

Current State of Infrastructure Maintenance and Monitoring in Japan

(ACECC TC-28 Meeting in Mar 2022)

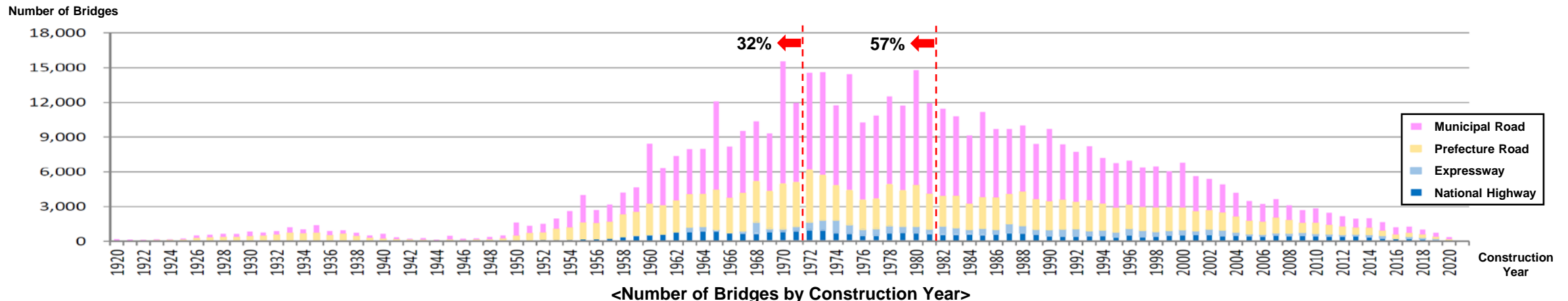
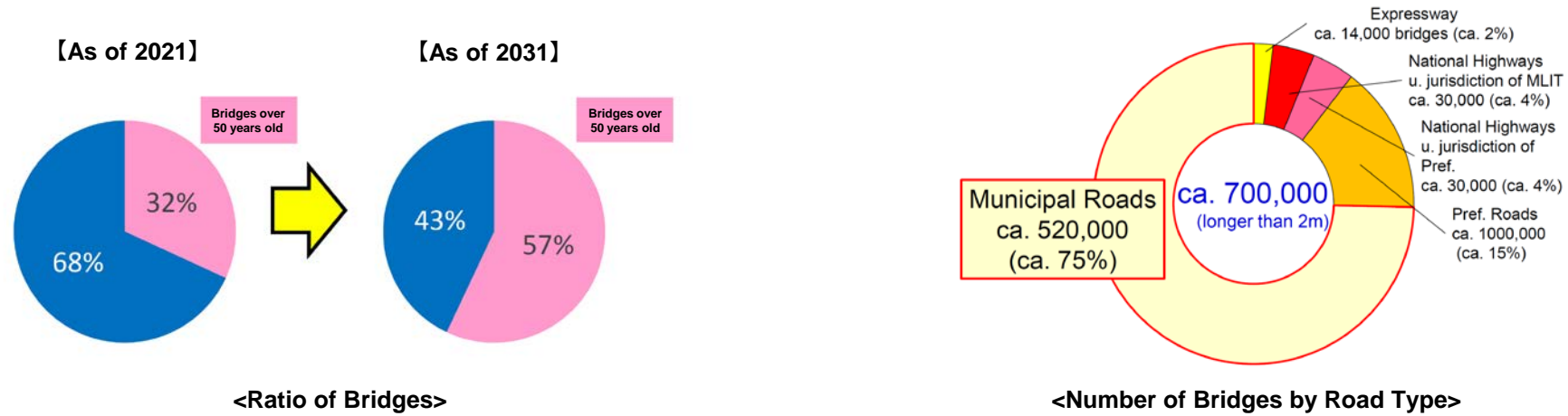


Outline

- 1. Deterioration of Infrastructures in Japan**
- 2. Periodical inspection**
- 3. Basic strategy on maintenance**
- 4. Monitoring technologies**
- 5. Current state and issues on monitoring**
- 6. Needs and challenges on monitoring**

1. Deterioration of Infrastructures in Japan

- There are about 700,000 bridges in Japan. 75% of them are classified into municipal road.
- In 2031, the ratio of bridges over 50 years old will become about 57%.



2. Periodical inspection (Background)

2012.12 **Ceiling board falling accident in Sasago Tunnel**

2013.6 **Amendment of road regulation**
(Maintenance, inspection, measures are regulated)

2014.3 **Implementation of new road regulation**
(Clarification of road manager's obligations, e.g.: inspect every 5 years, execute by visual inspection)

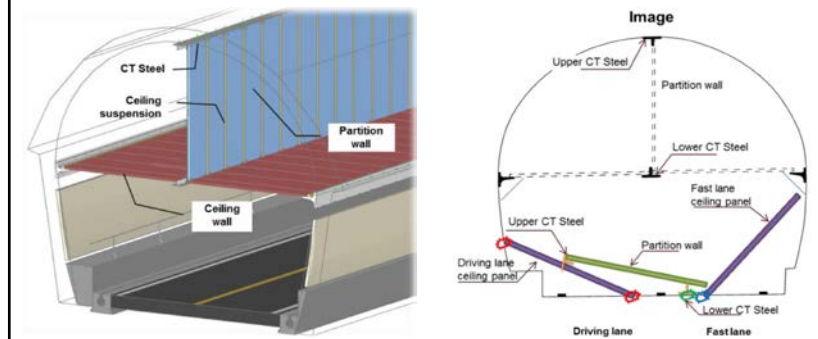
2014
- 2018 **First Round of Inspection (5 years)**

2019.2 **Revision of routine inspection regulation**
(Enhance efficiency of inspection by employing new technologies. Narrow focus points according to damage and structural characteristics)

2019
- 2023 **Second Round of Inspection (5 years)**

Accident at Sasago Tunnel

- December 2, 2012
- Tunnel opened: 1977 (35 years old)
- Daily Traffic Volume: 40,576 (both directions, as of 2010)
- 3 vehicles involved, 9 dead, 2 injured
- Dec. 29: Re-opened a single-lane in each direction
- Feb. 8, 2013: Fully re-opened



Sasago Tunnel (east bound) to Tokyo



driving lane

fast lane







(Dec. 5, 2012)

2. Periodical inspection

- Implement, once-every-five-years, a close visual inspection of all bridges and tunnels, according to the uniform national standard.



- Evaluation of structure conditions across the nation using a uniform standard.

Category		Condition		
I	Good	No structural deficiency	<Concrete Crack>	<Steel Corrosion>
II	Preventive maintenance	Preventive maintenance is desirable, although no structural deficiency is found.		
III	Early rehabilitation	The structure needs early rehabilitation, or it can become deficient.		
IV	Emergency rehabilitation	The structure needs emergency rehabilitation because it is deficient, or it will most likely become deficient.		

3. Basic strategy on maintenance

- Shift from “BM” to “PM”. It leads to lifecycle extension and lifecycle costs reduction.
Breakdown Maintenance (BM): large-scale repair when damage becomes serious
Preventive Maintenance (PM): repair when damage is still moderate

PM

Example1: Concrete deck

Crack occurs due to repeated traffic load



Reinforced by installing carbon fiber sheet

Without Repair

Example2: Steel Girder

Progression of paint deterioration in coastal area



Early measures by repainting

Without Repair

BM

Sedimentation of pavement



Replacement with pre-cast deck slab

Severe corrosion or penetration



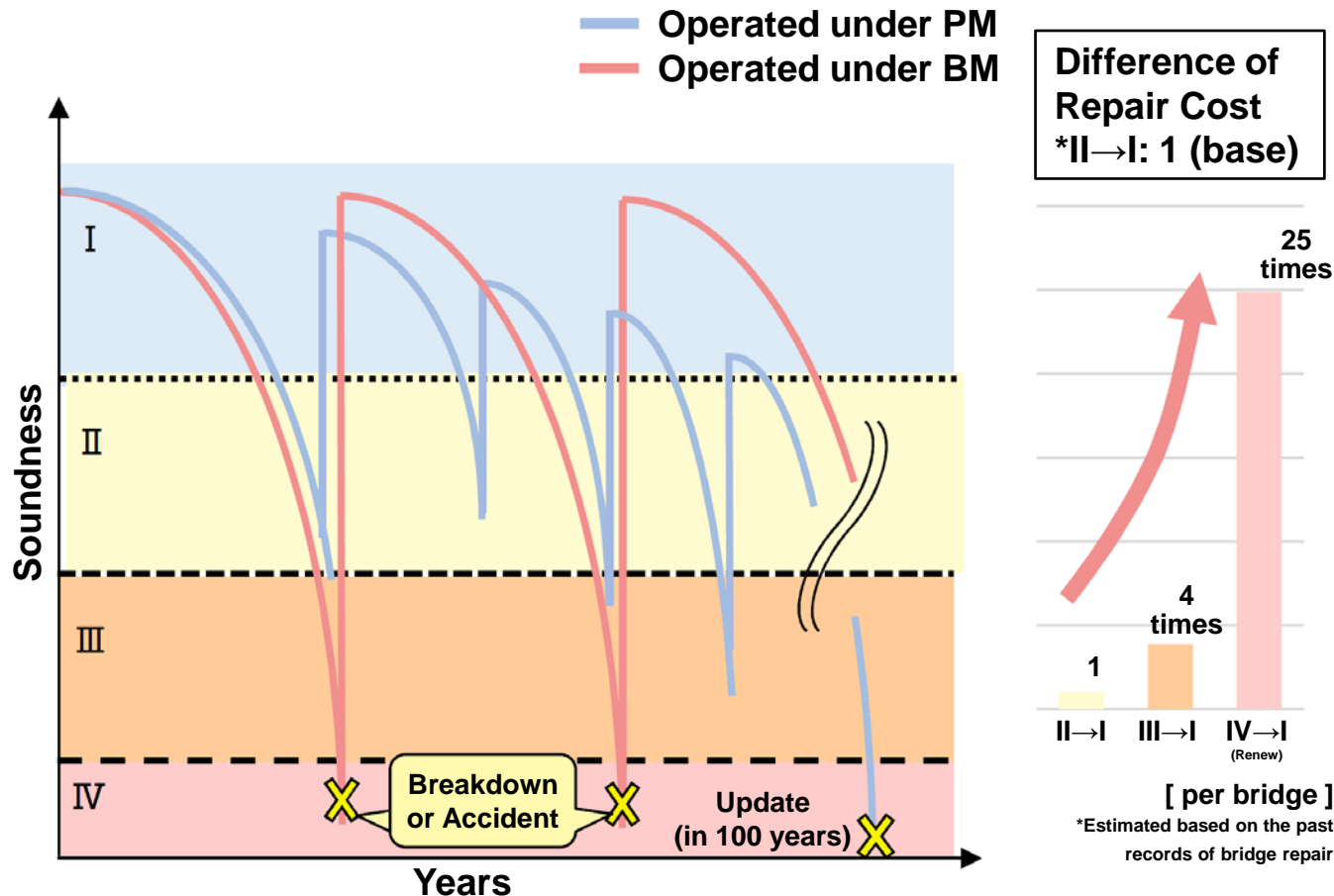
Reinforced by putting cover plate

*Different bridges are depicted in upper and lower row.

3. Basic strategy on maintenance

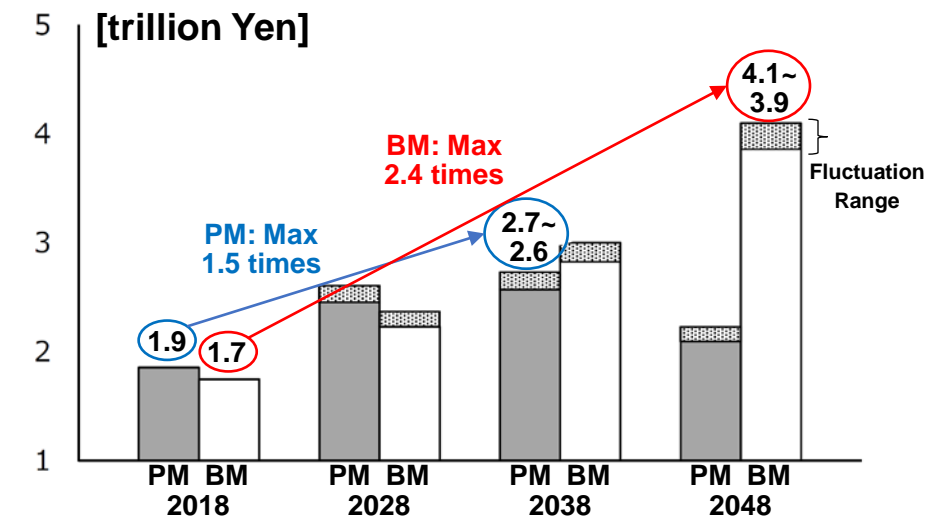
- Preventive Maintenance (PM) can reduce the total maintenance cost compared to BM.

Conceptual Figure of Maintenance



Deference in Total Cost

Maintenance cost related to road sector



PM is more economical than BM for total maintenance cost.

3. Basic strategy on maintenance (Current State)

- Bridges classified into III / IV shall be repaired within 5 years after inspection. However, about 30% of them under local government have not been started yet.

Administrator	Bridges to be repaired (A) [nos.]	Bridges already started for repair (B) [nos.]		Bridges without repair [nos.]	Inspection year	As of 2020, (B) / (A) and (C) / (A)					
			Completed (C)			0%	20%	40%	60%	80%	100%
MLIT (National gov)	3,411	2,845 (83%)	1,439 (42%)	566 (17%)	2014	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><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Late due to engineer shortage and limited budget

*Data as of the end of 2020

4. Monitoring technologies

- We have several kinds of monitoring technologies for various purposes.

Case	Monitoring technology	Evaluation index
(a)	Observation of deck slab cracking using images	Crack density, crack width
	Observation of beams using images	Crack widths, traces of water leakage
	Observation of paint surfaces using images	Amount of occurrence of corrosion
	Measurement of the amount of adhering chloride with a chloride detection meter	Amount of airborne chloride
	Measurement of the natural electrical potential in the concrete using reference electrodes	Natural electrical potential (reinforcement corrosion environment)
(b)	Monitoring of drop in deck slab using optical fiber	Step in the bottom of the deck slab
	Measurement of deflection of deck slab using deflection gauge	Amount of deflection
	Monitoring of Pca deck slab joints using optical fiber	Cracking, opening
	Vibration properties of the deck slab using accelerometers	Vibration modes and comparison of degree of damage
	Separation and spalling of concrete using infrared camera	Existence and extent of separation and spalling
	Vibration properties of beams using accelerometers	Natural frequency, damping factor, vibration modes, bending angle
	Detection of problems at beam ends using deflection gauges	Displacement of beam ends
	Measurement of deflection of beams using images, optical fiber, etc.	Amount of deflection, stiffness of beam
	Measurement of displacement of beam gaps using deflection gauge	Status of movement of bearings
	Measurement of natural frequency of bridge pier foundations using accelerometers	Natural frequency of foundation (amount of scouring, stability)
(c)	Measurement of displacement of slopes using inclinometers	Amount of change in angle of inclination with time
	Measurement of displacement of slopes using satellite positioning	Rate of displacement of the ground surface
	Determination of rock fall hazard using vibration meter	Difference of vibration properties between ground and rock mass

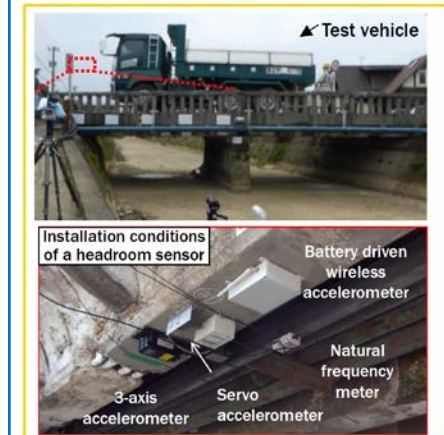
(a) Cases where the control standard value is set from an allowable value determined from design standards or guidelines, etc.

(b) Cases where the relationship between the performance of the structure and the monitored value is determined by structural analysis or test, and the control standard value is set in accordance with the limiting state of the structure. It is necessary to investigate each structure.

(c) Cases where values statistically derived from actual data are taken to be the control standard values.

Floor slab monitoring

Field application



Salt damage monitoring



5. Current state and issues on monitoring

< Current State >

- Monitoring technologies have been developed and experimented in a certain degree.
- However, they are rarely employed for practical usage...



< Issues >

- We need to consider the following points when applying monitoring technology;

What should be observed? (Index)

What sensor should be used? (Accuracy)

What frequency should be chosen? (Data amount, Period)



Importance of structure (Social Impact) and Budget, etc.

- However, we do not have specific criteria to know the optimal balance of above points...

6. Needs and challenges on monitoring

- Importance of infrastructure is high. → High quality monitoring technology with high cost
- Importance of infrastructure is low. → Simple, user-friendly and inexpensive technology

