National overview of the bridge condition and management: Japan

CAESAR
Center for Advanced Engineering Structural Assessment and Research, PWRI, Japan

Road network in Japan

	Owner (Operator)	Highway length (km)	# of bridges (15 m or more in total span)	Heavy truck travels
National Expressways (Toll roads)	Government (Designated corporations)	7,400 (0.6%)	6,402 (4.3%)	28%
National Highways *Designated sections*	**Government**	22,200 (1.9%)	10,794 (7.3%)	**29%**
National Highways *Non-designated sections*	Prefectures	32,000 (2.7%)	12,778 (8.6%)	43%
Prefecture roads	Prefectures	128,700 **(10.9%)**	32,516 **(21.9%)**	
Municipal roads	Municipalities	992,700 **(83.9%)**	85,733 **(57.8%)**	

The government almost completely delegates prefectures and municipalities to operate and maintain their roads.

Percentages of bridges by material types (L ≥ 15 m)

Most bridges are made of steel or PC.

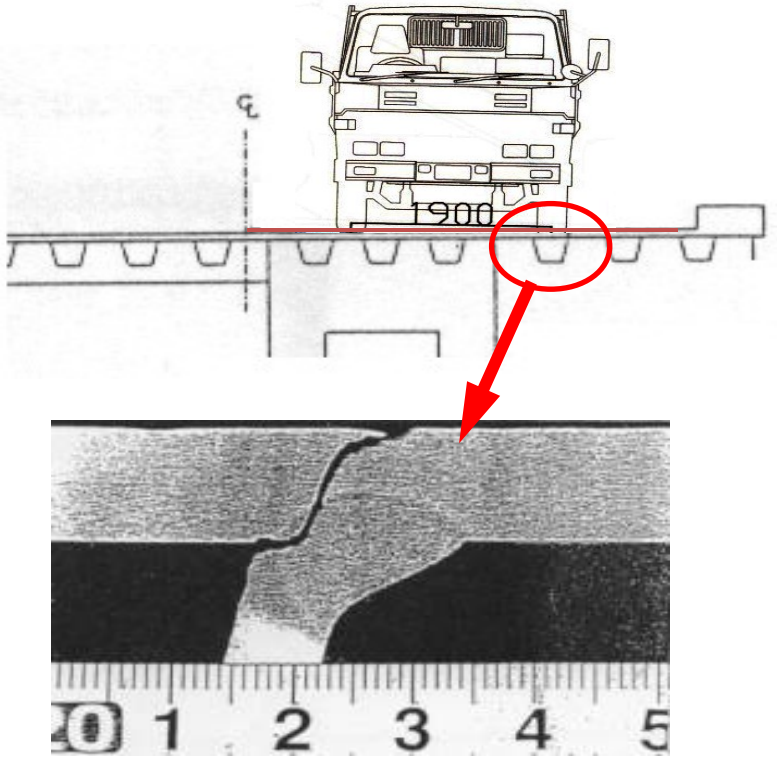
	Steel	RC	PC	Combo	Others
Essential NH routes	50.7%	8.6%	36.9%	3.3%	0.4%
Prefecture roads	39.1%	17.9%	40.6%	1.9%	0.4%
Municipal roads	36.7%	17.5%	41.7%	2.0%	2.1%

Recent traffic shutdowns because of bridge distress in essential NH routes in Japan

Many instances of damage such as fatigue cracks and corrosion have already appeared, some of which could have led to collapse.

Fatigue fracture in a steel main girder, Yamazoe Bridge, R25, constructed in 1971.
(Traffic shut down for 2 days, ADTT 36,000)

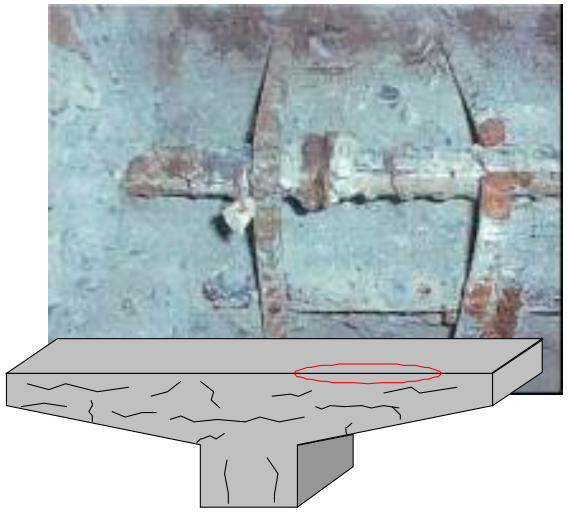
Fatigue fracture at welding parts of U-rib and deck plate appears in metropolitan areas



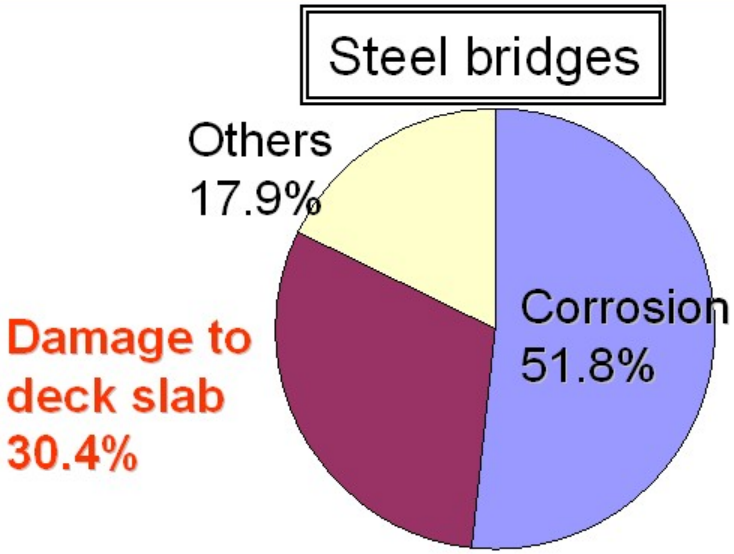
Chloride-induced deterioration and ASR are also major distress

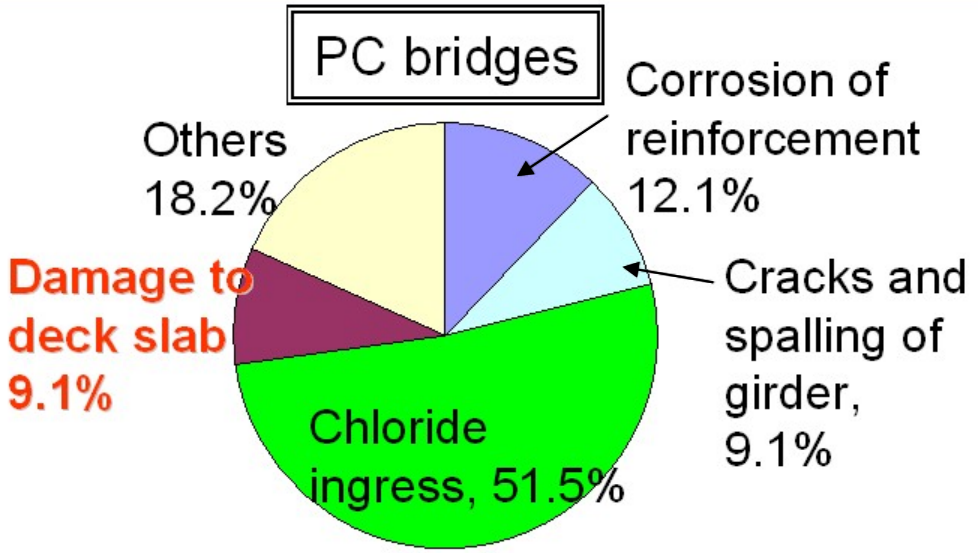
Severe salt environment

ASR



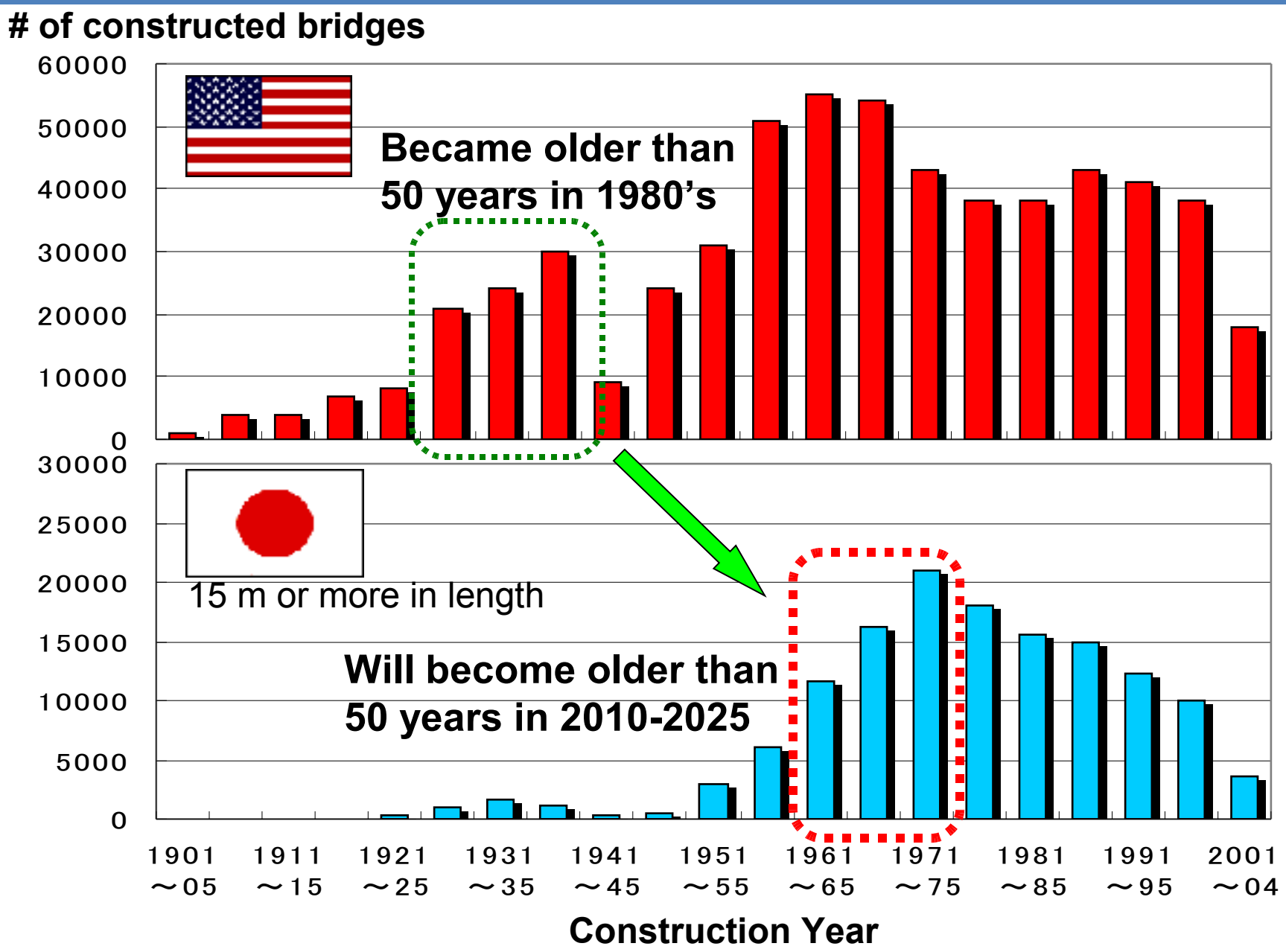
Percentages of damage type for the bridges demolished due to deterioration of superstructure (1996-2006)



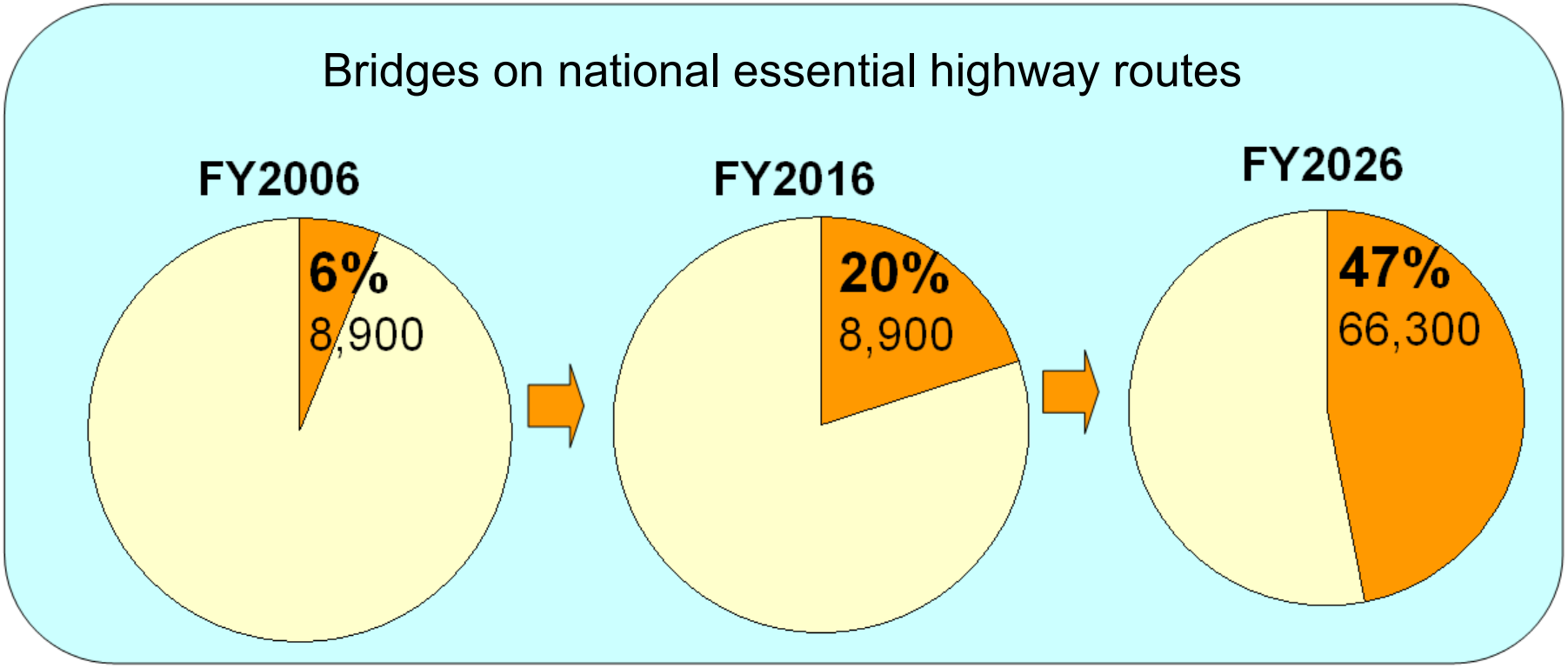


Fatigue distress of RC deck slab is also a serious concern.

US bridges vs Japanese bridges in Year built



Percentage of bridges 50 years or older



Preventive maintenance initiatives

A preventive maintenance initiative was raised in 2003.

The Ministry notified and mandated a new-every-five-year inspection program for their bridges on essential NH routes in FY2003.
(Previously (since 1988): Just a recommendation; Interval < 10 years)

Damage

Check every element of every member to track the time evolution of damage

Damage rank				
a	b	c	d	e

Small — Large

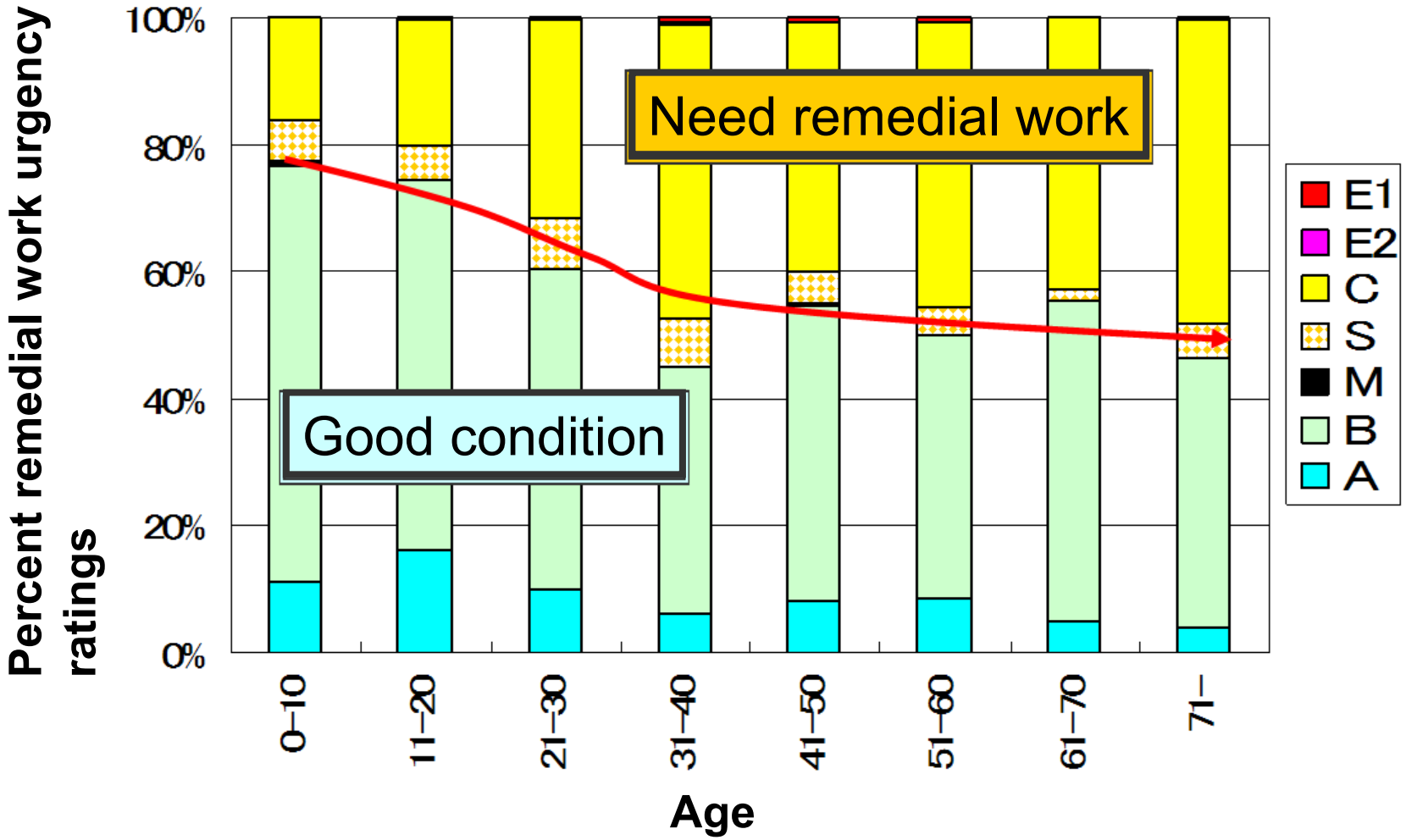
Remedial work urgency

A	No damage or negligible
B	Need if necessary
C	Immediate work is necessary
E1	Urgent in terms of structural safety
E2	Urgent in terms of other perspectives
M	Repair should be conducted as a part of ordinary maintenance work
S	Details investigation is necessary.

Now we're in the middle of the second 5-year term of the new program

Hands-on, Visual inspection for all members

Remedial work urgency ratings by age

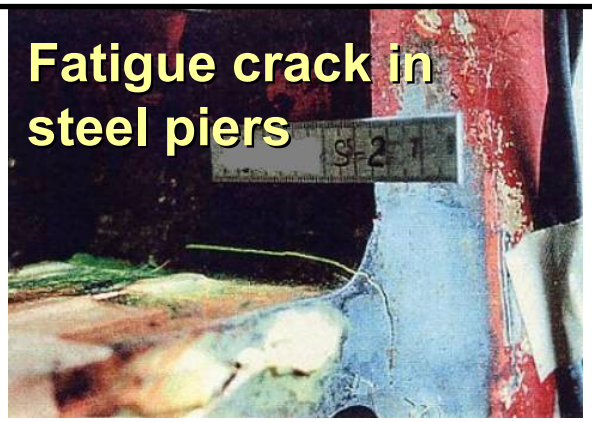


Remedial work urgency increases with increasing their age.

Remedial work needs increase as bridges approach their 30th year.

Prioritized remedial works

A high priority of detailed inspection and remedial work on the bridges that needed urgent remedial work for these types of distress for a three-year period of FY2005-2007.

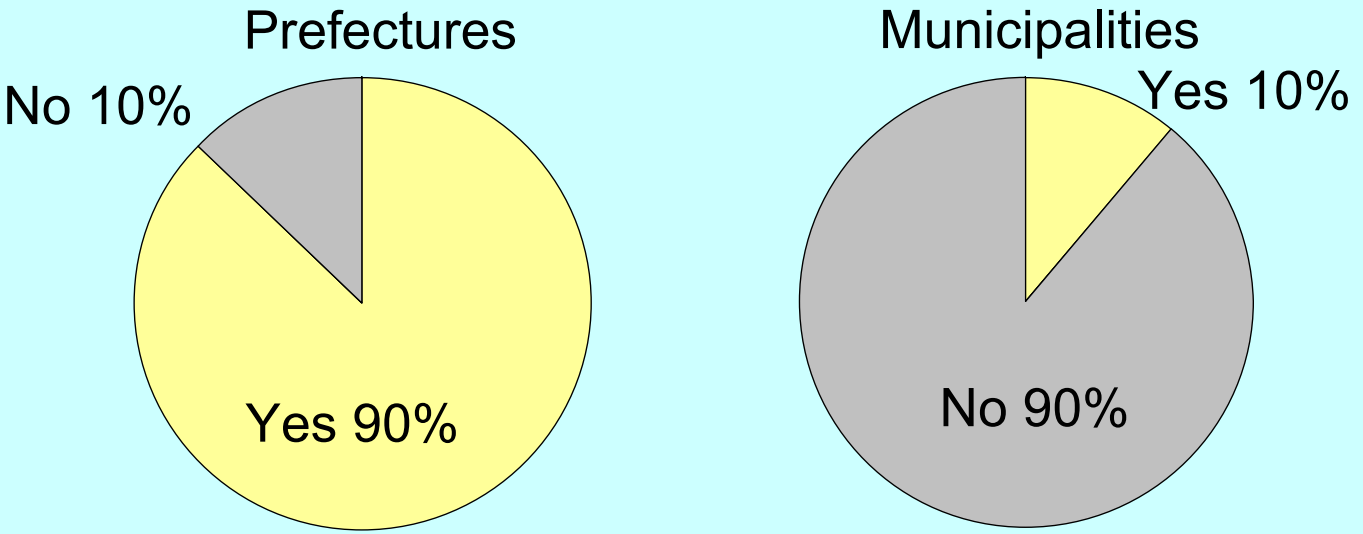


A BMS algorithm was also developed and now it's been used as a trial in some highway offices by referring when they make budget.

We still don’t know about local bridge conditions.

Local highway administrators, especially community governments, did not inspect their bridges.

Have you ever inspected your bridges? (as of September, 2007)



Main reasons (Questionnaire survey):

65% of local governments admit they are not good at technical issues.

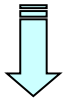
62% admit budget is deficient.

50% admit the lack or shortage of in-house engineers.

Recommendations for the outline inspection of bridge condition

Aim:

Inspect all bridges as immediately as possible while avoiding the critical misunderstanding of a bridge condition as much as possible



The amount of collected data reduces 50% of that of the government every-five-year inspection based on the statistical analysis for damage data collected in the government inspection.

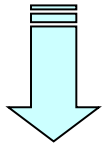
Government program	**Recommendation**
All element	e.g. Girder ends for corrosion
Hands-on	e.g. hands on are not necessary for substructures
26 damage types × 5-tier ratings = 130	12 damage types × 2-5-tier ratings = 33

A new subsidy program for local governments

A subsidy program for local governments to inspect their bridges and establish their long-term bridge maintenance program was invented in FY2007, ending in FY2011.

A half of the cost to make up a long-term maintenance program for the longevity of bridges

A half of the cost to inspect the bridges that will be taken into account in the expected long-term maintenance program



After FY2012, as for a damaged bridge, if its rehabilitation plan is not listed in their long-term bridge maintenance program, the local government cannot obtain the subsidiary to repair from the Ministry.

Outcomes of the subsidy program

Municipalities will get the inspection of 50.5% of their bridges achieved by the end of FY2009. (Formerly, almost none!)

However (or, deep down, as we suspected), …..

the number of weight-restricted or closed bridges increases as the inspection progresses.

	FY2006	F2007 (The program started)	FY2008
# of closed bridges	83	138	193
# of bridges with weight limitations or lane closures	510	724	1002

Towards the second stage of bridge management: Strategic management

At the first stage

The top priority is to know and analyze the current structural status of all stocks.

However, it is not sure that they will continue to inspect and take care of all bridges under this cash-strapped situation.

⇒ At the second stage --- Strategic management

1. Rationalization of inspection items and frequencies
2. Coordination of in-house and outsourcing responsibilities

Rationalization of inspection items and frequencies

Two major aims in inspection

A structural safety inspection is needed to confirm if there is little expectation to reach a fatal failure. --- All bridges

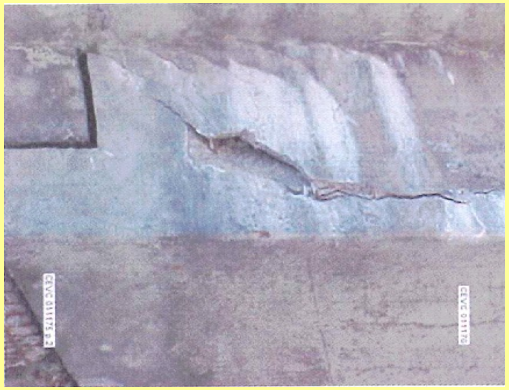
A thorough inspection such as the government inspection program is needed to predict the deterioration rate and life cycle cost for a bridge. --- Is this kind of thorough inspection really necessary for all bridges?

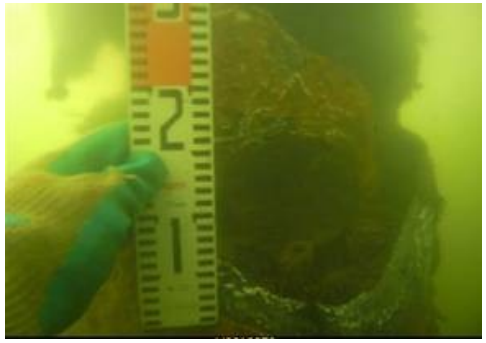
⇒ We are seeking different inspection frequencies and items for both aims, respectively, based on earlier experience and statistics.

Empirical approach by CAESAR: Fracture critical structures

Learning from earlier experience in bridge failure or structural safety issues

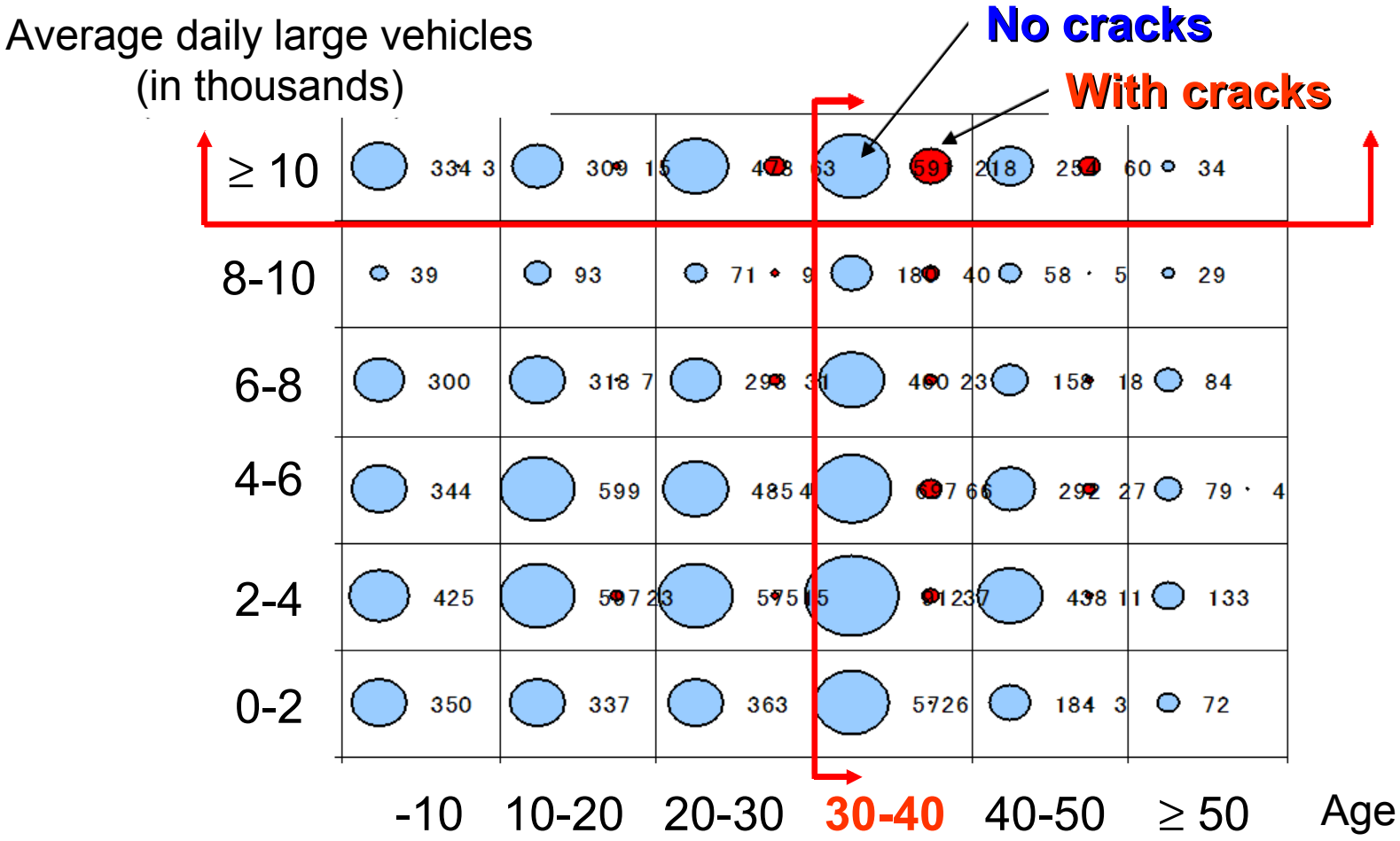
Need to know an expected failure process with changing its appearance





Probalistic approach by NILIM: # of spans not having or having cracks in steel girder & box-girder bridges

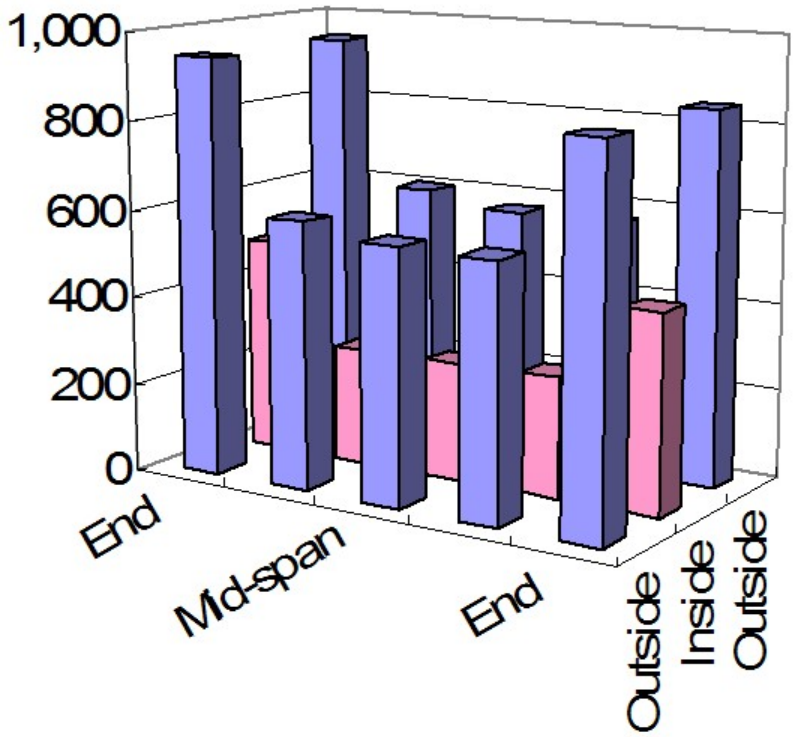
Inspection for fatigue in steel girders and box girders may not be necessary if a bridge does not carry heavy traffic and is younger than 30 years old.



One other example of statistics: Corrosion in steel girders

Different inspection frequency may be able to set for girder-ends and other parts, respectively, in terms of corrosion in steel girders.

# of damage detections



Corrosion at girder-ends

Which way should we go?

Questionnaire survey for local governments on why they could not carry out bridge inspection:

65% of local governments admit they are not good at technical issues.

62% admit budget is deficient.

50% admit the lack or shortage of in-house engineers.

Probably, we'll face some questions of which way we should go to:

A. Outsourcing to industry

B. Hiring and educating in-house engineers

Need to coordinate in-house and outsourcing responsibilities

Proc. of ICE, Bridge Engineering 161(BE3), 2008 ``Inspection and maintenance of highway structures in England'' by A. S. Jandu, HA

Excerpts:

``HA is an executive agency of DfT.''

``The inspection and maintenance activities are undertaken by managing agents and contractors appointed by HA.''

``Inspections are carried out by staff employed by the maintaining agents.''

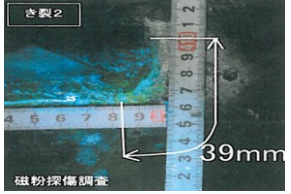
``The maintaining agents are required to consider potential work programs.''

``The Agency uses a risk-based approach for the prioritization of maintenance needs.''

Who is responsible what if a bridge fell down because of irrelevant diagnosis, HA or agents?

How do in-house engineers check and approve the relevance of the remedial work programs and the prioritization suggested by BMS (or the accuracy of BMS prediction for individual bridges)?

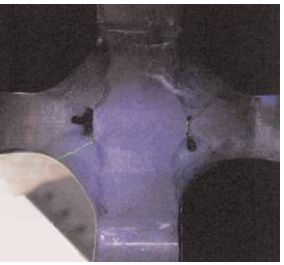











Thank for listening

Center for Advanced Engineering Structural Assessment and Research (CAESAR)