Bridge Management

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Outline

- Overview
- What we have to consider
- Bridge maintenance management system
  - Field Stress Measurement
  - Remote Monitoring System

Introduction

Metropolitan Expressway, Kanda Bridge, Tokyo

Metropolitan Expressway (40 Years Ago)

Social Infrastructure

Constructed in Order of Demand

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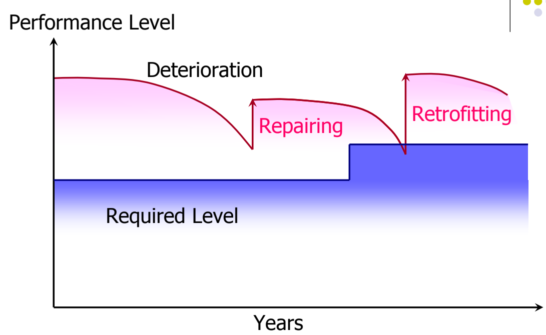
The Greater the Importance
The Earlier the Used Technology

Performance Curve of Structures



Bridge management

to ensure that the bridge remains fit for its purpose throughout its design life.
→ without the need for excessive maintenance

- Fitness for purpose
  - → Safety
  - → Serviceability
  - → Durability

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Age of Roman

Roman approach to durability management

"the engineer responsible for the structure was required to carve his name in the stone and if the structure fell down within 40 years, his head was cut off."

Ancient Aqueduct in Rome
Total Length: 728m

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What to consider ??

- Design stage
- Construction stage
- In-service stage

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Design stage

- Steel structures vs Concrete structure

Old days,
steel structures have to be painted regularly.
concrete structures need not further maintenance.
Recent experiences show that this is a fallacy .

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Design stage

- At this stage, following points are considered
  1) structure and durability
     → structural details, connection details and welding details
  2) inspection and maintenance
     → difficulty for inspection and possibility of detection

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Construction stage

- Concept of quality assurance (QA)

Fatigue performances of welded joints strongly depend on the quality of welded joints
→ defects, deformations, residual stress

⬇

Application of NDE and the required level of welds

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In-service stage

- In service
  → Carry traffic
  → Exposed to the environment

In-service stage

- The bridge may have to carry heavier traffic loading than it was originally designed for

Japan

design vehicle load 20 ton → 25 ton (1994)

England

vehicle load 32 to 38 ton in early 1980s

It is now considered that the codes may be too conservative for the assessment of existing structures

In-service stage (cont')

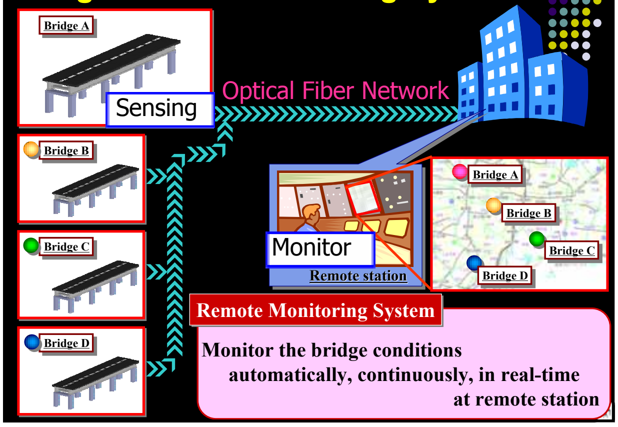
- First requirement
  Information about all the bridges on the network
  → Bridge inventory
- Next requirement
  Knowledge of the state of bridges at any given times
  → Bridge inspection and monitoring

General inspection

Principal inspection
detailed inspection within toughing distance

General inspection
close inspection of specific parts

Bridge Remote Monitoring System



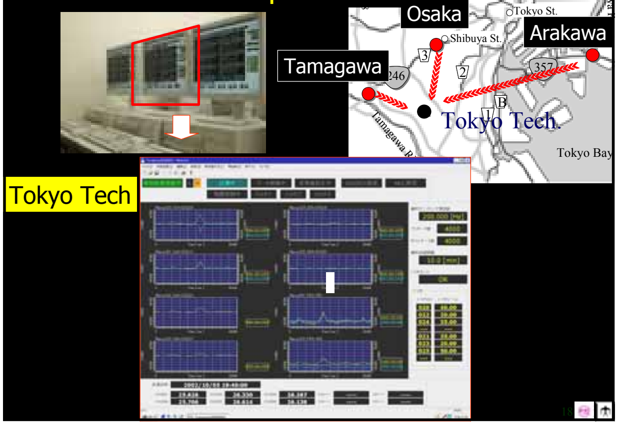
Process in Monitoring System

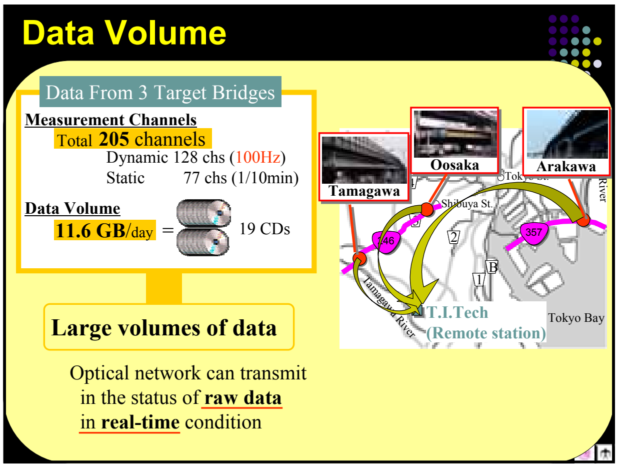
Real Time Data Transmitting
Strain, Deflection, Displacement, Temperature, Corrosion Electric Current

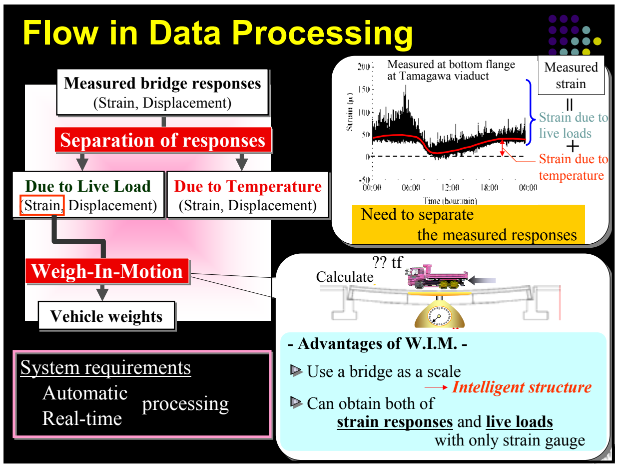
Real Time Data Processing
Separation of Effects of Live Loads and Temperature

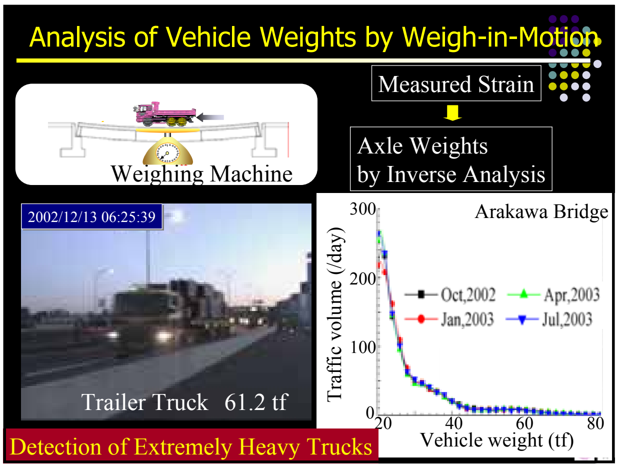
Monitoring of Service Condition
Weigh-in-Motion
Deformation due to Temperature

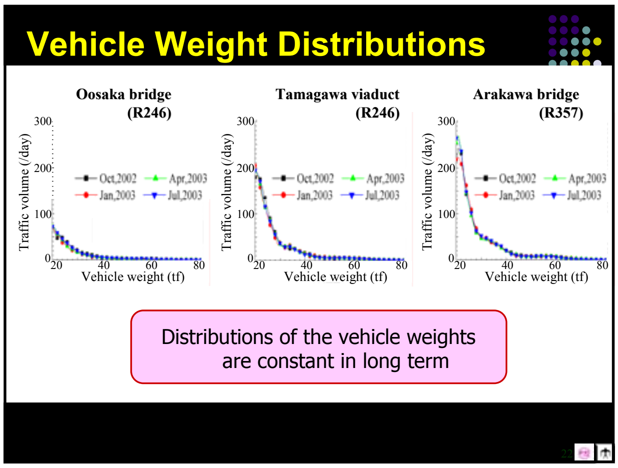
Real Time Data Acquirement

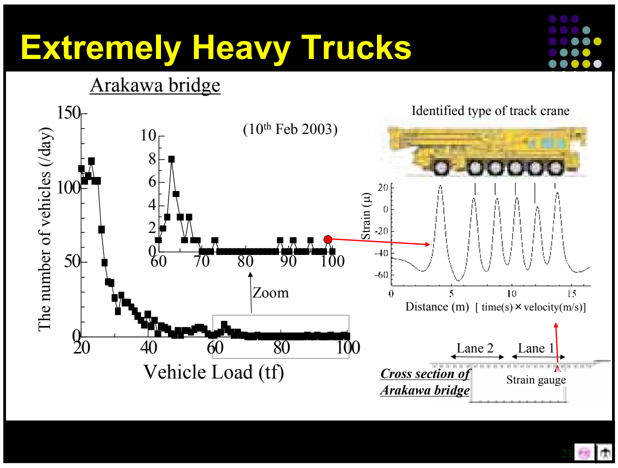


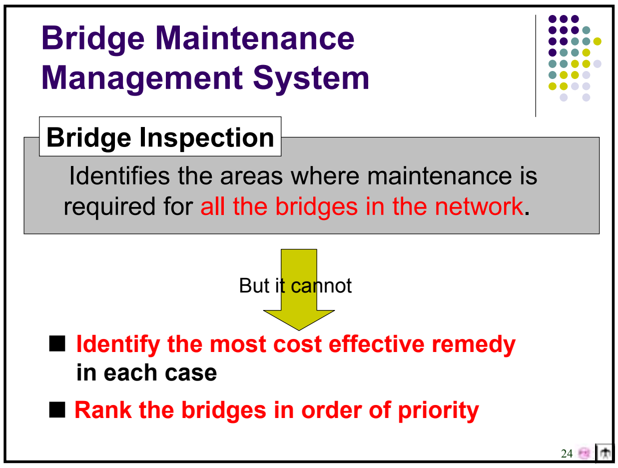

Data Volume
Data From 3 Target Bridges
Measurement Channels
Total 205 channels
Dynamic 128 chs (100Hz)
Static 77 chs (1/10min)
Data Volume
11.6 GB/day = 19 CDs
Large volumes of data
Optical network can transmit
in the status of raw data
in real-time condition
Tamagawa
Oosaka
Arakawa
Shibuya St.
T.I.Tech
(Remote station)
Tokyo Bay


Flow in Data Processing
Measured bridge responses
(Strain, Displacement)
Separation of responses
Due to Live Load
(Strain, Displacement)
Due to Temperature
(Strain, Displacement)
Weigh-In-Motion
Vehicle weights
System requirements
Automatic
Real-time
processing
Measured at bottom flange
at Tamagawa viaduct
Measured strain
Strain due to live loads
Strain due to temperature
Need to separate
the measured responses
Calculate
?? tf
- Advantages of W.I.M. -
Use a bridge as a scale
→ Intelligent structure
Can obtain both of
strain responses and live loads
with only strain gauge


Analysis of Vehicle Weights by Weigh-in-Motion
Measured Strain
Axle Weights
by Inverse Analysis
Weighing Machine
2002/12/13 06:25:39
Trailer Truck 61.2 tf
Detection of Extremely Heavy Trucks
Arakawa Bridge
Traffic volume (/day)
Oct,2002
Apr,2003
Jan,2003
Jul,2003
Vehicle weight (tf)


Vehicle Weight Distributions
Oosaka bridge
(R246)
Tamagawa viaduct
(R246)
Arakawa bridge
(R357)
Traffic volume (/day)
Vehicle weight (tf)
Oct,2002
Apr,2003
Jan,2003
Jul,2003
Distributions of the vehicle weights
are constant in long term


Extremely Heavy Trucks
Arakawa bridge
(10th Feb 2003)
The number of vehicles (/day)
Zoom
Vehicle Load (tf)
Identified type of track crane
Strain (μ)
Distance (m) [time(s) × velocity(m/s)]
Lane 2
Lane 1
Cross section of
Arakawa bridge
Strain gauge


Bridge Maintenance
Management System
Bridge Inspection
Identifies the areas where maintenance is
required for all the bridges in the network.
But it cannot
Identify the most cost effective remedy
in each case
Rank the bridges in order of priority
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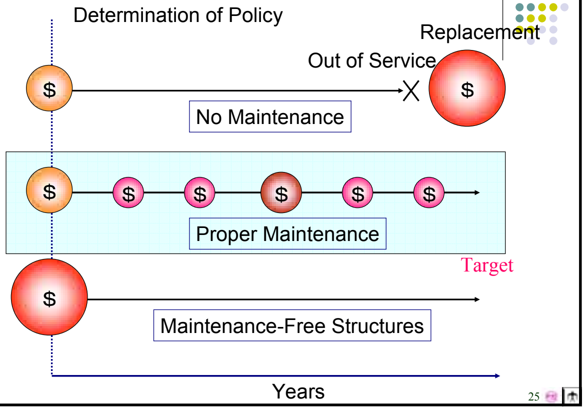
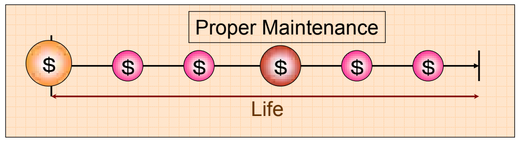
Maintenance Plan of Steel Bridges



Proper Maintenance Plan



⇨ Min. of LCC (Life Cycle Cost)
Asset Management

Cost/Benefit Analysis

- To determine the optimum treatment by comparing different maintenance strategies

  The Maintenance Profile
  The Whole Life Cost

The Whole Life Cost

Actual Maintenance Cost
＋ the Cost of Delays and Additional Operating Costs
＋ the Increased Cost of Accidents,
All discounted to **the Present Value**

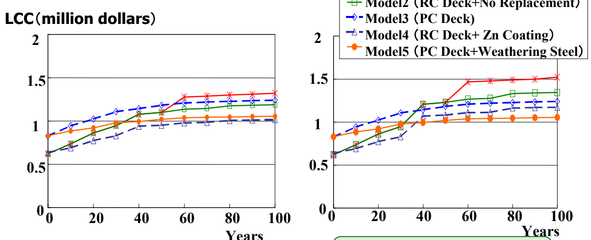
Benefits

Benefits and Dis-benefits that would accrue if the particular item of maintenance was not done, also discounted to the present value.

Evaluation of LCC

LCC＝Initial Cost＋Maintenance Cost
＋Renewal Cost＋Social and Broader Economic Cost

Example



Without Social Cost

With Social Cost (Miki et al, 2000)

Evaluation of Various Maintenance Options

- **Maintenance Profile for Each Option**

  The Selected Maintenance Treatment, Its Cost, Its Effectiveness, Subsequent Actions and Costs, and so on.
- **Traffic Delays, Operating Costs, Accident Costs**

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Present Value Analysis

The Calculation of the cost of alternative schemes in present-day monetary items. i.e. the amount that is required in today's value to obtain goods and services at any future date.

It allows for the comparison of alternative schemes on an equitable basis.

$$PV = \frac{C}{(1+r)^n}$$

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Present Value Analysis

The Present Value (PV) of an expenditure *C* in year *n* at a discount rate *r*

$$PV = \frac{C}{(1+r)^n}$$

The Present Value (PV) of a number of expenditures C_{1n} $n=1,2,\ldots,N_1$ for a period of N_1 years

$$PV_1 = \sum_{n=1}^{N_1} \frac{C_{1n}}{(1+r)^n}$$

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Asset Management System

- Evaluates of the present value of bridges and ranks them in order of priority

UK QUADRO

USA Pontis

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Risk Management

- General Term applied to systematic methods of hazard and risk identification, assessment, evaluation, creation of risk management strategies and performance monitoring.
- The use of risk engineering techniques lead us to recognition that there is an economic and value engineering dimension to the philosophy of when to repair.

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