overall picture of the problems concerning infrastructure in the U.K and solutions to them and the plans of the government for the next 10 years and beyond. **National Infrastructure Plan (NIP) 2013** stipulated the establishment of MIT (Major Infrastructure Tracking) for monitoring the progress and a special contact department in I-UK for project implementing bodies in order to implement the 40 projects in priority areas defined in "Investing in Britain's Future."
2010	**Infrastructure Cost Review 2010** The maximization of investment effects was pursued by establishing a goal for 15% cost reduction and an action plan based on the information on civil engineering infrastructure procurement collected from more than 300 organizations.
2013	**Investing in Britain's Future**, HM Treasury Long-term strategic plan for dealing with problems in the next 10 years for modern infrastructure improvement. It established pioneering priority projects in the road, housing, chemical, and energy areas, etc. and gave priorities by securing long-term fund sources for them.

[40] Publicly Available Specification

3.3 Infrastructure Management Initiatives in the U.S.A. and Europe

3.3.1 Infrastructure Management Initiatives in the U.S.A.

(1) Approaches Taken in Water Supply Sector

In the U.S.A., the waterworks business originated from providing water from privately owned wells and there was a trend of reliance on private sector companies. Due to this background, privatization and outsourcing of waterworks business has been commonly done since early times. Later, water came to be supplied by public organizations in more and more cases for the sake of equality of water distribution and improvement of water quality. In 2000, water was supplied publicly by municipalities and water committees in 85% of the country and privately in 15% of it. With the anticipated demand for finance associated with replacement of aging pipework, it is expected that more projects will be outsourced to the private sector in the future.[41]

1) Initiatives by Los Angeles Department of Water and Power

Most of the pipework of the Los Angeles city waterworks were laid down in the first half of the 20th century and deterioration is in progress. Figure 37 shows the percentage of pipes that were installed 100 years ago or more. As of 2012, 20% of pipes were installed 100 years ago or more, and at this rate the percentage will be 44% by 2021.

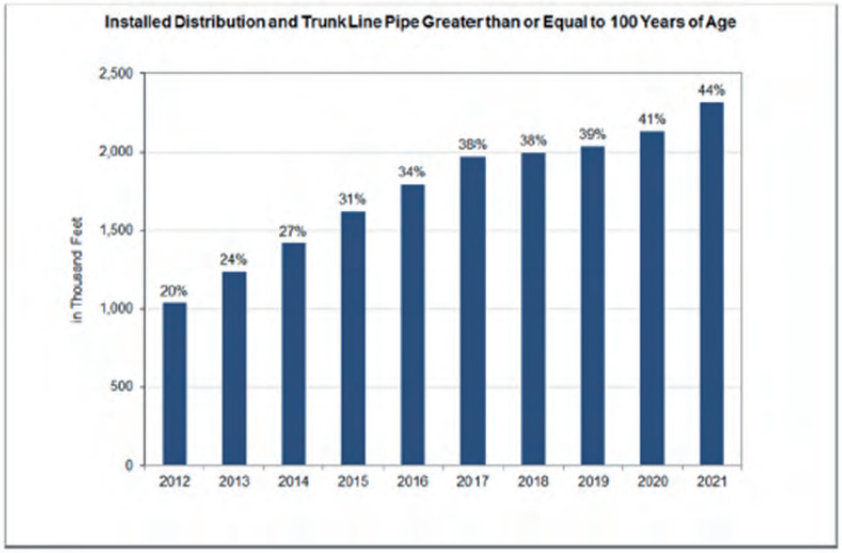


Figure 37 Percentage of Pipes that were Installed 100 Years Ago or More[42]

[41] IWA Workshop "Efficient Management of Water", April 2005
[42] Water System Rate Proposal FY 12/13 and FY 13/14 Summary and Supporting Information

Under these circumstances, a "Ten-year Investment Program for Improvement of the Water Supply System 2010 – 2019" has been formulated as an infrastructure investment plan, and it was decided that a budget of approximately $6.6 billion would be allocated to four priority areas over 10 years. The largest proportion of budget, 36%, goes to the Improvement of Infrastructure Reliability. The investment will be made in improvements in main water pipes and reservoirs, etc., for the Los Angeles waterworks system, with an order of priority determined by criteria such as the extent of aging, the frequency of obstruction of function, and fragility to earthquakes.

(2) Approaches Taken in Road Sector

As maintenance cost increases according to deterioration of roads and sluggish growth of gas tax as funding source, long-term concessions were introduced to operate toll roads. There are mainly two concession types: lease of toll roads in use and Design, Build, Finance and Operate (DBFO) of new toll roads.

Table 20 Examples of Concession of Toll Roads by Type

Type	Long-term lease contract	DBFO
Contents	Lease out existing toll road to concession company	Public organization owns toll roads and contracts out design, construction, operation and maintenance of new toll roads
Case	Chicago Skyway Indiana Toll Road Pocahontas Parkway Northwest Parkway	Dulles Greenway South Bay Expressway HOT lane on Ring Road

Source: Japan Expressway Holding and Debt Repayment Agency, 2009

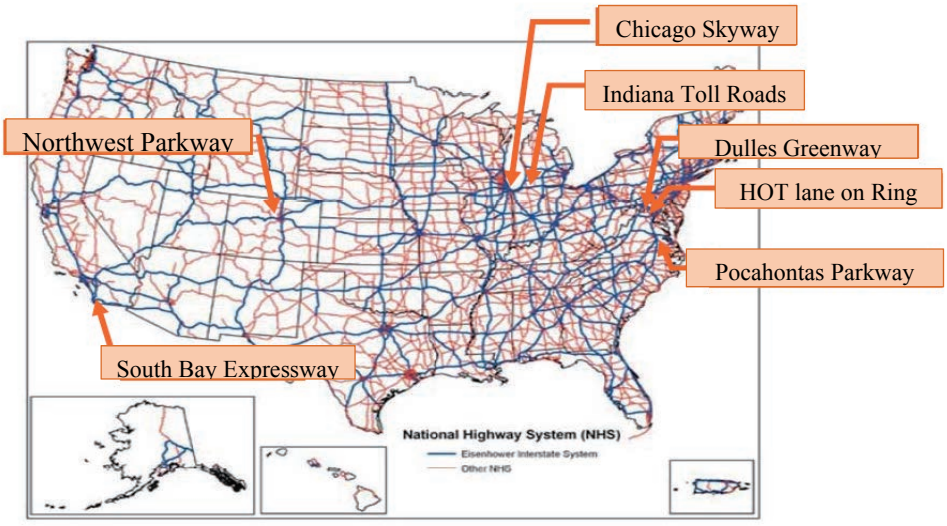


Figure 38 Major Concession Toll Roads in U.S.A

Compared to concessions in Europe, which started earlier, concessions in U.S has the following characteristics.

1. There are no concession companies experienced with overall management since the history of concessions started 1995.

2. Concession is a federal policy and it takes time to introduce new administration method through legislation in the states.

3. Concessions longer than the economic life (generally 45 years) of an infrastructure is considered as purchase and has tax incentive to depreciate earlier than lease.

4. Concession period is long.

In Europe a concession period is generally between 30 years and 40 years, for revenue balances with investment in 30 to 40 years.

- France Generally 35 years and extends later
- Italy Starting from 30 years and extends later
- Spain Max 40 years and extends up to 60 years,
  20 years for operation only

In the U.S.A, a concession period is longer because of tax reasons, and concession fee is rather expensive.

Table 21 Concession Period and Fee in the U.S.A and Europe

Toll Roads	Lease period	Concession Fee
Chicago Skyway	99 years	1.83 bill USD
Indiana Toll Roads	75 years	3.85 bill USD
Pennsylvania TP	75 years	12.80 bill USD
Northwest Parkway	99 years	0.543 bill USD
Dulles Parkway	60 years	0.62 bill USD

Source: Japan Expressway Holding and Debt Repayment Agency, 2009

For free roads as well there is vigorous outsourcing to the private sector as a result of the 1997 assistance grants and easing of regulations on tax exemptions. The most common form of this type is Utility Operation & Maintenance (O&M). Other formats include Management Contracts, Design, Build and Operate (DBO), Build, Operate and Transfer (BOT), etc.43

For maintenance of roads, etc., the state of Texas was the first to comprehensively outsource services and adopt Performance-Based Maintenance Contracting (PBMC) and later some other states also adopted PBMC. This is a contract method that does not define the construction

[43] Outline of Water supply Business in the U.S.A., December 2006, Council of Local Authorities for International Relations

method or quantity but the required performance. The minimum function of roads, etc., is defined, and the contractor is paid based on whether the defined management level is being achieved. The effects of adopting PBMC include change to long-term contracts, emphasis on results due to performance definition, and outsourcing of multiple tasks.[44]

Table 22 Time Introduced PBMC by State

State	Time Introduced PDMC
Texas	August 2004
Washington DC	July 2005
Florida	July 2005
Virginia	March 2006
North Carolina	June 2006

[44] Outline of Performance-Based Maintenance Contracting (PBMC) in the U.S.A. and Suggestions for Japan, Doboku Gijutsu (Civil Engineering), Vol. 66, No. 3 (March 2011), Takashi Mizuno (Yachiyo Engineering), pp. 54 – 58

3.3.2 Infrastructure Management Initiatives in Europe

In Europe private participation started earlier than U.S.A in areas where user fees can be expected. In the road sector, more than 70% of expressways are toll roads in France and Italy, where most toll roads are operated by a concession company. On the other hand, in U.K. PFI methods is used even for free roads, where public organizations pay shadow tolls to operating companies.

(1) Infrastructure Management Initiatives in the U.K.

In the U.K., as a result of the privatization of the governmental corporations during the Thatcher administration, from 1990 onwards public facilities were developed by the PFI method. When PFI is adopted the cost must be compared with the case that the project is implemented by the normal procurement method (Public Sector Comparator: PSC), to confirm that value for money (VfM) is being obtained. The merits and expected effects of adopting the PFI method for maintenance of public facilities are as follows.

- Financial effects due to reduction in costs (large projects can be implemented without the burden of procurement of finance)
- Observance of construction period and initial contract amount
- Off-balance effect (loans are removed from public accounts)
- Improvement in services to the public by utilizing know how obtained in private project
- Efficient implementation of work

PFI is used for operation and maintenance of free roads. The first four examples were DBFO including connecting road of 30km between M1 and A1 in Leads City in 1995. In this L1-A1 Motorway Link Project, HA pays “shadow toll” to the concession company based on (i) travel distance of vehicles (ii) Level of service (iii) Performance considering traffic accidents avoided by the company’s safety plan and impact of closed traffic lanes.

The following is an introduction to examples of cities that have introduced the PFI method for maintenance of toll-free roads.

1) Road Projects in the City of Portsmouth

In 2005, the City of Portsmouth outsourced the maintenance of a total length of 414km of road for 25 years. The PFI project format was comprehensive outsourcing to the private sector by the Design, Build, Finance, and Operate (DBFO) method. Initially the amount of payment was set based on the amount of vehicle traffic (a fee set up per vehicle). However, with the change in city government in addition to the basic service procurement costs incentives were added such as reduction in congestion and reduction in traffic accidents, in accordance with the concept that road service is about having roads that are open.

Table 23 Details of Comprehensive Road Management Project in the City of Portsmouth

Project name		Portsmouth Highways Management PFI Project
Public sector organizations	Local government	Portsmouth City Council
	Central government jurisdiction	Department for Transport: DfT
Project period		2005 – 2030 operation (25 years)
Target roads		Total length about 414km
Project content		- Large scale repair and improvements (core investment period 5 years) - Large scale repair and improvements (during the operation period) - Maintenance and operation (during the operation period) - Inspection and maintenance (including maintenance of appearance), cleaning (excluding collection of trash) - Road management (excluding traffic signals) - Issue of licenses for road use (stall holders, etc.), dealing with third-party complaints, coordination with statutory businesses (electricity, waterworks, gas),etc.
Contractors	Company (SPV)	Ensign Highways Ltd.
	Financers	Colas UK Ltd. (50%) Colas S.A. (50%)
	Contractor	Colas UK Ltd.
Project cost	Contract amount	£500 million (about 120 billion yen)
	Sources of finance	City of Portsmouth £300 million (general subsidy) DfT £200 million (of which PFI project £121 million)
Construction cost, maintenance cost	Repair and improvement costs	Core investment period (£59 million) Operating organization (£47 million)
	Maintenance cost	Operating organization (£257 million)

2) Road Projects in the City of Birmingham

In 2006, the City of Birmingham adopted Common Standards for Streetworks Management, which contain reference guidelines and standards for those engaged in road projects, including points to note regarding planning, construction, and maintenance.

Birmingham Highways Maintenance and Management Service covers a total length of 2,500km in accordance with these guidelines, it is the largest road maintenance outsourcing project in Europe, and it is managed while checking for consistency with Birmingham's Vision for 2026.

Table 24 Details of Comprehensive Road Management Project in the City of Birmingham

Project name		Birmingham Highways Maintenance and Management Service
Public sector organizations	Local government	Birmingham City Council
	Central government jurisdiction	
Project period		June 2010 25 years 5 years Core Investment Period (CIP)
Target roads		2,500km of highway
Project content		- Improving the average condition of roads, carriageways and pavements - Replacing around 41,000 street lighting columns - Replacement of trees in the city center area - Tunnels with modern safety equipment - Strengthening works to bridges - Renewing the large number of old traffic signal controllers and improving the Council's capability to link its traffic management systems with other agencies
Contractors	Company (SPV)	
	Financers	
	Contractor	Amey plc (a subsidiary of Ferrovial)
Project cost	Contract amount	£2.7 billion
	Sources of finance	£608 million PFI Credit Equates to £1.22 billion as a cash grant over the 25 years of the contract (£48.9 million per annum)

3) Hounslow Borough Road Projects

In 2006, Hounslow Borough formulated the 1st version of its Highways Asset Management Plan (HAMP), and the 3rd version was revised in 2009. This plan was produced for operation by members of staff engaged mainly in road maintenance and management, with plans over a 1 to 5 year period, but the service standards and implementation periods, etc., were expected to be outsourced to private companies by the PFI method. The outsourcing of the road projects to private companies is planned for a 25 year period from 2013, including a five-year core investment period.

Table 25 Details of Hounslow Borough Comprehensive Road Maintenance Project

Project name		Highways Maintenance Private Finance Initiative (PFI) Project
Public sector organizations	Local government	London Borough of Hounslow
	Central government jurisdiction	Department for Transport: DfT
Project period		January 2013 – (25 years) 5 years Core Investment Period (CIP)
Target roads		458 miles of pavements and 259 miles of roads
Project content		- Road maintenance - Sidewalk maintenance - Street lights - Bridges - Others, public green spaces, etc.
Contractors	Company (SPV)	Ringway Hounslow Highways Ltd.
	Financers	
	Contractor	VINCI Concessions (VINCI Group) Ringway (VINCI Group)
Project cost	Contract amount	£800 million
	Sources of finance	PFI credits of £267 million Government grant of approximately £350 million spread out over 25 years

(2) Infrastructure Management Initiatives in France

Continental countries such as France separate ownership and operation of infrastructure facilities and public organizations own infrastructure and outsource operation and maintenance to private companies. This style is called concession or lease contract (affermage). Public organizations keep ownership to keep sustainability of public service regardless of the private companies' conditions.[45]

1) Approaches taken in water supply

Inter-communal public cooperation entities mainly operate waterworks and sewerage in France. As initially the waterworks business was privately operated, there are now many communes that comprehensively outsource to the private sector. France has two major water companies, Veolia Water and Suez Environnement, who have 25% of the world's water and sewerage market of 800 million people, and these two companies have great power. As of 2008 71% of waterworks and 55% of sewerage works are outsourced to the private sector, and the contract format in 80% of cases is a lease contract (affermage).[46]

However, dissatisfaction among city residents of Paris increased due to the rapid increase in water charges. In 2009, waterworks business was transferred back to the public sector with the aim of setting appropriate water charges, it was reorganized from third-sector company into a

[45] PPP News 2010, No. 17 Fujitsu Research Institute

[46] Survey Research Report on Introduction of Private Sector Management Methods into the Water Industry 2-6, Forms of Privatized Management and Overseas Examples, July 2006

waterworks public company, and entrusted with operations. The policy was that profits that were allocated to stockholder dividends and retained earnings when it was privatized would be spent on reinvestment in order to improve services. In addition a reduction in annual costs of €30 million was achieved as a result of rationalization associated with transfer back to the public sector.[47]

2) Approaches taken in road sector

Tolls are applied to expressways that can be financially profitable and operated by concession companies. First toll roads started in 1955 and law amendment in 1970 allowed operation by private companies and resulted in establishment of concession companies, most of which were fully privatized by 2005. Based on a concession contract of 45-75 years with the central government, concession companies construct, operate, and maintain toll roads and repay construction costs from their toll revenue. Roads are returned to the government after the concession period. There are 12 private companies and each company operates several lines to balance risk.

For example, Millau Viaduct, which is a part of A75-A71 autoroute axis from Paris to Beziers and Montpellier, was planned in 1994, and in 2001 French government and a concession company, Eiffage, signed a 78-year concession contract including a construction period of three years and an operation period of 75 years with structural assurance of 120 years. The concession contract will end in 2044 if the company has earned enough by then.

Figure 39 Millau Viaduct

The contract also sets maintenance level and contracts on maintenance and toll modification structure are renewed every five years. For bridge maintenance, specific safety guidelines for

[47] CLAIR Forum, January 2012

structures called IQUA and bridge maintenance support system called LAGORA are used and necessary budget for maintenance is calculated based on structural states identified by IQUA and LAGORA accumulated necessary data.

On the other hand, Contract de Partnariat, which is similar to PFI developed in U.K. was first introduced in 2004. Private companies are in charge of design, build, finance, and operate and public organizations payback for the service. Nearly of the half cases in the transportation sector are applied for free roads.

3) Approaches taken in road sector

The law amendment in 2006 allowed railway sector to use PPP and PFI was applied to construction and operation of Ligne à grande vitesse (LGV) when subsidy from the national and local government and finance by Réseau Ferré de France (REF) was not enough and resulted in a substantial delay in the LGV development plan. In the 2008 economy-rejuvenation plan, French government identified the LGV development plan as a priority, which stimulated use of PPP.

Two out of four new lines were constructed under Contrat de Partnariat and one under concession in 2012. REF signed a 50-year concession contract with private company, LISEA of 7.8 billion Euro for LGV-SEA line connecting Tours and Bordeaux in June 2011 and a 25-year Contrat de Partnariat for LGV-BPL line connecting Le Mans and Rennes in January 2011 and a 25-year Contrat for Nimes-Montpellier line in June 2012, with 2.5-3.5 billion Euro, which is smaller than concession fees.

(3) Infrastructure Management Initiatives in France

In Italy 86% of expressways are toll roads and these are operated by private companies based on concession contracts. The basic scheme is the same as that in France and contracts on maintenance and toll modification structure are to be renewed every five year as maintenance performance is reflected on fees. The basic concession period is 35 years and there are about 25 private concession companies.

(4) Joint Infrastructure Management Initiatives in Europe

National highway research laboratories in the U.K., France, Germany, Norway, Slovenia and Spain undertook a project to develop a framework for a bridge management system, Bridge Management in Europe (BRIME) for the European road network that would enable bridge stocks to be managed on a rational basis and enable bridge maintenance to be optimized taking account of all factors affecting bridge management.

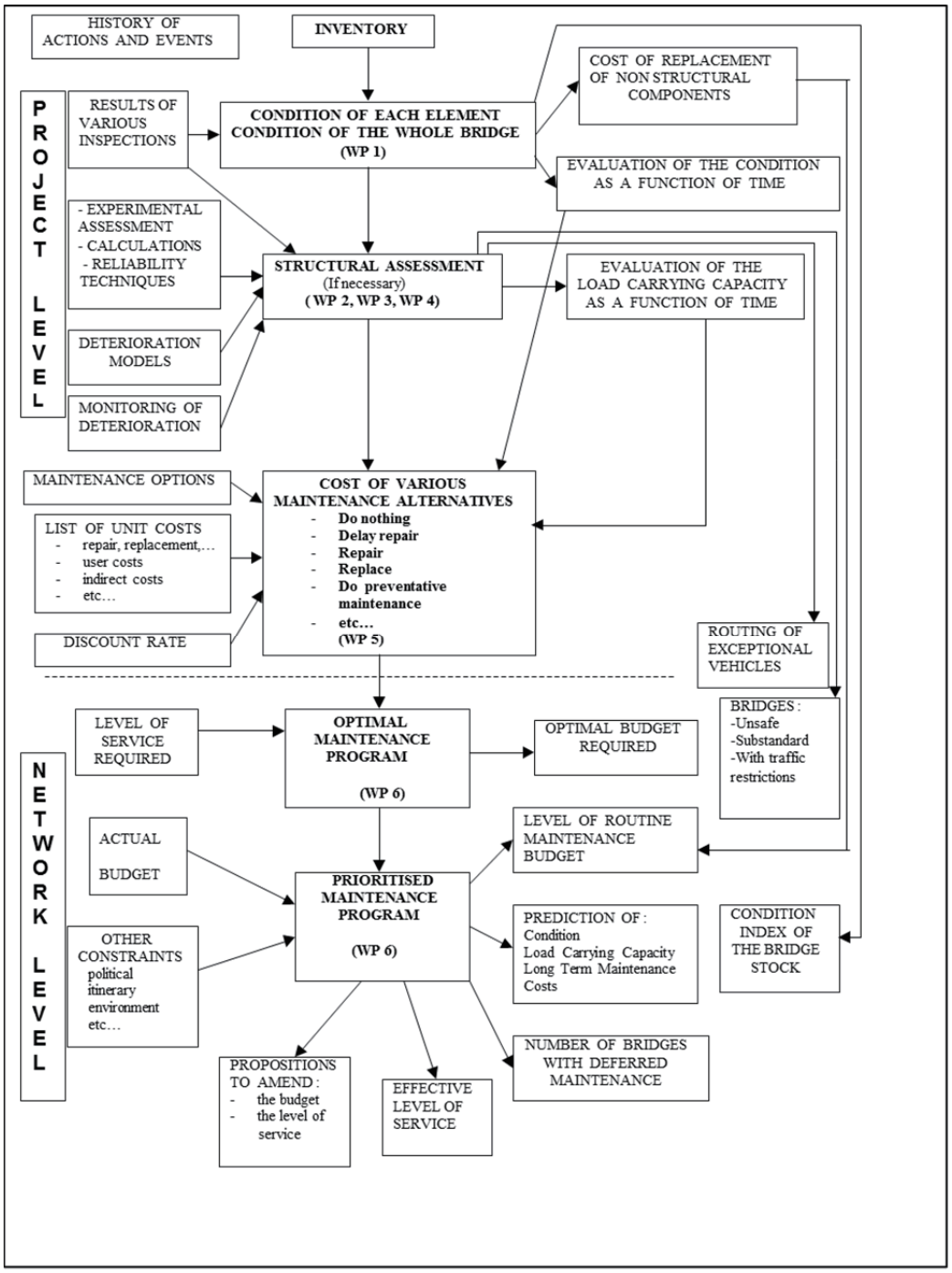


Figure 40 Architectural Framework of BRIME

Source: BRIME: European Commission, 2000

3.4 New Technologies in the U.S.A. and Europe

Road inspection and repair technology in Europe is introduced as maintenance technology in the U.S.A. and Europe. The Ministry of Land, Infrastructure, Transport and Tourism's New Technology Information System (NETIS) database, which was used in the previous section, was used for the latest research into infrastructure management from among the projects adopted in the European Union's Seventh Framework Programme for Research (FP7)[48].

Table 26 New Major Technologies Used in Europe

Application Type	Technology
Bridge Inspection Technologies	Technical Research into Rapid Inspection of Concrete Bridges by the Non-destructive Method
	Bridge Deck Diagnosis Technology
Road Repair Technologies	Repair Technology Using Ultra Violet Cured Glass Fiber Reinforced Plastic Sheet
	Development of Resin Material for Repairing Asphalt Pavement
Railway Inspection Technology	Subway Monitoring System Using Wireless Connections

[48] A framework research program covering the period 2007 to 2013 to strengthen links and complementarity between the initiatives and policies of each of the countries of the EU and the EU's initiatives and funding.

Classification: Road Inspection Technology

Name: Technical Research into Rapid Inspection of Concrete Bridges by the Non-destructive Method

Explanation of the function

This is a monitoring system for determining the integrity of bridges by measuring the internal state of the concrete which cannot be inspected visually, using the advantages of the measurement technologies of ground penetrating radar and ultrasonic guided waves. The continued research and development is in progress so that measuring instruments can be incorporated into structures for monitoring in the future.

Use

The coordinates of the positions of the reinforcement within the concrete are measured with the ground penetrating radar, and the inspection determines the position of cracking or corrosion of reinforcement if occurred. A 3-dimensional model produced by a system to which measuring instruments can be quickly connected can be checked.

Effect

- The structure integrity survey results can be quickly obtained, so it is economical.
- Traffic restrictions are not necessary during inspection.
- The interior of concrete, which cannot be visually inspected, can be measured.
- It is possible to prevent the occurrence of major accidents.

Applicability in Thailand

This technology has been developed to monitor structures using built-in measuring instruments in them in the future and does not require traffic restriction nor have an impact on the surrounding environment. In Thailand, especially in Bangkok, where traffic congestion often occurs, an inspection method that does not require traffic restriction is assumed to be applicable.

Developer of the technology

Developers: TWI Ltd. (leading company: UK), NTUA (Greece), Technology Assistance BCNA 2010 s. l. (Spain), INETEC (Croatia), Acutech Ltd. (Greece), Atkins plc. (UK)

References: CROSS-IT Project HP http://www.crossit-project.eu/

European Union's Seventh Framework Programme for Research Website

http://cordis.europa.eu/result/rcn/57182_en.html

Classification: Road Inspection Technology

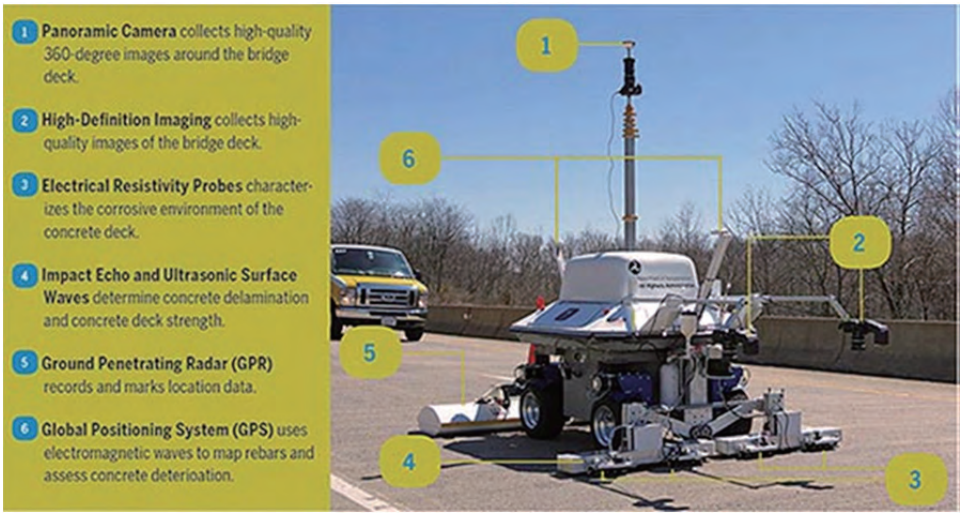
Name: Bridge Deck Diagnosis Technology

Explanation of the function

This bridge deck assessment tool has been developed to acquire somewhat detailed soundness data using grounding technologies such as impact echo, ground penetrating radar (GPR), and electrical resistance methods.

Use

A non-destructive assessment robot, "RABIT™ that has a Panoramic Camera, High-Definition Imaging, Electrical Resistivity, Impact Echo and Ultrasonic Surface Waves, GPR, and GPS is used to inspect the conditions of concrete surface and inside of the bridge deck. Data is immediately collected via a wireless network.



Functions of Non-Destructive Assessment Robot for Bridge Deck, RABIT™

Effect

- The time for traffic restriction during inspection can be shortened.
- The soundness inspection of a structure allows the user to acquire the results immediately and is economical.

Applicability in Thailand

This technology facilitates diagnosing the concrete surface and inside and is assumed to be highly applicable in Thailand.

Developer of the technology

Developer: Federal Highway Administration (FHWA)

References:

http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/structures/ltbp/ltbpresearch/rabit/index.cfm

Classification: Road Repair Technology

Name: Repair Technology Using Ultra Violet Cured Glass Fiber Reinforced Plastic Sheet

Explanation of the function

This is a technology for repair of corroded parts and prevention of corrosion to steel road structures (lighting columns, bridges, pedestrian footbridges, etc.).

Use

The old paint film is removed from the construction surface, and FRP sheet made from polyester cut to the required size is applied to the location of the repair. The repair location is irradiated with ultra violet light to harden it.

Construction Example

Effect

- This technology can be applied easily.
- The construction time from application of the sheet to hardening is short.

Applicability in Thailand

This method enables repair of corroded parts and preventive maintenance for a wide range of steel structures on roads and is assumed to be highly applicable in Thailand.

Developer of the technology

Developers: FibreTech (UK)

References:

http://www.netis.mlit.go.jp/NetisRev/Search/NtDetail1.asp?REG_NO=CB-990022&TabType=2&nt=nt

Classification: Road Repair Technology

Name: Development of Resin Material for Repairing Asphalt Pavement

Explanation of the function

A low-viscosity resin that can be chemically synthesized is under development as a repair material for reinforcement, cracks, potholes, and joints of asphalt pavement.

Use

A low-viscosity resin material is infiltrated into asphalt to reinforce the binding of aggregate and reduce openings. It is also possible to make a dual layer consisting of a resin-infiltrated layer and a highly dense asphalt layer.

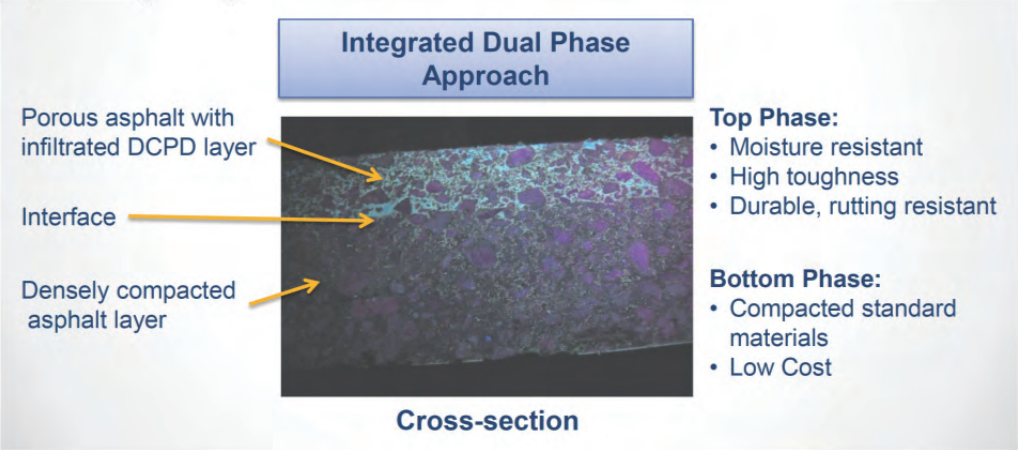


Figure Cross-section of Resin-Infiltrated Asphalt

Effect

- This resin material will have superior moisture resistance and durability and reduce the maintenance cost in a long term.

Applicability in Thailand

This technology, if commercialized, will enable reinforcement and repair of asphalt pavement in a simple way and is assumed to be highly applicable in Thailand.

Developer of the technology

References: Technical Innovation Program by National Institute of Standards and Technology (NIST)

Materia Inc (Pasadena, CA), The Regents of the University of California, (UCLA) (Los Angeles, CA)

http://www.nist.gov/tip/upload/UCLA-NIST-3-14-14.pdf

3.5 Comparative Advantages of Japan Compared with the U.S.A. and Europe

This section examines the infrastructure initiatives in the U.K. described so far as an example in Europe and compares the infrastructure management initiatives in the U.S.A., U.K., and Japan to verify in which technologies Japan has a technical advantage.

Table 27 Comparison of Infrastructure Management Initiatives in Japan, U.S.A. and U.K.

Item	Japan	U.S.A.	Europe (mainly U.K.)
Comprehensive infrastructure management policies and initiatives			
Basic policies of infrastructure management	Life extension of all necessary facilities in the future.	NPM (Apply management principle of private sector to activate efficiency	Concentrated investment in priority projects.
Initiatives of infrastructure management	The central government manifests comprehensive basic policies and requires all the infrastructure administrators to establish action plans.	Due to the federal system, state and local municipalities conducts sector-by-sector management.	Promote active private participation by law amendment and periodic quality check .
Utilization of private companies	Comprehensive outsourcing of multiple tasks to private companies.	Outsourcing to private companies (such as O&M and BOT).	Privatization. PFI and concession.
Area-by-area infrastructure management systems and national-level initiatives			
Roads	Roads are managed by the central government and municipalities under MLIT. Outsourcing to private companies is also used. The toll expressways were privatized.	Roads are managed by the central government and municipalities under FHWA. Outsourcing to private companies is also used.	Roads are managed by the central government and municipalities under HA. Outsourcing to private companies is also used.
Roads: National-level initiatives	The basic plan for life extension requires all the infrastructure administrators to establish individual plans.	Federal government assists municipalities' initiatives by providing regulations and maintenance systems	Law amendment and periodic check to promote private participation
Waterworks	Water is supplied by public water corporations of municipalities under the control of the central government.	Waterworks by municipalities is outsourced to private companies.	Owned by municipalities and outsourced to private companies.
Waterworks: National-level initiatives	The infrastructure administrators are required to establish a local waterworks vision.	Federal government assists municipalities' initiatives by providing information, etc.	Law amendment and periodic check to promote private participation
Sewerage	Municipalities are the implementing organizations of sewerage under the control of MLIT.	Sewerage is mostly implemented by municipalities but is often outsourced to private companies.	Owned by municipalities and outsourced to private companies.

Sewerage: National-level initiatives	The basic plan for life extension requires all the infrastructure administrators to establish individual plans.	Federal government assists municipalities' initiatives by providing information, etc.	Law amendment and periodic check to promote private participation
Railways	Privatization	Privatization	Privatization
Power supply	Privatization	Privatization	Privatization

In Japan, the central government plays a major role as the competent authority even if a municipality is the implementing organization. For infrastructure management, too, the central government promotes the life extension and formulates specific policies for infrastructure facilities. Furthermore, the central government requires the infrastructure administrators to formulate action plans by showing the formulation method. It provides specific instructions as technical assistance for formulation of plans so that management activities are implemented throughout Japan. In contrast, the U.S.A. has a federal system so that the federal government does not take the lead in the comprehensive initiative for infrastructure management across several sectors. On the other hand, European governments provide assistance to develop environment for private participation.

In areas other than power supply and railway operation that have already been mostly privatized, the utilization of private companies is as follows: In Japan, municipalities are outsourcing multiple tasks to private companies in lump-sum contracts because the road administration agency is specified by law and outsourcing to an external party is prohibited. In the U.S.A., operation and maintenance of profitable facilities are outsourced to private companies. The European government is actively introducing the PPP/PFI methods to infrastructure facilities which can generate user fees.

The management of toll-free roads is either the responsibility of the central government or municipalities and the competent authority, develops and provides implementation-oriented asset management guidelines and road management systems. The U.K. uses PPP/PFI for toll-free roads by paying shadow tolls to operating companies.

Regarding waterworks, the Japanese Ministry of Health, Labour and Welfare is taking the lead in the initiatives for promoting infrastructure management to ensure appropriate maintenance ahead of the Ministry of Land, Infrastructure, Transport and Tourism. In the U.S.A. and U.K., no central-government-led comprehensive initiatives like those of Japan are found probably because water has been historically supplied by private companies. The same goes for sewerage.

Regarding individual technologies, Japan has a comparative advantage over the U.S.A. and U.K. in terms of skills for safe work on roads, which are often narrow and leading to intricate alleyways, and in terms of durable materials in a climate with large annual temperature variations and many natural disasters such as typhoons and earthquakes. Granted that Japan often uses technologies that have been imported from Western countries, some of them have

been improved and localized to suit the urban structures and climate of Japan.

Table 28 lists the technologies in which the advantages of Japan are acknowledged.

Table 28 Classification of Japanese Technologies and Know-how that are More Easily Applied than those of the U.S.A. and Europe

Category	Technologies
Overall structure	● Work steps for replacement where there are narrow roads
Inspection	(Road) ● Crack measuring system ● Concrete soundness diagnosis portable kits (waterworks and sewerage) ● Camera survey of inside water pipe
Repair, reinforcement, Replacement	(Road) ● Highly durable epoxy adhesive ● Reinforcement by carbon fiber sheet ● Concrete removal prevention etc. (waterworks and sewerage) ● SPR Engineering ● Seamless System Engineering ● EX Engineering

Therefore, the advantages of Japan over the Western countries are found in the national-level planning of comprehensive infrastructure management across several sectors, systems and methods for providing assistance to infrastructure administrators in planning, initiatives of municipalities in the waterworks and sewerage, technologies for working in narrow and intricate roads, and material technologies in consideration of earthquake resistance and disaster prevention functions.