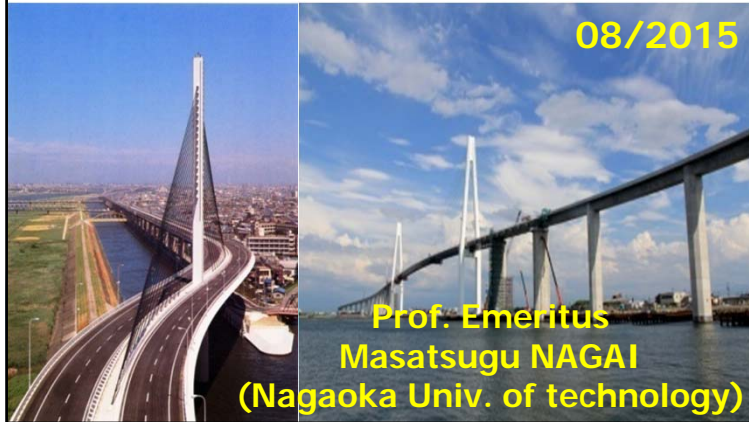


IABSE-JSCE Joint Conference on
Advances in Bridge Engineering-III
Towards Owning a Resilient Infrastructure

Prof. Emeritus Masatsugu Nagai
Nagaoka University of Technology
Japan

Keynote Presentation

Design, Construction and Maintenance of Steel and Composite Bridges in Japan



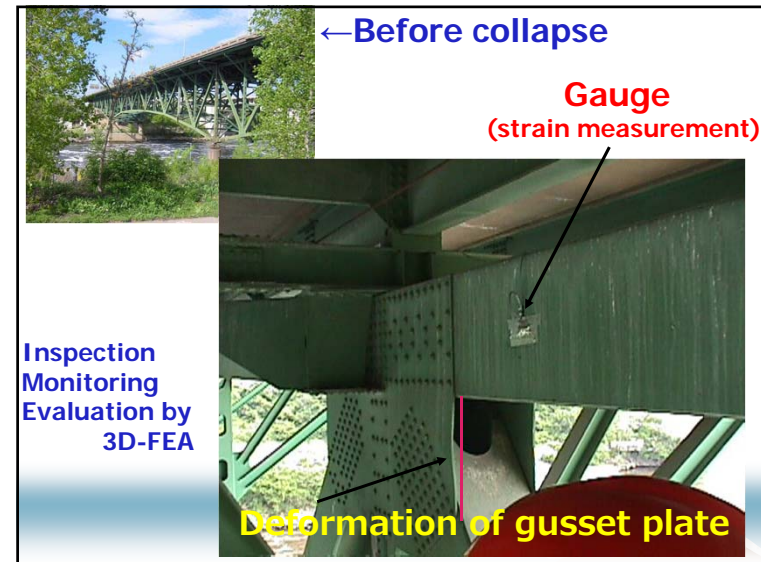
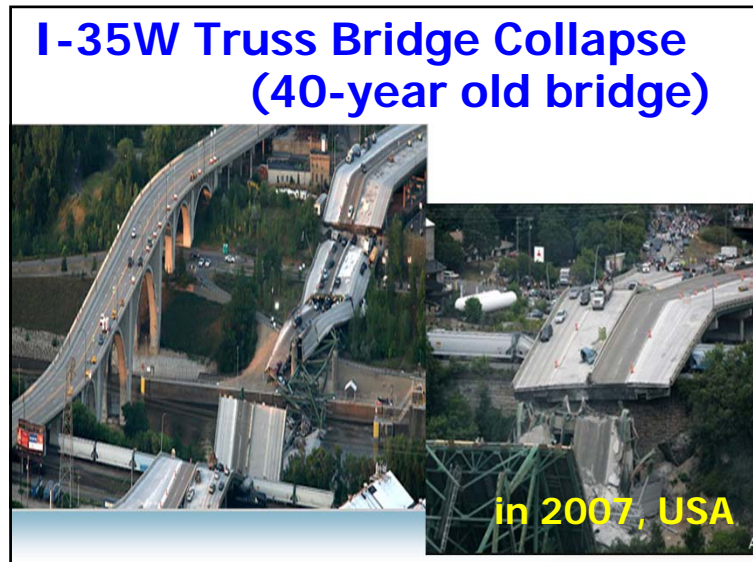
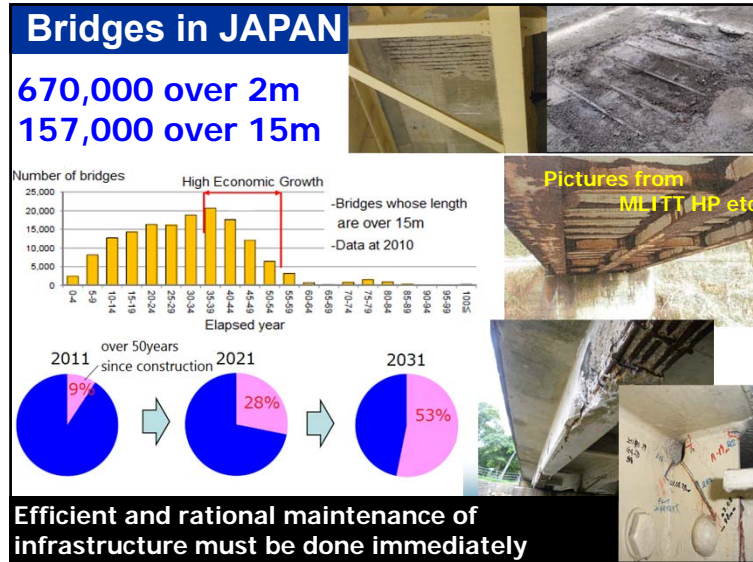
Memorial photos



Contents

- 1) Current situation
on bridge engineering in Japan
- 2) Design Code
- 3) Long-span bridge technology
& Competitiveness
of composite bridges
- 4) Maintenance

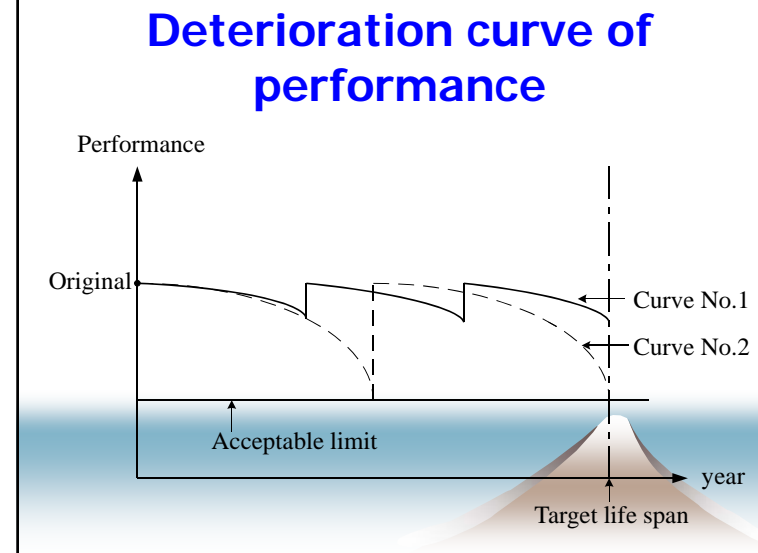
- New bridge construction business
(decreasing)
- Old bridges
(increasing)
- Maintenance business
(increasing)



Trigger of switch of maintenance policy in Japan

From remedial (or breakdown)
to preventive maintenance

Cyclic inspection of all bridges
and repair, if necessary
[continuation]



Accident in Tunnel (2012) Fall down of roof panel in tunnel



Trigger of inspection (compulsory) & neighbor eye-sight inspection (at 5-year cycle detailed inspection)

Future important research topics


- Evaluation of current (and accurate) performance of deteriorated structures
- Prediction of (accurate) deterioration rate for reliable LCC, BMS & Asset management

Large-scale Renewal & Repair Project by Expressway company Ltd.

Ex. **Nippon Expressway Co. Ltd. (NEXCO)**
 (15-year 24 billion US \$PJ has started)
 {Main PJ work (13 billion US \$) is
 replacement of RC slab}




Outline of Renewal Project NEXCO



- Replacement of Slab
- Replacement of Girders
- Waterproof for RC slab
- SFRC for Steel Deck
- Coating for Concrete

SFRC (steel fiber reinforced concrete)




slab Pre-cast PC slab

対面通行規制 橋梁補修工事



Design Code



Specifications for Highway Bridge in Japan



$$f \leq \min\{f_y, f_{cr}(\leq f_y)\} / 1.7$$

f : produced stress
f_y : yield stress
f_{cr} : buckling strength

Allowable Stress Design Method (ASD)
 now being revised to **LRFD**

JSCE Design code for steel and composite structures

Committee on Steel Structures, JSCE

First published in 1987

- Part A : Structures in general
- Part B : Specific structures

based on **Allowable Stress Design**

Revised in 1997

- Part A : Structures in general
- Part B : Composite structures

based on **Limit State Design**



FIRST [Performance-based Limit State Design] in Civil Steel Structural Engineering



General provision,
 Basic plan,
 Design
2007

Earthquake Construction
2008

2009

2014

Long-span
cable supported bridges

&

Composite bridges

for medium span



Akashi Kaikyo Bridge
 (Honshu-Shikoku Bridge Expressway Company Ltd.)
 World longest span of 1,991m

Dry-air injection system ⇒

Courtesy by
 Honshu-Shikoku Bridge Expressway Company Ltd.

Dry-air Injection System of the Akashi Kaikyo Bridge

Air Injection Pipe
 Air Exhaust Cover
 Air Injection Cover
 Dry-Air Injection System
 Stiffening Girder

Air-injection Cover

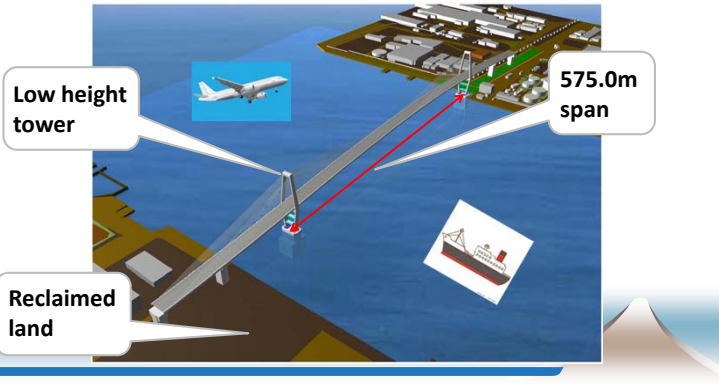
Air-Injection System

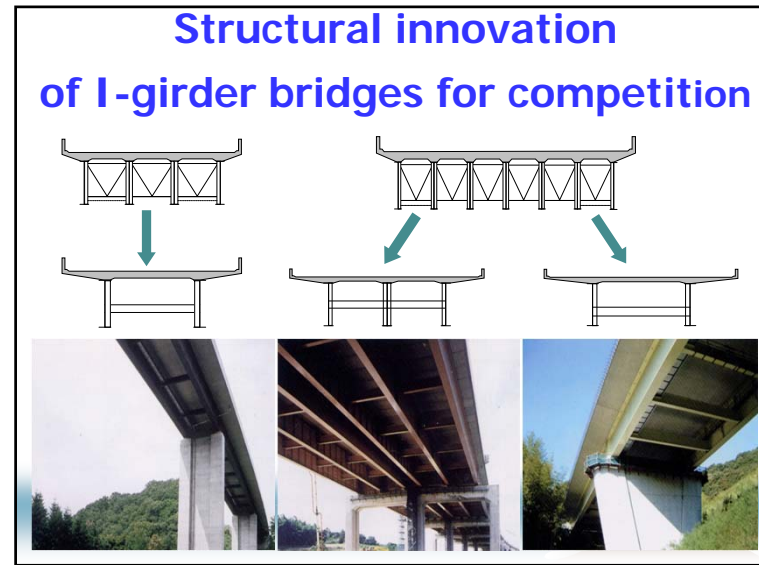
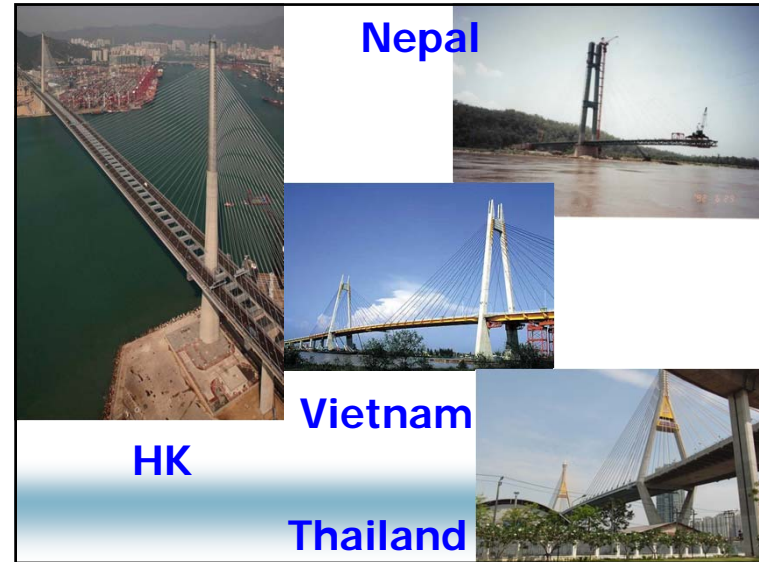
- A: Control panel
- B: Filter
- C: Dehumidifier
- D: Roots blower
- E: Discharge silencer
- F: Cooler

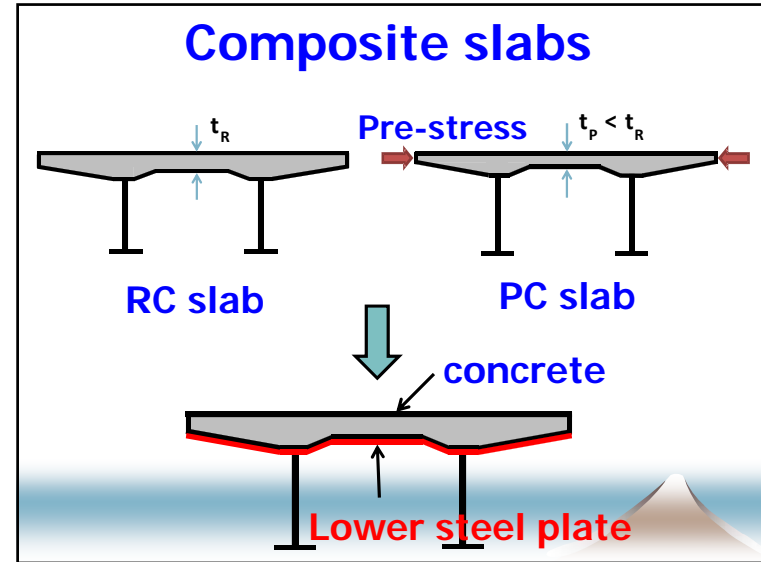
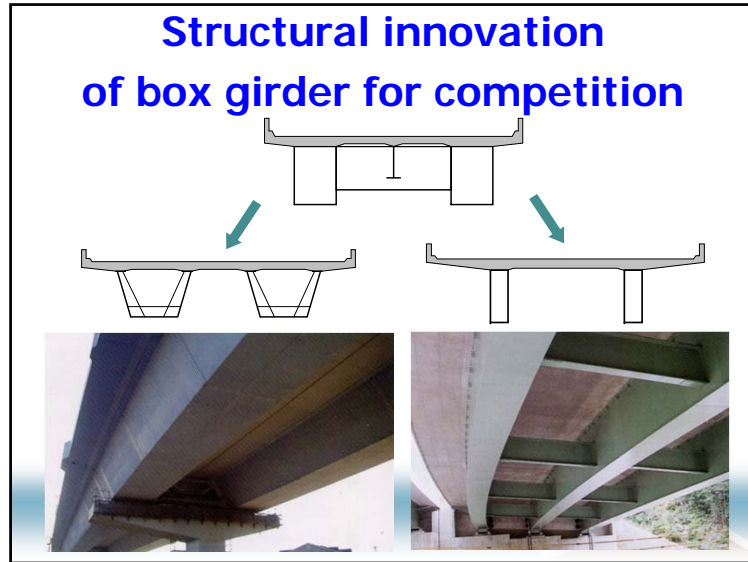
Courtesy by
 Honshu-Shikoku Bridge Expressway Company Ltd.

Tokyo Gate Bridge
 (located near Haneda Int. Airport)

A large cable-stayed bridge with low height tower is planned crossing a channel near major airport in Japan.









Brief introduction of

[SIP]

Strategic Innovation Program

Since 2014 by Cabinet Office of Japan

Cross-ministerial Strategic Innovation Promotion Program
by Cabinet Office of Japan since 2014

To be the Top, Innovation!
Prime Minister Shinzo ABE

10 subjects are selected as significant and necessity challenges for society and growth of Japanese economy and industry. (50 billion JPY= 400 million USD (2014))

私たちは再び世界一を目指します。世界一を目指すためには、なんと、**真っ当にイノベーション**であります。安倍政権として、新しい方針として、イノベーションを重視していく。そのことをはっきりと示していきたい。

第107回総合科学技術会議 総理発言

○科学技術イノベーション総合戦略 (平成25年6月7日閣議決定)
○日本再興戦略 (平成25年6月14日閣議決定)

総合科学技術・イノベーション会議の司令塔機能強化
Council for Science and Technology Policy
(HP of Cabinet Office)

Innovative Fuel Technology
Future-generation Power Electronics
Innovative Structural Material
Energy Carrier
Future-generation Marine Resource Survey Technology
Auto Driving System

Infrastructure Maintenance / Renovation / Management
Resilient Capability Development for Disaster Prevention and Reduction
Future-generation Innovative Technology for Agriculture, Forestry and Fisheries
Innovative Production Design Technology

Infrastructure Maintenance/Renewal/Management Technology

Project Director: Prof Yozo FUJINO
(Yokohama National University)



Set Target Fields in this Subject

1. Inspection/Monitoring/Diagnosis Technology
2. Structural Material/Damage Progress/Retrofit/Repair Technology
3. Information and Communication Technology (ICT)
4. Robot Technology
5. Asset Management Technology



What is the innovation in our field in the project?
Prof. Fujino says *'Implementation is the innovation in this project'*

Overall Research Scheme

- PDCA cycles of maintenance in the levels of Bridges, road, region.
- One head and four sub-project groups are set in this project

```

    graph TD
      HG[Head Group U Tokyo  
Prof. Maekawa, Prof. Ishida etc.  
(conduct a research of Group 1)]
      SG1[Sub group 1  
Life-span estimation of RC Slab  
Prof. Iwaki Nihon U]
      SG2[Sub group 2  
Road asset management  
Prof. Nasu Kochi TU  
Prof. Kobayashi Kyoto U]
      SG3[Sub group 3  
Asset management in regional level  
Prof. Horita UTokyo, Prof. Iwanami TIT, Prof. Ozawa UTokyo]
      SG4[Sub group 4  
Establishment of international hub of asset management  
Prof. Yokota Hokkaido U, Dr. Nagai UTokyo]

      HG --> SG1
      HG --> SG2
      HG --> SG3
      HG --> SG4
      SG1 --> SG2
      SG2 --> SG3
      SG3 --> SG4
  
```

Head Group (U Tokyo)
Prof. Maekawa, Prof. Ishida etc.
(conduct a research of Group 1)

Sub group 1
Life-span estimation of RC Slab
Prof. Iwaki (Nihon U)
Life-span estimation, High durability, Long-life technology

Sub group 2
Road asset management
Prof. Nasu (Kochi TU)
Prof. Kobayashi (Kyoto U)

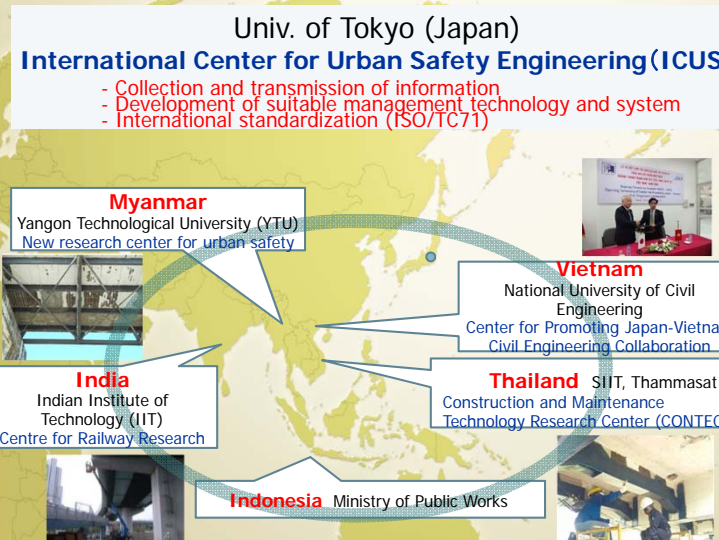
Sub group 3
Asset management in regional level
Prof. Horita (UTokyo), Prof. Iwanami (TIT), Prof. Ozawa (UTokyo)

Sub group 4
Establishment of international hub of asset management
Prof. Yokota (Hokkaido U), Dr. Nagai (UTokyo)

Univ. of Tokyo (Japan)

International Center for Urban Safety Engineering (ICUS)

- Collection and transmission of information
- Development of suitable management technology and system
- International standardization (ISO/TC71)



Myanmar
Yangon Technological University (YTU)
New research center for urban safety

Vietnam
National University of Civil Engineering
Center for Promoting Japan-Vietnam Civil Engineering Collaboration

Thailand SIIT, Thammasat U
Construction and Maintenance Technology Research Center (CONTEC)

India
Indian Institute of Technology (IIT)
Centre for Railway Research

Indonesia Ministry of Public Works

Target area of the Project

Inspection (Existing & New)



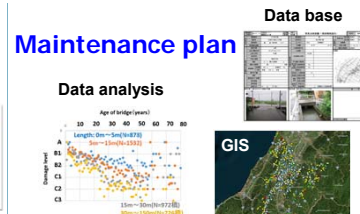
Corrosion

Permeability

Maintenance plan

Data base

Data analysis



GIS

Repair



FRP

Fiber reinforced concrete

Relating leading research

Simulation

Experiment



Material development

Introduction of Maintenance related technology (PJ involved)

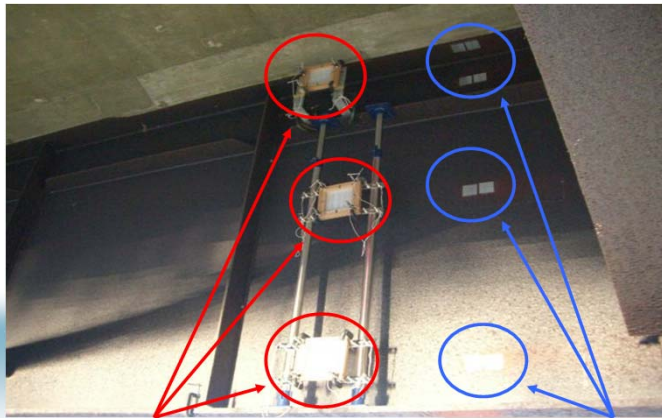
- 1) Weathering steel (no painting system)
- 2) Repair by new material (CFRP sheets)
- 3) Joint-less system
for short length old PC bridges

Weathering steel

Stabilized surface rust
protects and delays the corrosion

Stabilized surface rust
depends on the environment
(**airborne salt attack**)

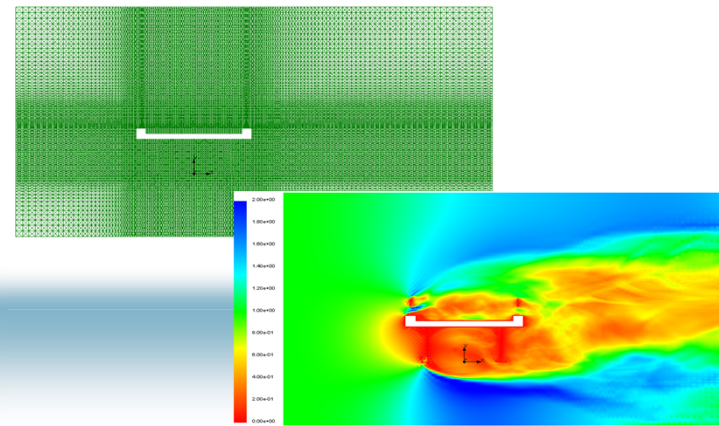
In Japan, applicable area
(distance from coast line) is stipulated



Instrument for gathering flying salt

Exposure piece

Prediction of airborne salt by FEA



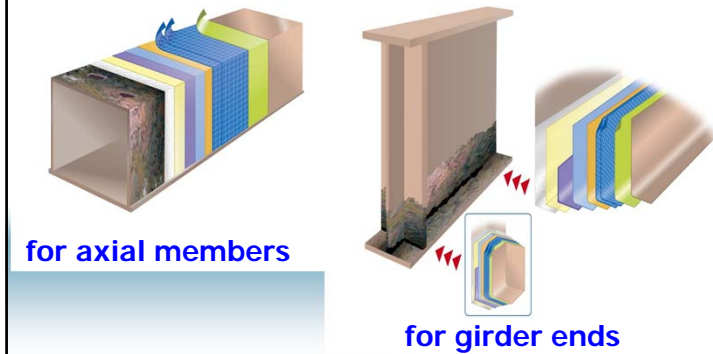
Repair of corroded steel by new material (CFRP)

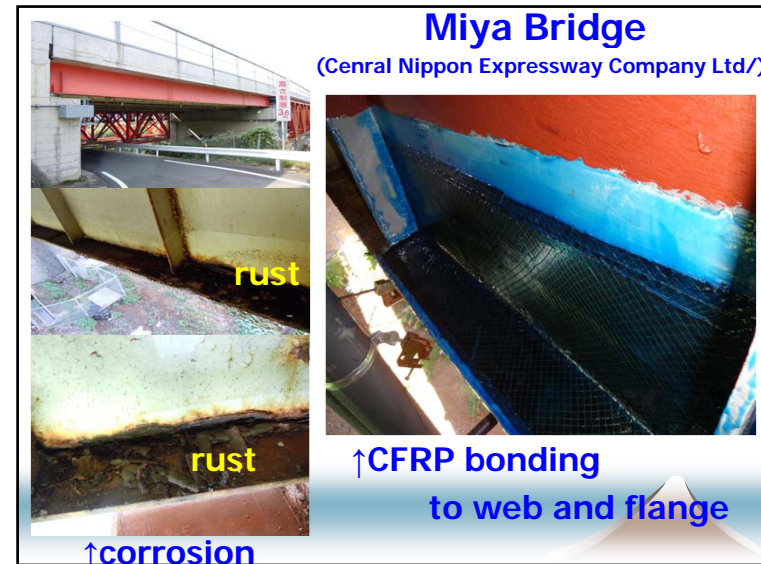
Joint research PJ by
Nippon Expressway Research Institute Company Ltd.
Nagaoka University of Technology
NIPPON STEEL & SUMIKIN MATERIALS, CO, Ltd.
KURABOU INDUSTRIES, Ltd.
Kawasaki Heavy Industries, Ltd.

Example of replacement of new members at the corroded part



Proposed method (CFRP Repair)

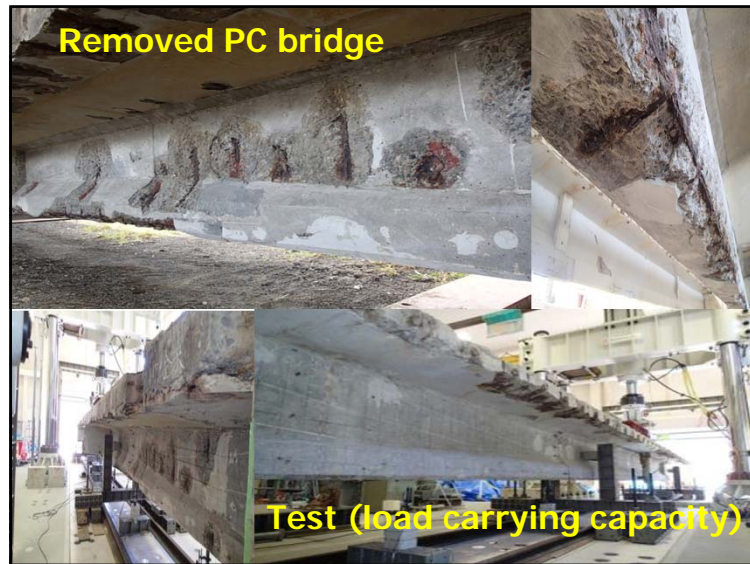




Joint-less system for short length ($\leq 30\text{m}$) old PC bridges

Joint research PJ by
Central Nippon Highway Engineering
Nagoya Company Ltd., Kanazawa branch
& Nagaoka University of Technology





**The most important point (issue) &
Key of technological development**

- [1] catch "sign" or "alarm" of sudden change (collapse) of deteriorated structures
- [2] correct evaluation of performance of deteriorated structures (quantitatively)
- [3] Accessible & visible every point in structures
- [4] See inside of solid(concrete) structures

Measurement itself is not the aim



Thank you for your kind attention

