Japan's Infrastructure Grades 2020 & Introduction of Maintenance Technologies

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Japan Society of Civil Engineers

JSCE 公益社団法人 土木學會 Japan Society of Civil Engineers

Contents

Introduction

Civil engineering has greatly contributed to the formation of the national land and infrastructure of Japan, and to Japan's development. However, aging of the structures in the infrastructure has become a major problem. In the future it is anticipated that aging of the structures will proceed rapidly, and repairs and renewal will increase. It goes without saying that the structures and infrastructures support society and economic development, and plays an important role in maintaining the sustainability of our lifestyles. In order to maintain the quality of our lifestyle safely and securely with limited resources and finance, it is necessary that the public understands the importance of aging infrastructures' maintenance and renewal. Securing the necessary budget and personnel for this purpose is of vital importance for the sustainability in Japan.

Considering the importance of infrastructures, the Japan Society of Civil Engineers (JSCE) decided to evaluate the grades of Japan's infrastructures as a third-party organization, and in May 2016 published "Report on Infrastructures' grades". The 2016 Infrastructures' grade was applied only to bridges and tunnels for roads, where the inspection and diagnosis had been systematized in advance of the other infrastructures. Thereafter, rivers, sewage, ports, waterworks, and railways were evaluated, and the grades of their infrastructures were published.

This brochure summarizes these reports on the infrastructures' grades published in 2020. Also, it introduces the latest inspection, repair, and strengthening technologies in Japan. We hope that this brochure will contribute towards the awareness of Japan's infrastructure grades and help to provide the information on Japan's civil engineering technology that maintains infrastructures.

Infrastructure Integrity Diagnosis Subcommittee
Japan Society of Civil Engineers

Report on Japan's Infrastructure Grades 2020

A Grade Associated with Infrastructure's Health Condition

Facility inspection results and information on the maintenance systems was collected from published data and surveys, and condition assessment was carried out by the experts from Japan Society of Civil Engineers. After evaluating the data considering the regions and infrastructure owners, the grades were evaluated as the national average.

Grade					
Section	A Sound	B Good	C Requires attention	D Requires vigilance	E Dangerous
Roads Waterworks Sewage works	There is no degradation in almost all the facilities	Degradation is progressing to a certain extent in the facilities	Degradation is progressing in a significant number of the facilities, and repair will be needed in the near future	Degradation is apparent in most of the facilities, and repair or strengthening, etc., is required	There is severe degradation overall, and urgent measures are required
Rivers Ports Railways (bridges, tunnels)	There is no deformation in almost all the facilities	Deformation is progressing to a certain extent in some facilities	Deformation is progressing in a significant number of facilities, and repair will be required in the near future	Deformation of many facilities is apparent, and repair and strengthening, etc., is required	Deformation has progressed overall, and urgent measures are necessary
Railways (tracks)	Tracks are constantly maintained in good condition by track strengthening and condition monitoring	Track irregularity has occurred, but a constant level is ensured by periodic repair	Track irregularity has progressed in a significant number of tracks, and repair will be required soon	There is track irregularity in most of the tracks, and measures such as repair, etc., is necessary	Track irregularity has progressed overall, and urgent measures are required

Maintenance system in term of prediction of future integrity status (Actions in order to maintain or recovery integrity)

Facility maintenance system		
↗ (Likely to improve)	→ (Current state likely to be maintained)	↘ (Likely to get worse)
If the current management system is continued, it is considered that the status of integrity will improve	If the current management system is continued, it is considered that the current status of integrity will be maintained	Unless the current management system is improved, there is a possibility that the status of integrity will get worse

in Terms of Structural Health Condition

Summary of Grades among Infrastructures in Japan

Roads

Bridges	C ↘
Tunnels	D ↘
Road pavements	C ↘

Railways

Bridges	B →
Tunnels	B →
Tracks	B →

Ports

Mooring facilities	C →
Protective facilities for harbors	C →

Rivers

Levees	C ↘
River structures	D ↘
Dam	B ↘

Waterworks

Pipe facilities	C →

Sewage works

Pipe facilities	B ↘

Although in many facilities degradation and deterioration are progressing, the current average grade of the infrastructure is that overall it has not became poor at risk.
However, with the current maintenance management system, it is difficult to improve the infrastructure condition. It may exhibit significant deterioration in near future without more financial support.

Measures for improving the condition of the infrastructure
System for managing maintenance and budgets

To efficiently perform maintenance, (1) establishing systems, (2) constructing mechanisms, and (3) cultivating human resources, etc., are important, while ensuring the necessary budgets over a long period of time. In particular, it is necessary to cultivate the maintenance industry considering preventive maintenance and maintenance as economic activities.

- The public should understand the importance of infrastructure for their lifestyle and for socioeconomic activities, and they should cooperate in problem solving.
- The national government should provide financial support so that operators can perform appropriate maintenance, and establish systems that enable sustainable financial measures.
- The national government should implement improvements in the contract system and close cooperation among those involved, in order to construct an appropriate maintenance system.
- Operators should establish long-term plans not only for budgets, but also for human resource training and securing human resources.

Implementation of appropriate and effective inspection, diagnosis, and corrective actions

It is necessary to change the focus of maintenance from inspection and diagnosis to repair and strengthening based on the inspection and diagnosis results. What is required is to change from the current status in which when a problem occurs on a facility rapid corrective actions are implemented, to preventive maintenance actions in which the actions are performed before a problem occurs.

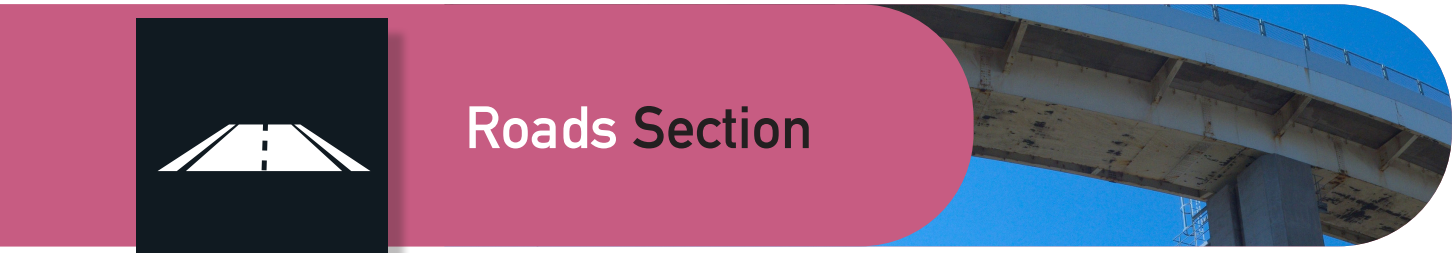
- The public should also understand that temporary restrictions on the use of infrastructure will be placed in order to carry out inspection, diagnosis, and corrective actions.

Development of Effective and Efficient Maintenance Technologies

It is necessary that the cost of maintenance be reduced by preventive maintenance and technical innovation, so that the burden on the public is reduced in the long-term.

- The Japan Society of Civil Engineers should evaluate the technologies that have been developed and propose easy-to-use technical mechanisms and inform the public.

Grade Results of Infrastructures



Roads Section

Roads Section (Bridges, Tunnels and Road Pavements)

Bridges	Tunnels	Road pavements
C ↘	D ↘	C ↘

- In the case of bridges and tunnels, many of the facilities operated by cities, wards, towns, and villages have significant aging, and there are large differences in the degree of integrity among the facilities for each operator.
- Regarding safety for traveling, there are good road pavements, but also damaged pavements that are not receiving appropriate treatments can be seen.
- In the case of maintenance systems, in all cases if they remain as they are the situation is likely to get worse.

Measures to Maintain and Improve Grades

- **The reasons for the maintenance systems trending downwards are insufficient budget and systems for road maintenance by local governments. Central government should provide long-term financial and technical support so that local governments can appropriately implement the maintenance cycle and their maintenance system can be improved.**
- **Road administrators should secure more specialist engineers and budget than before, and formulate plans for cultivating systems within their organization and specialist engineers and long-term plans for bridges, tunnels, and road pavements including long-term budget, disclose these plans, and then execute them. In particular the local government inspection results for pavements have only been disclosed in part, so it is necessary that they be disclosed.**

Bridges

C ↘

Grades according to operator and percentage of repairs completed		National roads	Prefectural and ordinance designated city roads	City, ward, town, and village roads	Urban expressway	National expressway
Grade		B	C	C	B	C
Percentage of repairs completed	Action desirable for preventive maintenance	26 %	2 %	2 %	2 %	
	Action should be taken soon	53 %	24 %	18 %	32 %	
	Action should be taken urgently	100 %	94 %	20 %	-	

- The grade is the same as last year, C (requires attention). Evaluation for each operator is also the same.
- Maintenance systems have been evaluated lowly as "likely to get worse" from the current state of maintenance. There is concern over the low rate of starting repairs, except for central government.
- The degree of integrity of bridges according to operator has been evaluated for each prefecture. It is desirable that each operator is aware of the network maintenance, and maintains the integrity of each of the bridges they manage in a good condition.

Measures to be taken

- **Support from the public for day-to-day maintenance**
- **Understanding of the diversity of bridges, and introduction of maintenance technology in accordance with the circumstances of the facility operators**
- **Improvement in the overall capability of maintenance engineers in order to reduce omission and variation in inspections**

Tunnels

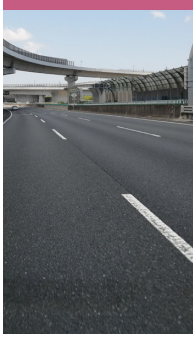
Grades according to operator and percentage of repairs completed		National roads	Prefectural and ordinance designated city roads	City, ward, town, and village roads	Urban expressway	National expressway
Grade		C	D	D	A	C
Percentage of repairs completed	Action desirable for preventive maintenance	29 %	5 %	6 %	4 %	
	Action should be taken soon	64 %	26 %	18 %	72 %	
	Action should be taken urgently	100 %	92 %	85 %	-	

- The grade is the same as last year, D (requires vigilance).
- Maintenance systems continue to be evaluated as "likely to get worse" from the current state of maintenance. There is concern over the low rate of starting repairs, except for central government and expressway companies.
- The degree of integrity of tunnels according to operator has been evaluated for each prefecture. It is desirable that each operator is aware of the network maintenance, and maintains the integrity of each of the tunnels they manage in a good condition, the same as for bridges.

Measures to be taken

- **Planned preventive maintenance should be implemented together with urgent and early actions that should be taken for tunnels**
- **The focus should not be on just the lining surfaces, but also on the ancillary items**
- **The reliability of inspection results should be improved starting from the initial inspection**

Road Pavements



Grades according to operator and percentage of repairs completed		National roads	Prefectural and ordinance designated city roads	City, ward, town, and village roads	Urban expressway	National expressway
Grade		C	C	D	B	B
Percentage of repairs completed	Action desirable for preventive maintenance	19%	16 %	22 %	6 %	7 %

- The grade is the same as last year, C (requires attention). The evaluation for city, ward, town, and village roads with new evaluation areas for each operator was also the same as before.
- Maintenance systems are evaluated as "likely to get worse", the same as previously. Apart from expressways, it is difficult to maintain the current degree of integrity, due to the effect of reduction in budget for pavements, postponing areas for repair and improvement, and the increase in the number of complaints, etc.
- The inspection results for prefectural and ordinance designated city roads, and city, ward, town, and village roads have been disclosed by only some operators, and it is desirable that the inspection results be disclosed.

Measures to be taken

- **Utilization of pavement inspection guidelines and setting appropriate management standards in accordance with the importance of roads**
- **For inspections, visual or measuring instrument methods should be selected as appropriate**
- **Appropriate repair and improvements should be implemented including preventive measures, so that the life of the pavement is extended and the integrity of the subgrade and lower levels is not compromised**

Railways Section

Railways Section (Bridges, Tunnels and Tracks)

Bridges	Tunnels	Tracks
B →	B →	B →

- Overall maintenance is being implemented for bridges and tunnelsÐ and the integrity is generally good.
- The integrity of tracks tends to be low in sections where the traffic density is lowÐ such as local railwaysÐ etc.
- Regarding maintenance systemsÐ although local railway operators are currently implementing maintenanceÐ it is necessary for the system to be further enhanced in the future.

Role of Grading the Railways' Condition and Points to Note

Target of the Railways Section

- The targets among railway facilities are bridges (excluding elevated bridges), tunnels, and tracks.
- 169 railway operators were classified into 3 groups, taking into consideration scale, total length of line, etc., to which was added the Shinkansen. The integrity of facilities was evaluated for each structure for these 4 groups.

Data used in the evaluation: A questionnaire was sent to the 169 railway operators, and the evaluation was based on the replies.

- The integrity of the bridges and tunnels used the survey results for evaluation of soundness into 4 stages, based on the "Maintenance Standards for Railway Structures"
- For tracks, the annual average number of times per km that the maintenance criteria value for track irregularity was exceeded, was used as track irregularities inspected by the railway operators.
- For the maintenance system, the responses to a questionnaire regarding budgets, personnel, and future plans (human resourse cultivation, technical development) for maintenance was used.

Measures to maintain and improve the grades

- In the railway industry, there should be joint implementation to secure human resources and cultivate and train the human resources, and new qualification systems established, across organizational boundaries.
- In the railway industry, technical development should be implemented and horizontally deployed, and unification of specifications for inspection instruments and joint ownership should proceed, across organizational boundaries.
- In the railway industry, promotion of mechanization, ensuring train intervals for work, and levelization of work should proceed for transformation of working practices and improvement of productivity.
- Local railway operators should review their transport service levels in accordance with the maintenance level, with the understanding of local governments, users, etc.
- Central and local governments and major railway operators should enhance their support for local railway operators to ensure continuation of their operation as a business.
- If it is difficult to ensure safe transport on local lines and the business is not viable in spite of the measures of the railway operators to maintain and improve integrity and even with enhanced public support, etc., then local governments, users, etc., in cooperation with the railway operators should discuss the future transport system, such as whether it is necessary to switch the transport mode, etc.

Bridges

B

	Shinkansen	JR East, Central, West Major private railways Public metros	JR Hokkaido, Shikoku, Kyushu Quasi-major private railways Third sector railways	Local private railways Third sector railways Freight railways
Grade and Maintenance system	A	B ↗	B ↗	B ↘

Current grad

- The status is good, whether viewed overall or by operator. However, it is still necessary to continue to determine the status by inspection, analyze and evaluate the results, and perform the necessary repairs, etc.

Maintenance system

- Overall it is considered that if the current management system continues, the current status of integrity can be maintained.
- It is clear that the local railways, etc., are in a severe environment in all aspects such as budgets, insufficient staff, human resource development, and technical development. Therefore there is a possibility that it will not be possible to maintain the status of integrity in the future, and this will be an obstacle to operation of trains.
- It is necessary to enhance the maintenance systems in the future.

Tunnels

B

	Shinkansen	JR East, Central, West Major private railways Public metros	JR Hokkaido, Shikoku, Kyushu Quasi-major private railways Third sector railways	Local private railways Third sector railways Freight railways
Grade and Maintenance system	B	B ↗	B ↗	B ↘

Current grad

- The status is good, whether viewed overall or by operator. However, it is still necessary to continue to determine the status by inspection, analyze and evaluate the results, and perform the necessary repairs, etc.

Maintenance system

- Overall it is considered that if the current management system continues, the current status of integrity can be maintained.
- It is clear that the local railways, etc., are in a severe environment in all aspects such as budgets, insufficient staff, human resource development, and technical development. Therefore there is a possibility that it will not be possible to maintain the status of integrity in the future, and this will be an obstacle to operation of trains.
- It is necessary to enhance the maintenance systems in the future.

Fig. Inspection of a bridge (using an elevated working platform)

Tracks

B

	Shinkansen	JR East, Central, West Major private railways Public metros	JR Hokkaido, Shikoku, Kyushu Quasi-major private railways Third sector railways	Local private railways Third sector railways Freight railways
Grade and Maintenance system	A	B ↗	B ↗	D ↘

Current grad

- Overall the status is good, but local railways, etc., are at the "requires vigilance" level.
- In particular in those lines with low density of transport in the local railways, etc., deformation of the tracks frequently occurs and there is a possibility that they will be unable to implement appropriate maintenance.

Maintenance system

- Overall it is considered that if the current management system continues, the current status of integrity can be maintained.
- It is clear that the local railways, etc., are in a severe environment in all aspects such as budgets, insufficient staff, human resource development, and technical development. Therefore there is a possibility that it will not be possible to maintain the status of integrity in the future, and this will be an obstacle to operation of trains.

Fig. Track realignment using a multiple tie tamper

Ports Section

Ports Section (Mooring Facilities and Protective Facilities for Harbors)

Mooring facilities (quaywalls, jetties, etc.)	Protective facilities for harbors (breakwaters, etc.)
C ➡	C ➡

- The status of integrity of mooring facilities such as quaywalls and jetties and protective facilities for harbors such as breakwaters, etc., in the ports of Japan is that deterioration is progressing in many facilities, and repairs will be necessary soon.
- It is likely that the maintenance systems for port facilities can maintain the current status, but there are some facilities where sufficient maintenance is not able to perform because of restrictions of budget, personnel, etc.

The target facilities of the ports section are

- Typical facilities in ports, namely mooring facilities (quaywalls and jetties, etc.) and protective facilities for harbors (breakwaters, etc.).
- The target was nationally-owned facilities and port management body-owned facilities, and excluded the facilities of private businesses.
- The other types of port facilities such as waterways and basins, etc., can not be sufficiently assessed with the concept of degree of integrity, so they were excluded.

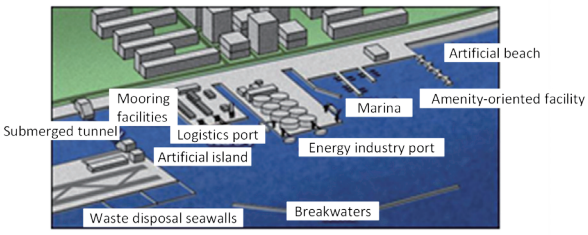


Fig. Port facility
(Japan Dredging and Reclamation Engineering Association)

Measures to maintain and improve the grades

- National and other port management bodies (local bodies such as prefectures, cities, etc.) should perform proper maintenance based on a maintenance plan formulated for each facility. In addition an asset management plan should be formulated for each group of facilities, to promote the optimized maintenance for the port as a whole.
- In the case of facilities where aging has progressed to a serious extent and facilities that are not being used because of changes in loading and unloading formats, etc., the port management bodies should investigate effective use of their existing stock by conversion of use or renewal, so that the port as a whole is revitalized.
- National and other port management bodies should continue their efforts to secure and cultivate human resources and to improve technical capability, both for their own staff and also the staff of private sectors.
- There are ports that have not yet sufficiently developed their infrastructure, and there are some ports that have not progressed with seismic measures. Therefore in the future it is necessary to perform appropriate maintenance in a planned manner, in parallel with proceeding the necessary infrastructure development.

Results of mooring facilities (quaywalls, jetties, etc.)

	National facilities	Facilities owned by port management bodies
Grade and Maintenance system	C ➡	C ➡

Current grade

- There are many facilities in which aging has progressed, and repair will be necessary soon.

Maintenance system

- It is considered that if the current management system is continued, the current integrity status will be maintained.

Note:

- The occurrence of deterioration or damage could lead to a serious accident such as collapse of an apron that would involve users performing loading and unloading, or ordinary users of ferries or cruise ships, etc.
- If the degradation or damage progresses further, not only will the repairs be very costly, but also it will not be possible to use the facility for a long period of time, and this could cause major loss to the local economy.
- In the case of mooring facilities, inspection, diagnosis, and repair are being implemented based on a maintenance plan formulated for each facility. However there are facilities in which it is not possible to carry out sufficient maintenance, due to restrictions of budget, personnel, etc.

Results of protective facilities for harbors(breakwaters, etc.)

	National facilities	Facilities owned by port management bodies
Grade and Maintenance system	C ➡	C ➡

Current grade

- There are many facilities in which aging has progressed, and repair will be necessary soon

Maintenance system

- It is considered that if the current management system is continued, the current integrity status will be maintained

Note:

- The occurrence of deterioration or damage could increase the wave height within the port, cause flooding of the hinterland, and affect not only the safety of users performing loading and unloading and ordinary users of ferries, etc., but also the safety of facilities and people in the hinterland.
- If the degradation or damage progresses further, not only will the repairs be very costly, but also if the breakwater is damaged then it will not be possible to use the mooring facilities behind it, and this could cause a major loss to the local economy.
- In the case of protective facilities for harbors, inspection, diagnosis, and repair are being implemented based on a maintenance plan formulated for each facility. However there are facilities in which it is not possible to carry out sufficient maintenance, due to restrictions of budget, personnel, etc.

Rivers Section

Rivers Section (Levees, River Structures and Dams)

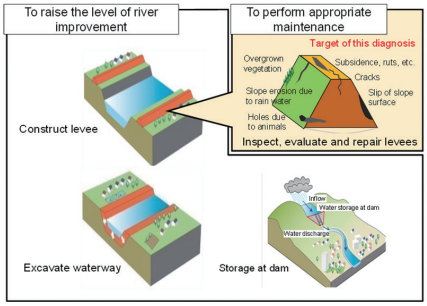
	Grades				Maintenance system
	Overall	By administrator			
Levees	C	Central government		C	↘
		Prefectures, etc.		C	
River structures	D	Central government		C	↘
		Prefectures, etc.		D	
Dams	B	Civil engineering structures	Central government, Japan Water Agency	A	↘
			Prefectures	A	
		Mechanical and electrical equipments	Central government, Japan Water Agency	B	
			Prefectures	B	

Overall evaluation

- It is not possible to be optimistic about the condition of levees and river structures.
- Regarding the condition of dams, Civil engineering structures are sound, but Mechanical and electrical equipments, etc. are unsound because of their aging.
- It is necessary to enhance the budget and personnel for maintenance of river management facilities. In particular it is necessary for prefectures to develop a system that enables to inspect, evaluate, and repair their facilities.

In order to protect the areas from flooding,

- It is necessary to raise the level of river improvement, and to perform appropriate maintenance
- We evaluated the status of the “maintenance” in this diagnosis.



The target facilities of Rivers Section were,

- Levees, river structures (floodgates, sluice gates, and sluice pipes), and dams of River management facilities defined in the River Act
- [Levees and river structures (floodgates, sluice gates, and sluice pipes)] The facilities managed by central government, prefectures and ordinance-designated cities
- [Dams] The facilities managed by central government, prefectures, and Japan Water Agency
  (Power generation dams, water supply dams, agricultural dams, landslide dams, etc., were excluded in the target facilities)

Measures to maintain and improve facilities

- The Japan Society of Civil Engineers should continue to disseminate information regarding the importance of maintenance of river management facilities, and promote understanding of the public for enhancement of budgets and personnel.
- River administrators should formulate and implement inspection and evaluation methods in accordance with the current circumstances of levee management, based on the understanding of the levee characteristics that extend in long distances and with many invisible parts.
- Dam administrators should maintain facilities by securing budget and performing thorough repair based on evaluation by asset management, to keep the functions and benefits of dams as long as possible.
- In rivers managed by prefectures, etc., cooperation between central government, prefectures, etc., and the Japan Society of Civil Engineers should be strengthened to enable the prefectures, etc., to carry out sustainable and appropriate river management. Central government should support the creation of systems and frameworks, and the Japan Society of Civil Engineers should provide technical support and advice. Prefectures, etc., should categorize the management sections in accordance with the properties and importance of rivers, formulate their maintenance plans by themselves, and develop management systems for implementation of these plans.

Results of Levees

	Levees
Grade	C ↘

	Levees managed by central government	Levees managed by prefectures, etc.
Grade	C	C

Current grade

- There are many places where there is damage, cracking, etc., in the bank protection of levees, that it could cause deformation to progress impairing the function of the levee.
- It is desirable to take preventive actions.
- In levees managed by prefectures, etc., it is necessary that the targets of inspection be categorized in accordance with the characteristics and importance of rivers, categories are defined for the methods of performing inspection and evaluation, and inspection and evaluation methods are formulated in accordance with the conditions on site.

Maintenance system

- Maintenance systems are being institutionalized in which inspection is performed at least once per year, and maintenance plans are being formulated, etc.
- There are concerns over insufficient budgets and personnel for maintenance. It is becoming difficult to succeed knowledge and experience.

Fig. Erosion on the slope of a levee

Results of River Structures (floodgates, sluice gates, and sluice pipes)

	River structures
Grade	D ↘

	River structures managed by central government	River structures managed by prefectures, etc.
Grade	C	D

Current grade

- There are many places where there is cracking or steps in box units, etc., and there is concern that if this damage progresses it could impair the functions of the structures.
- It is desirable to take preventive actions early.
- In river structures managed by prefectures, etc., classification of the degree of deformation and grasp the state is insufficient. It is necessary that the targets of inspection be categorized in accordance with the characteristics and importance of rivers, the rules of performing inspection and evaluation be defined by the categories, and the inspection and evaluation methods be formulated in accordance with the conditions on site, just as for levees.

Maintenance system

- Maintenance systems are being institutionalized in which inspection is performed at least once per year, and maintenance plans are being formulated, etc.
- In addition there are concerns over insufficient budgets and personnel for maintenance, under aging in progress.

Fig. Crack in a sluice pipe

Results of Dams

	Dams
Grade	B ↘

Grade	Dams managed by central government and Japan Water Agency	Dams managed by prefectures
Civil engineering structures	A	A
Mechanical and electrical equipments	B	B

Current grade

- The status of Civil engineering structures in dams is sound.
- The status of Mechanical and electrical equipments are good overall, but it is necessary to perform maintenance, repair, and renewal depending on the equipments age.

Maintenance system

- Daily managements, periodic inspections (every 3 years), and comprehensive dam inspections (every 30 years) are institutionalized. Systems for maintenance have been developed.
- It is necessary to integrate a wide range of technologies. The number of engineers with extensive experience is becoming fewer. It is necessary to strengthen the management system for skill succession, budgetary aspects and personnel aspects.

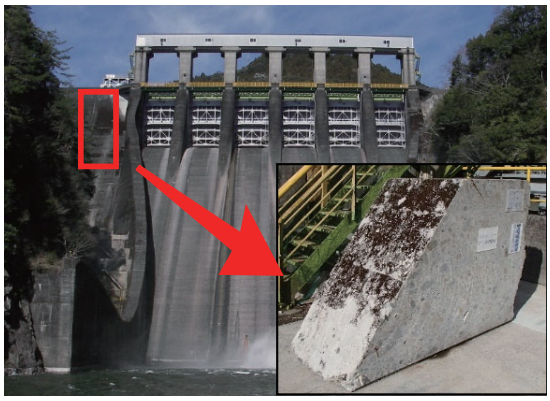


Fig. Concrete block from a dam excavated during dam re-development (sound even though more than 50 years had passed)

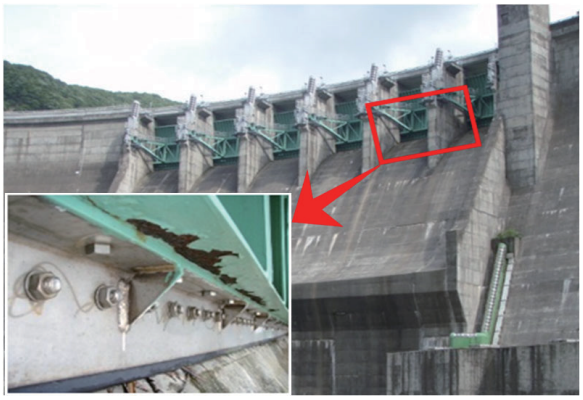


Fig. Corrosion in an emergency spillway (crest gate)

Waterworks Section

Waterworks Section (Pipelines)

	Size of water supply population	600,000 or more	100,000 or more	30,000 or more	10,000 or more	Less than 10,000
Pipes C →	Grade	C	C	C	D	D
	Maintenance system	→	→	↘	↘	↘

Note:

- The grade was the same as last year C (requires attention). For populations 10,000 or more the evaluation dropped from C to D.
- Evaluation of maintenance systems has changed from "Likely to get worse" to "Current status likely to be maintained", reflecting the fact that index values at small utilities are tending to improve. However, there has been no change compared with last year regarding the result by the size of water supply population.

Measures to Maintain and Improve Grade

- The central government should provide technical and financial support for water utilities.
- Local municipalities should promote wide area cooperation, in order to strengthen the basis of the water supply utilities.
- Water supply utilities should make efforts to secure human and financial resources.
- Research institutions should investigate development of technologies that can be carried out more efficiently.
- Academic and industrial associations, and educational institutions should continue to undertake human resource cultivation and technical capability improvement.

Sewage Works Section

Sewage Works Section (Pipelines)

	Size of population	23 wards of Metropolitan Tokyo Ordinance-designated cities	300,000 or more	100,000 or more	50,000 or more	Less than 50,000
Pipes B ↘	Grade	C	B	B	A	A

- Regarding grades, overall the evaluation is B (good). However, in the major cities it is C (requires attention).
- Regarding maintenance systems, the length inspected and the number of technical staff per total length have decreased in Japan as a whole. In particular, there is concern that the percentage reduction is significant in the medium and small municipalities, so the evaluation remains "likely to get worse".

Measures to Maintain and Improve Grade

- Central government should investigate measures to promote wide area cooperation, and to secure budgets, such as public-private partnerships, together with sewage works utilities.
- Utilities should expand their asset management initiatives.
- Research institutes and private companies should carry out research and development to improve the efficiency of pipe maintenance and renewal.
- Academic and industrial associations, and educational institutions should continue to undertake human resource cultivation and technical capability improvement.
- Users should take care to use the facilities properly, such as by not discharging oil, etc.

Roads Section

Roads Section-Bridges

Current Status of Facilities

- There are about 720,000 road bridges in Japan
- The percentage of facilities that have been constructed more than 50 years ago was 27% in March 2019, and will be 52% in March 2029, so the percentage is increasing rapidly
- The administrators of road bridges include the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the expressway companies, prefectures and ordinance designated cities, etc., and cities, wards, towns, and villages. Cities, wards, towns, and villages account for 66%, and prefectures and ordinance designated cities, etc., account for 26%, so together these local public bodies manage more than 90% of the total number of road bridges.

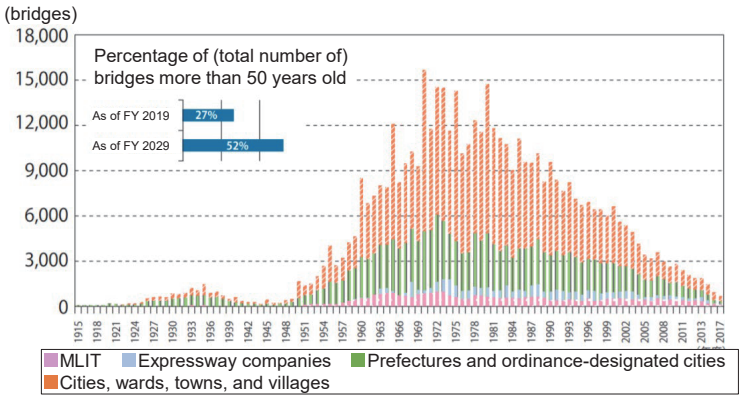


Fig. Number of bridges according to year of construction (from 2020 MLIT White Paper)

Overview of Periodic Inspection

- In accordance with the amendment of the Road Act of 2013, from 2014 close visual inspection must be carried out at a frequency of once in five years (technologies that supplement, replace, or enhance close visual inspection can also be utilized)

Fig. Close visual inspection of a bridge (bridge inspection vehicle, elevated working vehicle, construction scaffold)

Table. Categories of Integrity Diagnosis

Category		Condition
I	Sound	There is no impairment to the function of the structure
II	Preventive action stage	There is no impairment to the function of the structure, but it is desirable that action be taken from the point of view of preventive maintenance
III	Action required soon stage	There is a possibility of impairment of the function of the structure, so action should be taken soon
IV	Urgent action stage	There is impairment of the function of the structure, or there is a high possibility that this will occur, so action should be taken urgently

Exposure of deck slab reinforcement
*Deck slab: underside of the bridge

Scouring of bridge pier

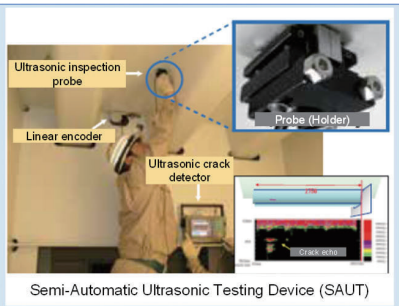
Fig. Examples of judgment categories III and IV in damaged locations

- Inspection must be performed by a person with knowledge and skill, and the diagnosis of integrity is categorized in four levels.
- The (recommended) qualification for inspection engineers is a qualification requiring a certain level of technical capability, operated by private sector organizations, etc., registered as a "Ministry of Land, Infrastructure, Transport and Tourism Registered Qualification"
- Road administrators maintain a certain level of quality of inspection, diagnosis, and maintenance, by using those with nationally registered qualifications

Inspection and Diagnosis Technologies (more efficient inspection and more advanced diagnosis using new technologies)

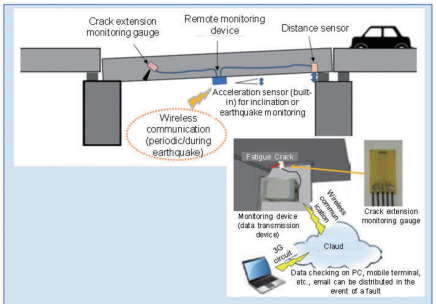
(From "Inspection Support Perfomance Catalog")

Image measurement technology
This is a technology to improve the efficiency of inspection by utilizing drones, etc., as an alternative method to close visual inspection



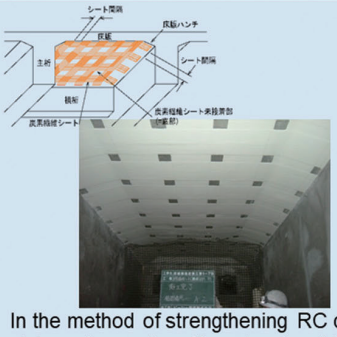
Semi-Automatic Ultrasonic Testing Device (SAUT)

Nondestructive testing technology
This is a technology for detecting fatigue cracks inside steel members (steel deck slab U-rib welds) that cannot be checked by close visual inspection

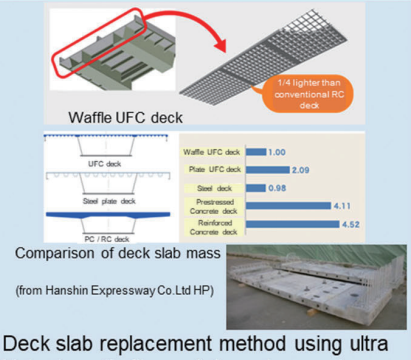


Measurement and monitoring technology
This is a technology for remote monitoring of measurement data from various sensors installed on the bridge in order to determine the condition

Repair and strengthening technology (improvement of constructability and durability by utilizing new materials and new methods)

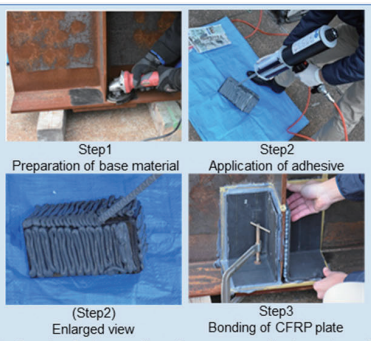


In the method of strengthening RC deck slabs using carbon fiber sheets, which are light and have excellent strength, during inspection of the deck slab, it is bonded in a lattice manner so that the underside of the deck slab can be seen



Comparison of deck slab mass
(from Hanshin Expressway Co.Ltd HP)

Deck slab replacement method using ultra high-strength fiber-reinforced concrete (UFC) deck slabs, which are lighter than conventional RC or PC deck slabs and have greater durability



Method of strengthening corroded parts of steel members by bonding CFRP plate, which has superior constructability than strengthening using conventional steel plate backing plates

Roads Section-Tunnels

Current Status of Facilities

- There are about 11,000 road tunnels in Japan
- The percentage of tunnels that were more than 50 years old was about 20% in March 2019, and for tunnels of total length less than 100 m, which are mainly in cities, towns, and villages, the percentage had already exceeded 50%.
- The administrators of road bridges include the Ministry of Land, Infrastructure, Transport and Tourism, the expressway companies, prefectures and ordinance designated cities, etc., and cities, wards, towns, and villages. Prefectures, ordinance designated cities, cities, towns, and villages manage about 70% of the tunnels

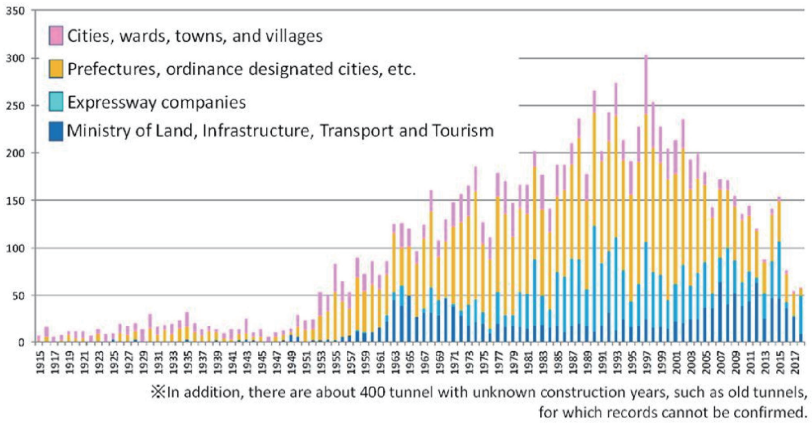


Fig. Number of tunnels of each administrator according to year of construction (2018 Road Maintenance Yearbook)

Overview of Periodic Inspection

- In accordance with the amendment to the Road Act of 2013, from 2014 close visual inspection must be carried out at a frequency of once in five years (technologies that supplement, replace, or enhance close visual inspection can also be utilized)
- Besides deformation of the tunnel main structure, attention is also focused on the hazards of ancillary items such as lighting, etc., or their connection members falling
- During inspection, emergency measures are taken, such as knocking off fragments of lining concrete if there is concern that it could fall off
- Inspection is carried out by personnel with proper qualification or experience in road tunnels
- Diagnosis of integrity in inspection is carried out in 4 categories
- Integrity is categorized by external forces, material degradation, and changes in water leakage, diagnosed by reference to guidelines for the occurrence of cracking, separation, and spalling.

Table. Categories of Integrity Diagnosis

Category		Condition
I	Sound	There is no impairment to the function of the structure
II	Preventive action stage	There is no impairment to the function of the structure, but it is desirable that action be taken from the point of view of preventive maintenance
III	Action required soon stage	There is a possibility of impairment of the function of the structure, so action should be taken soon
IV	Urgent action stage	There is impairment of the function of the structure, or there is a high possibility that this will occur, so action should be taken urgently

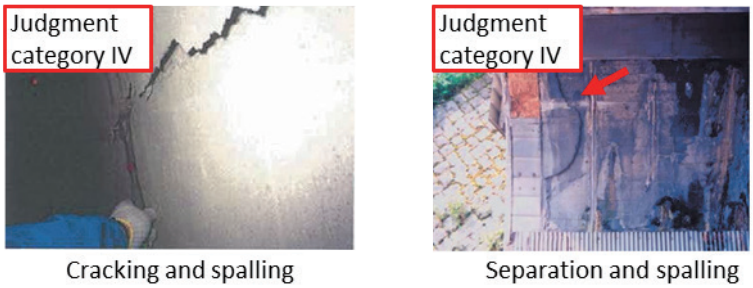
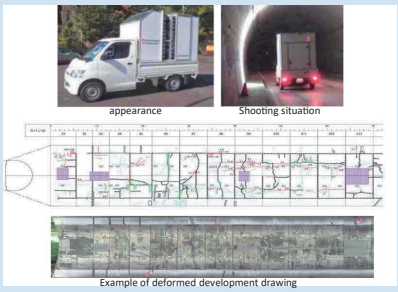


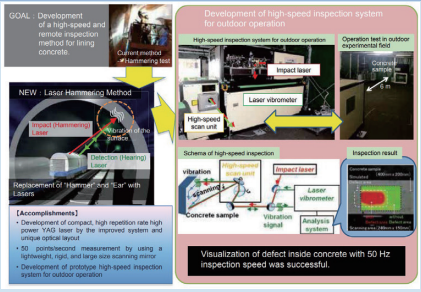
Fig. Examples of judgment category IV in damaged locations

Inspection and Diagnosis Technologies
(more efficient inspection and more advanced diagnosis using new technologies)



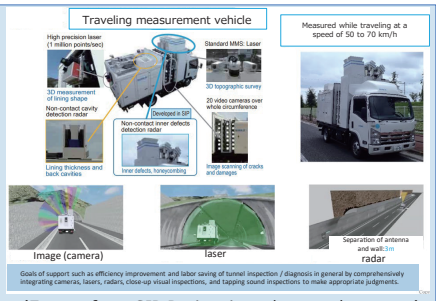
(Extract from inspection support performance catalog)

Traveling measurement technology
(image measurement)
This is technology to improve the efficiency of inspection utilizing an image-taking system mounted on a vehicle, as technology to support close visual inspection



(Extract from SIP Project introductory document)

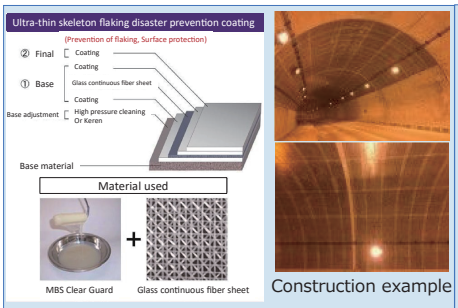
Laser percussion inspection
This is technology to determine the internal structure of the tunnel walls by laser percussion, to detect separation, spalling, etc.



(Extract from SIP Project introductory document)

Traveling measurement technology (image, laser, radar)
This is a technology to increase the efficiency of inspection by measurement of cracking, deformation, separation, and cavities in the rear while traveling at high-speed

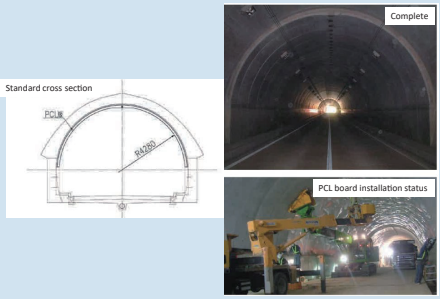
Repair and strengthening technology
(improvement of constructability and durability by utilizing new materials and new methods)



(Extract from NETIS)

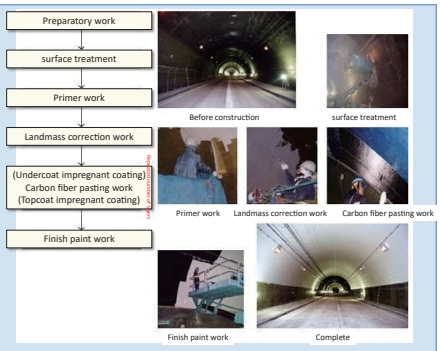
Construction example

Measure to prevent concrete fragments from falling by bonding sheets
(repair construction)



(Extract from PCL Association)

Repair method by wrapping the interior of a tunnel with circular arc-shaped precast concrete slabs divided into small units

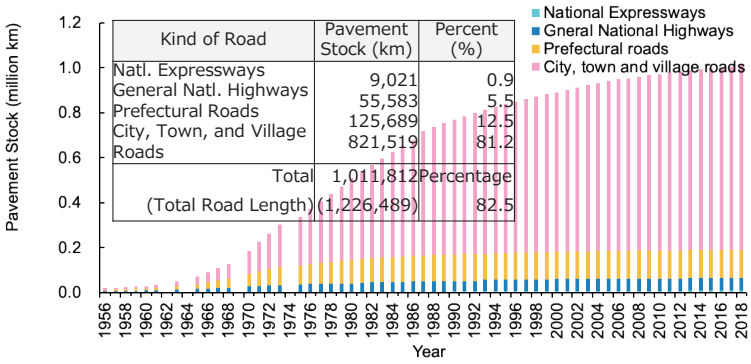


Strengthening the interior surface of a tunnel by applying carbon fiber sheet to the surface of lining concrete

Roads Section-Pavements

Current Status of Facilities

- The total length of roads in Japan as of the end of March 2019 was about 1.2 million km
- The total length of paved roads including pavements for light traffic is about 1 million km (percentage of paved roads is 82.5%)
- More than 90% of the total length is managed by local administrators



Kind of Road	Pavement Stock (km)	Percent (%)
Natl. Expressways	9,021	0.9
General Natl. Highways	55,583	5.5
Prefectural Roads	125,689	12.5
City, Town, and Village Roads	821,519	81.2
Total	1,011,812	Percentage
(Total Road Length)	(1,226,489)	82.5

Fig. Total length of paved road including pavements for light traffic (Source: the Annual Report of Road Statistics 2020)

Pavement Inspection Guidelines

The "Pavement Inspection Guidelines", which describes the basic concept of pavement inspection, was issued by the Roads Bureau of the Ministry of Land, Infrastructure, Transport and Tourism in October 2016, with the objective of achieving efficient maintenance and rehabilitation for life extension of pavements by preventing base course damage.

Table. Diagnosis levels in the Pavement Inspection Guidelines

Diagnosis level			Severity
I	Good		Low
II	Maintenance stage of surface layer function (for flexible pavements)"		Moderate
	Maintenance stage (for rigid pavements)		
III	Rehabilitation stage		High
		III-1 (for flexible pavements)	The service life of a surface layer will exceed the design period. Base course is assumed to be stable.
		III-2 (for flexible pavements)	The service life of a surface layer will fall below than the design life. Base course is assumed to be deteriorated.

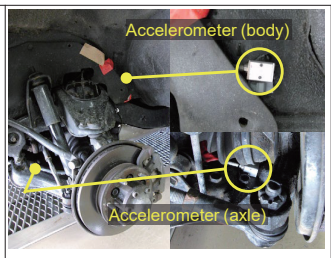
Road Categories and Inspection Viewpoints

Table. Viewpoints of inspection and diagnosis in accordance with road category

Category	Major category	Minor category	Viewpoint of inspection and diagnosis
A	High traffic volume roads (Rapidly deteriorate with high volume traffic)	e.g. High standard national highways	Paved roads in this category are required to serve a high-level of service such as high-speed traveling. Pavement inspection and diagnosis must be implemented by use of a surface characteristics survey vehicle due to the difficulties of visual inspection.
B			Pavement inspection must be implemented more than once every 5 years with arbitrary inspection methods. For flexible pavements, the diagnosis is basically performed on the basis of the criterion in terms of the crack ratio, rut depth, and IRI of which thresholds are decided by an administrator in accordance with the designed service life. For rigid pavements, the diagnosis is based on the condition of joints and the severity of crack in a slab.
C	Low traffic volume roads (Slowly deteriorate with low volume traffic)		Pavement inspection must be planned appropriately, but no frequency is specified. For flexible pavements, the diagnosis is performed on the basis of a specific index or the combination of indices in accordance with pavement distress characteristics. For rigid pavements, the diagnosis is based on the condition of joints and the severity of crack in a slab.
D		e.g. Residential roads	Pavement surface management can be relied on the outcomes of road patrol for daily inspection. The inspection and diagnosis following the Pavement Inspection Guidelines is not mandatory.

Inspection Technologies

Various pavement inspection devices have been developed depending on the application with the development of sensing technologies in recent years.

			
Surface characteristics survey vehicle: It enables three typical surface characteristics (cracking, rutting, and longitudinal roughness) to be obtained simultaneously	**Response type road roughness measuring system:** It enables roughness of a road surface to be measured using accelerometers mounted on a general passenger vehicle	**Inspection system using mobile devices:** It enables brief road surface inspection using a motion sensor built into the device or camera images	**Inspection device using image processing technologies**: It enables crack detection in a road surface to be detected on the basis of AI technologies from video images

Overview of Treatment

- In the maintenance stages for short to medium term, sealant injection in cracking and/or overlay on rutting should be executed to prevent inundation into under surface layers.
- In the rehabilitation stages for medium to long term, surface and/or binder course should be replaced mainly by applying mill and overlay.
- In the sections with early-aged deterioration categorized into the diagnosis level of III, a rehabilitation plan considering base course replacement must be developed by detailed survey.

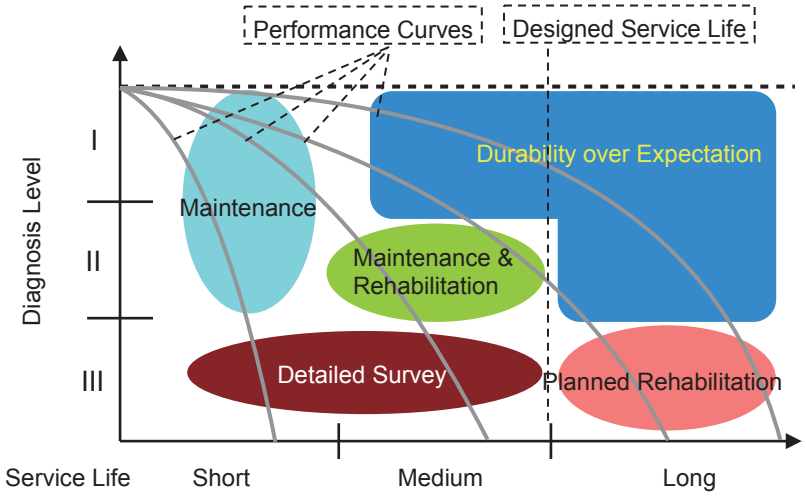


Fig. Optimization of treatment against service life and diagnosis level for road category B

Railways Section

Current Status of Facilities

Since opening of the first railway between Shimbashi and Yokohama in 1872, the framework for many routes had been completed World War II. Then, throughout the period of postwar reconstruction and the era of high economic growth, etc., transport between cities and commuting transport was strengthened, and development of the Shinkansen progressed. As a result, from the early stages standards of inspection, etc., were defined, organizations and rules were instituted and modified, and maintenance was conducted systematically in accordance with the facility in each age.

It is difficult to provide alternative transport to railways, so maintenance construction work is mainly carried out at night time in the short period of time when the trains are not running. In particular, in the case of civil engineer structures such as bridges and tunnels, due to the conditions such as working environments, working hours, the cost and time for replacement of the structures and replacement of their large-scale members is greater than for new construction. Therefore, the basic concept of maintenance of these facilities is early detection of defects by inspection, and early repair in order to ensure life extension. The average age of civil engineering structures is more than 60 years, which is higher than for other infrastructure, and many structures are more than 120 years old. On the other hand, the track facilities include rails, sleepers, and ballast, and deterioration such as track irregularity and wear of track proceeds in accordance with train travel, so the structures have been designed on the assumption of repair or replacement at a certain frequency, and they have been maintained using various inspection periods and repairmen and replacement criteria which are defined for each constituent material.

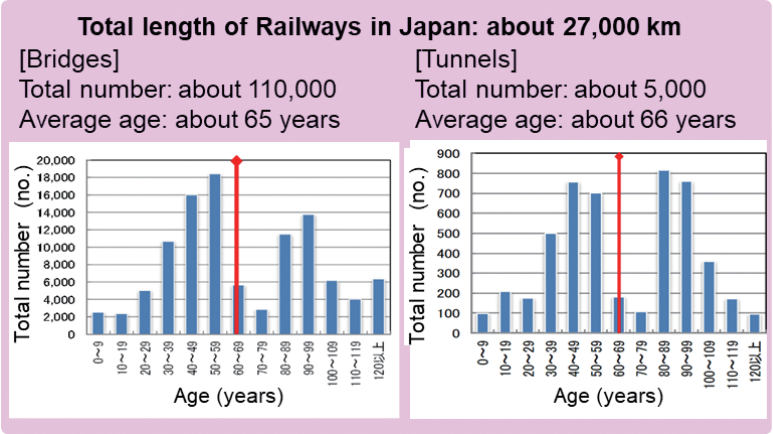


Fig. Age distribution of railway bridges and tunnels
(From Infrastructure Maintenance (Railways) Special Committee Report, June 2020 [Japan Society of Civil Engineers])

Overview of Periodic Inspection

At present the standards regarding inspection of railway facilities are prescribed in the "Technical Regulatory Standards on Japanese Railways", based on the Railway Operation Act.

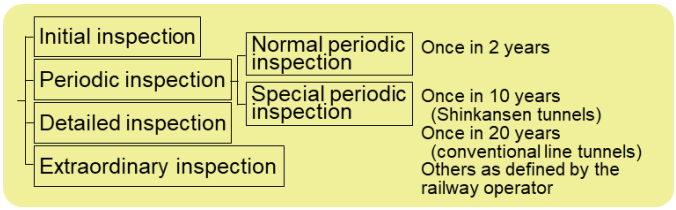


Fig. Categories of railway structure inspections

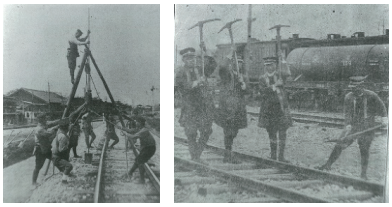
Table. Standard Soundness of railway structures and relationship to degree of deformation, etc.
(From Standards of Maintenance of Railway Structures and Commentary (Structures))

Soundness		Effect on operation safety and safety of passengers and the public	Extent of defect	Action, etc.
A	AA	Threat	Serious	Urgent action
	A1	An eventual threat Threat when an external force acts in an abnormal situation	There is defect that is progressing, reduction of performance is also progressing	Action to be taken soon
	A2	Future threat	There is defect, etc., that could cause reduction of performance	Action at the necessary time
B		Will become integrity A if it progresses	Will become soundness A if it progresses	Actions such as monitoring, as necessary
C		At present no effect	Slight	At the next inspection. inspect the details as necessary
S		No effect	None	None

Inspection, Diagnosis, and Repair Technologies (Mechanization, Systematization)

Inspection of track facilities and civil engineering structures is mainly carried out visually by engineers, but with the progress in ICT this is being made systematic in various ways and the introduction of instruments is progressing. Also, maintenance work is becoming mechanized in response to changes in working patterns and in preparation for insufficient labor in the future.

In addition, in the case of track facilities, the structures are becoming more resistance to deterioration with the replacement of timber sleepers with concrete sleepers and the introduction of continuous welded rails with fewer joints. The industry is working to reduce the future labor requirements for maintenance and reduce the lifecycle costs.

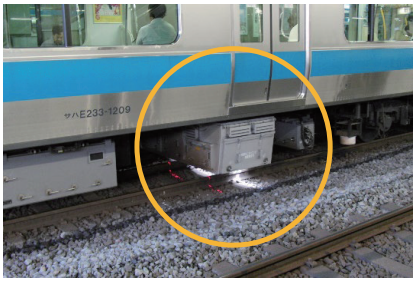


Track maintenance in the past

Multiple inspection train for inspection of Shinkansen tracks and electrical equipment (Doctor Yellow)

Tunnel inspection vehicle using laser light (vehicle taking images of the surface of tunnel linings)

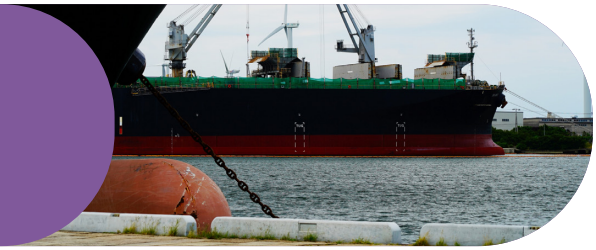
Mechanical vehicle correcting track irregularity (Multiple tie tamper)



Monitoring at high frequency using operating trains

Vehicle checking for obstacles around tracks using laser light (structure gauge measurement vehicle)

Mechanization of Shinkansen lcontinuous welded rail replacement

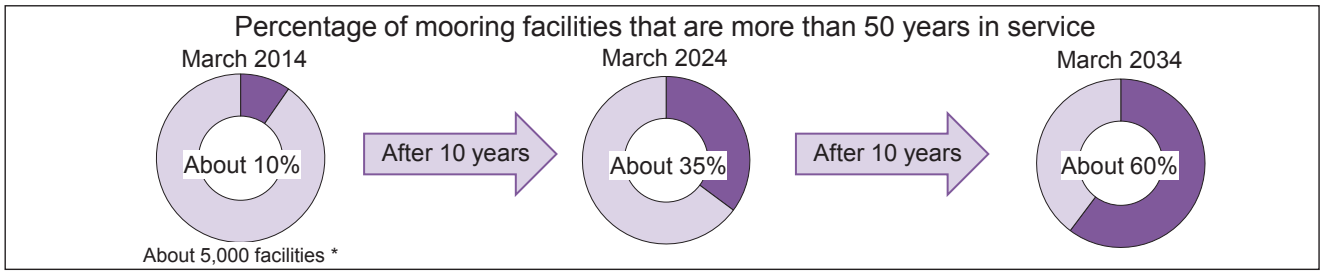


Ports Section

Ports Section

Current Status of Facilities

- There is a total of 993 ports in Japan. Of these, large-scale ports include strategic international hub ports (5 No.), international hub ports (18 No.), and major ports (102 No.).
- From the point of view of international competitiveness of ports, there is still insufficient large water depth mooring facilities, and it is necessary that development proceeds in accordance with the increase in size of shipping in the future.
- On the other hand, there are many facilities that are aging, and facilities for which seismic countermeasures have not progressed.
- About 14,300 mooring facilities have been developed in the ports of Japan, with a breakdown according to ownership of nationally-owned facilities about 1,900, and port management bodies-owned facilities about 12,400.
- The percentage of mooring facilities more than 50 years old was about 10% in March 2014, and this is expected to increase rapidly to about 60% in March 2034.
- At present about 21,600 protective facilities for harbors have been constructed in Japan's ports, with a breakdown according to ownership of nationally-owned facilities about 1,700, and port management bodies-owned facilities about 19,900.
- Note that besides ports, there are fishing ports throughout Japan, and their number is 2,806.



* Number of mooring facilities in strategic international hub ports, international hub ports, major ports, and regional ports (water depth 4.5 m or more): From Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Fig. Aging of port facilities

Overview of periodic inspection

- Port facilities are subjected to severe environments from the actions of high waves, strong winds as well as saltwater, so aging and accidental damage can easily occur.
- Most of the facilities are submerged in the sea, so it is not possible to easily determine the state of degradation and damage.
- Therefore, for each facility a maintenance plan is formulated, and inspection, diagnosis, and repair is implemented based on this plan.

Table. Inspection frequency based on Inspection and Diagnosis Guidelines for Port Facilities

Category of facility	Prioritized inspection-and-diagnosis facility	Ordinary inspection-and-diagnosis facility
Importance of the facility	Facilities that could have a major effect on human life, property, or socioeconomic activity	Facilities other than those listed on the left-hand side
Daily inspection	The port operator sets the appropriate cycle	
General periodic inspection and diagnosis	At least once in 3 years	At least once in 5 years
Detailed periodic inspection and diagnosis	At least once 10 to 15 years	At least once during the design service life When extending the design service life

Latest Inspection and Diagnosis Technology

Much of the work associated with inspection and diagnosis of port facilities is on or in the sea, and there are also facilities that people cannot approach, so there is a great demand for labor saving and fully automated work.

Three-dimensional shape measurement using a green laser mounted on a UAV

- **This is a technology for three-dimensional survey by a UAV with green laser equipment, in order to efficiently and safely determine the status of the parts of a facility on land and in water**
- **Data can be acquired over a wide range at once for the shapes of structures and their elevations on land and in water**
- **Also, measurement can be performed in a short period of time, work underwater is not necessary, and it is possible to avoid entering into hazardous areas, so in addition to improving the efficiency of the work, the safety of the work is also secured.**

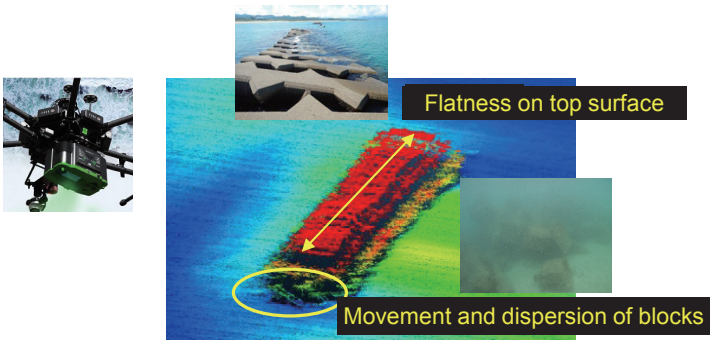
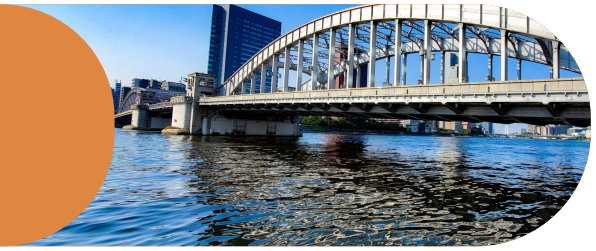


Fig. Example of shape measurement (detached breakwater)



Rivers Section

Present status, roles, and characteristics of river management facilities

- River management facilities are basic infrastructure to prevent damage due to flooding, as well as to increase public benefits received from rivers.
- Rivers, as public entities, are changed by natural processes such as floods, etc., and human daily activities, so these affect various changes in river management facilities.
- [Levees] The total length of levees managed by central government, prefectures, etc., is about 62,000 km, of which about 20% is managed by central government, and about 80% is managed by prefectures. Levees are extremely long continuum structures, and the collapsion at even one point during a flood loses their control function over the whole area.
- [River structures] Floodgates, sluice gates, and sluice pipes are equipped across levees. They are fundamental river control facilities, which are fully closed to prevent backflow of the flood water during flooding. There are about 28,000 facilities in Japan (of which there are about 1000 floodgates, and about 27,000 sluice gates), of which about 32% are managed by central government and about 68% are managed by prefectures, etc. Most of the facilities were constructed up to about 1985, so they will be more deteriorated in the future.
- [Dams] Dams are fundamental social assets with various purposes such as controlling floods, maintaining the proper function of running water, replenishing irrigation water, and generating hydroelectric power, etc. There are about 580 dams as river management facilities in Japan. A high level of safety is required as a result of the importance of dams, but at the same time their comprehensive renewal is difficult.

Fig. Floodgate during a flood

Fig. **Levee during a flood**

Fig. Dam

Fig. Inspection sluice pipe

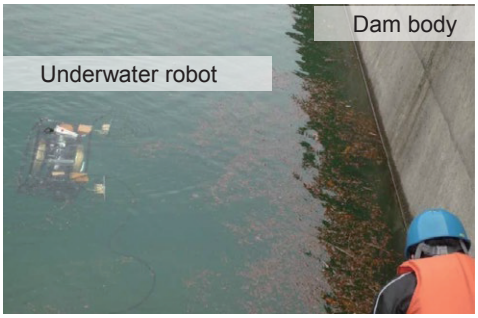
Overview of the inspection and evaluation of river management facilities

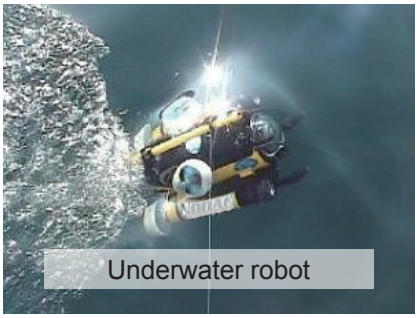
- [Levees] Levees are made from soil in principle. The materials forming the levees are non-uniform after they have been constructed and modified many times throughout the past. In addition, there are constructed in floodplains having a complex geological structure. No two have the same structure, so their safety is checked based upon many years of experience, etc.
- [River structures (floodgates, sluice gates, sluice pipes)] The material of these structures is different from that of the levees, which are made of soil, so it is important to inspect the changes such as leakage along the boundary surfaces, ground level up at the facilities on weak foundations, cavitation, etc.
- [Dams] It is necessary to maintain over a long period of time the function and the safety of dams, as fundamental structure, by performing maintenance effectively and efficiently, and utilizing the long-lived properties of dam bodies.
- Inspection and evaluation of levees, and river structures (floodgates, sluice gates, and sluice pipes) must be carried out at least once a year by visual inspection in accordance with "Guidelines for Inspection and Evaluation of River Control Facilities such as Levees, Etc., and Waterways".
- Inspection and evaluation of dams includes daily inspection, visual inspection at least once a year, as well as periodic inspectin by a person other than the dam administrator at least once every 3 years.

New technology for improving inspection and evaluation

- It is necessary to perform facility inspection more safely, effectively, and efficiently as the inspection is expected to increase as dams and other facilities age.
- Robots, etc., are being introduced for underwater maintenance in places where inspection has been performed in the past by divers.

* Manual for Utilization of Robots in Underwater Inspection, February 2019 (Draft) Preparation of "Dam Body" edition and "Dam Spillway" edition





Waterworks Section

Waterworks Section

Present status of facilities

About 680,000 km of pipeline has been installed in the national land of Japan (as of 2016), of which about 15% has exceeded its statutory service life. On the other hand the rate of pipeline replacement is low at 0.75%, and in recent years that percentage is reducing. Therefore, by a simple calculation it will take 130 years or more to renew all the pipelines, so it is likely that the percentage of pipelines that exceed their statutory service life (40 years) will further increase. Of the total, about 630,000 km is water distribution pipe for distributing water to users, which is subject to diagnosis.

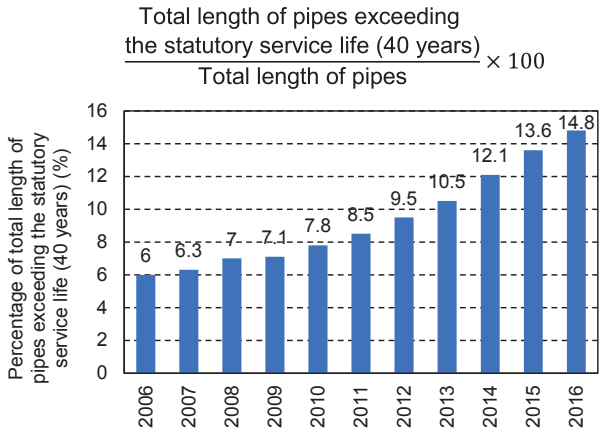
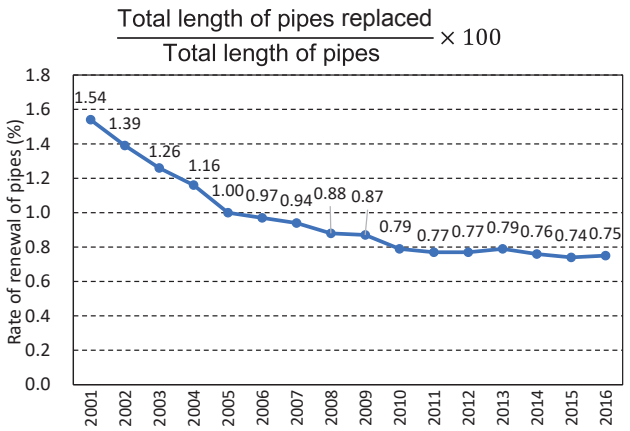


Fig. Aging of pipes



Source: Statistics on water supply

Fig. Rate of pipeline replacement

Overview of periodic inspection

With the amendment of the Water Supply Act, there is an obligation to perform inspection, maintenance, and repair of facilities, and guidelines have been formulated for daily inspections and periodic inspections.

Maintenance of water supply facilities is based on preventive maintenance, but almost all the water supply pipes are buried underground, and water is always flowing in a full state, so inspection of the inside and outside of the pipes is difficult.

Therefore, in addition to water leakage surveys, information is collected through surveys of the buried environment, such as surveys of the condition of the road surfaces, etc. Repair and strengthening is performed by renewal of pipes based on the concept of time-planned maintenance, taking into consideration the material of the pipes.

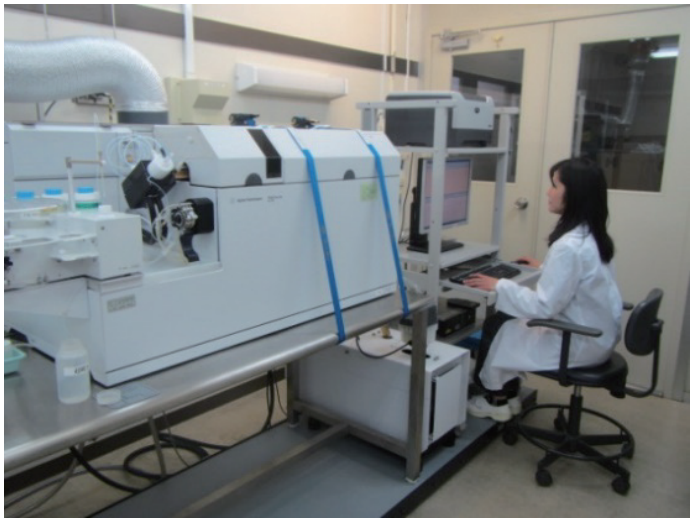
Provided by : Tokyo Metropolitan Government Bureau of Waterworks

Inspection and diagnosis technologies Maintenance using water leakage surveys

It is anticipated that the integrity of pipes worsens as the number of years since installation increases. In particular, there is a possibility of water leakage from pipes that have exceeded their statutory service life. Checks for water leakage are carried out at night time when the noise levels are low, using water leak detectors to listen to the road surface.

Periodic water quality monitoring

As pipes age, there is concern about the impact on water quality such as turbidity, etc. Periodically precise surveys are conducted using instruments such as the ICP-MS shown in the photo, for the water quality standards up to 51 items, to ensure the safety of the water.



Provided by : Tokyo Metropolitan Government Bureau of Waterworks

Repair and strengthening technologies: Seismic resistant pipes with flexibility

Seismic resistant ductile cast-iron pipes have joints that expand, contract, deflect, and have a pullout prevention function. Therefore, when suspended they bend as shown in the photograph. In this way seismic resistance is provided, which also contributes towards prevention of water leakage.

In addition, various types of water leakage survey technology and technology for utilizing water leakage history information are utilized.

Provided by: Japan Ductile Iron Pipe Association

Sewage Works Section

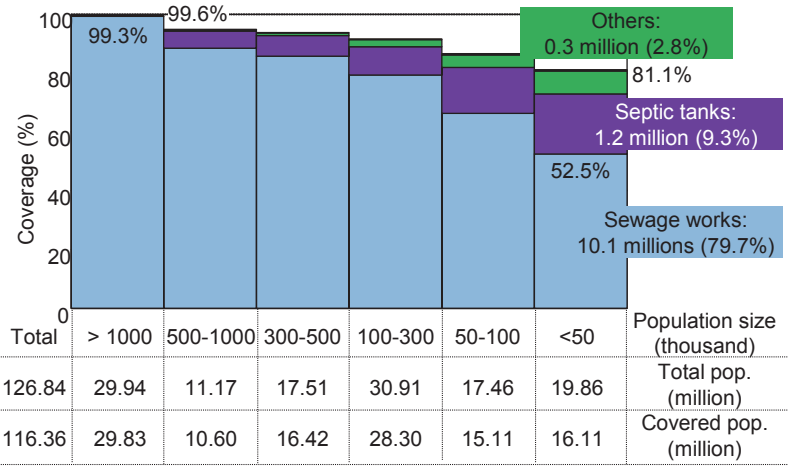
Present status of facilities

The coverage of wastewater management facilities, such as sewage works, wastewater treatment facilities in agricultural village, and septic tanks in Japan is about 91.7%. The percentage is as high as 99.6% in cities of population 1 million or more, and as low as 81.1% in local municipalities with a population of less than 50,000.

The coverage of sewage works is 79.7%, with 99.3% in cities of population 1 million or more, and 52.5% in local municipalities of population less than 50,000, so there is a large population using the other wastewater management facilities in local municipalities.

Note that in the case of areas where wastewater treatment has not spread, each prefecture is reviewing its development plans of wastewater management facilities, taking into consideration the changes in the local circumstances such as population reduction, based on the "Manual for Developing Prefectural Plan for Sustainable Wastewater Management Systems".

About 480,000 km of sewage pipes have been laid throughout Japan (as of 2018), and the length has increased by about 14% in the 10 years since 2008. About 4% has exceeded the standard service life of 50 years as of 2018, but this is expected to increase rapidly after 10 years to about 14%, and after 20 years to about 33%.



Total	> 1000	500-1000	300-500	100-300	50-100	<50	Population size (thousand)
126.84	29.94	11.17	17.51	30.91	17.46	19.86	Total pop. (million)
116.36	29.83	10.60	16.42	28.30	15.11	16.11	Covered pop. (million)

Fig. Percentage of population served with wastewater management at the end of FY 2019 (from survey by the Ministry of the Environment, Ministry of Land, Infrastructure, Transport, and Tourism, and the Ministry of Agriculture, Forestry and Fisheries)

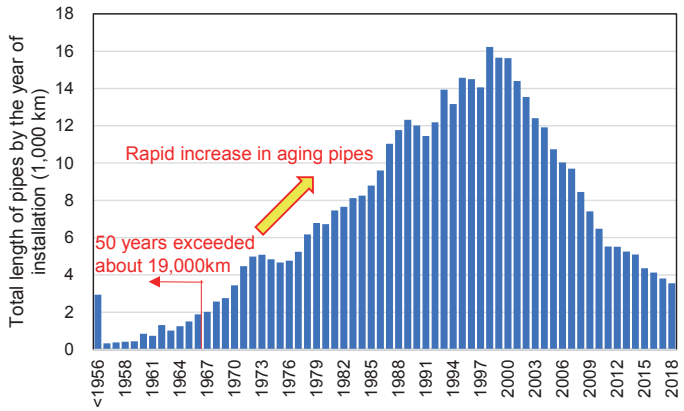


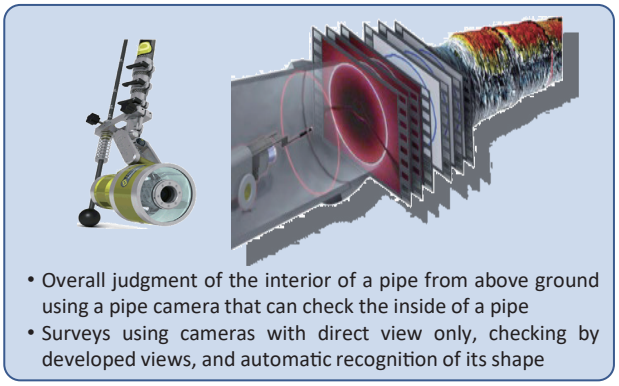
Fig. Total length of pipes as of end FY 2018 (prepared from Ministry of Land, Infrastructure, Transport and tourism document)

Overview of periodic inspection

In 2015 the maintenance and repair standards were established (amendment of the Sewerage Service Act). There is an obligation to perform inspection at the frequency of at least once every five years in locations where the possibility of corrosion is high, and the results and scheduled measures are published as "Sewage Pipes Maintenance Yearbook". In addition, stock management (SM) is promoted based on "Guidelines for Implementation of Stock Management in the Sewage Works" (2015). The following are implemented: (i) acceleration of 13 initiatives such as study groups, self-diagnosis by SM reports, etc., (ii) development of database for maintenance information and standardization of a maintenance cycle utilizing SM plan formulation for efficient repair and replacement, (iii) publication of inspection results and corrective actions.

Repair and strengthening technologies

Various technologies have been developed in order to reduce the effect on the livelihood of the residents and the repair and replacement cost.



- Overall judgment of the interior of a pipe from above ground using a pipe camera that can check the inside of a pipe
- Surveys using cameras with direct view only, checking by developed views, and automatic recognition of its shape

Fig. Pipeline inspection system using wide-angle camera
(documents provided by the Ministry of Land, Infrastructure, Transport and Tourism)

Inspection and diagnosis technologies

From 2011, the national government has supported for technical verification and development of guidelines for innovative technologies at actual scale facilities. There has been success in establishing guidelines for various new technologies such as pipeline inspection and diagnosis, etc.

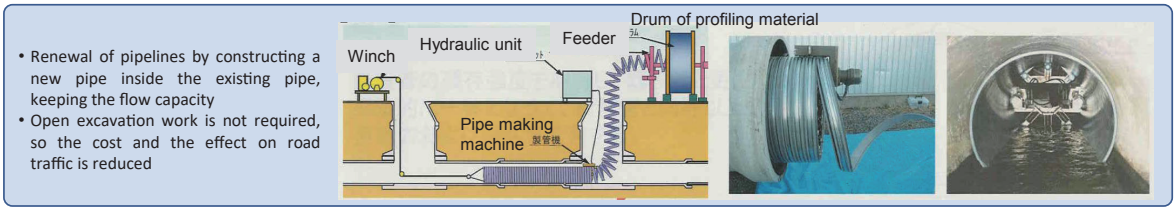


Fig. Development pipe renewal technologies
(document provided by the Ministry of Land, Infrastructure, Transport and Tourism)

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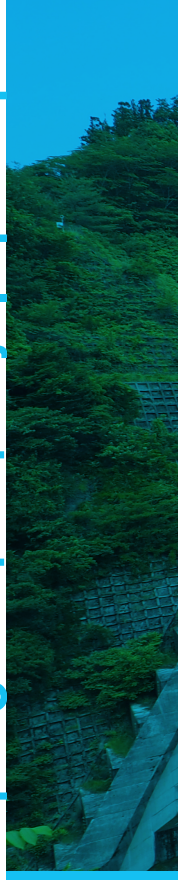

Japan's Infrastructure Grades 2020 & Introduction of Maintenance Technologies