Introduction of Chapter1 of ACECC Monitoring Guideline

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For a Better Quality of Life

http://www.acecc-world.org/

Outline

1. Chapter 2 Monitoring of Concrete Slabs
2. Chapter 3 Monitoring of Concrete Girders

CH. 2 Monitoring of Concrete Slabs

1. Purpose and Types of Monitoring

- 1.1 Target Structures and Changes
- 1.2 Current State and Challenges in Concrete Girder Inspection
- 1.3 Purpose of Monitoring and Anticipated Scenarios

2. Monitoring Technology and Concepts for Management Standards

- 2.1 Types and Purposes of Monitoring Technology
- 2.2 Introduction Standards for Monitoring Technology
- 2.3 Concepts for Management Standards in Monitoring

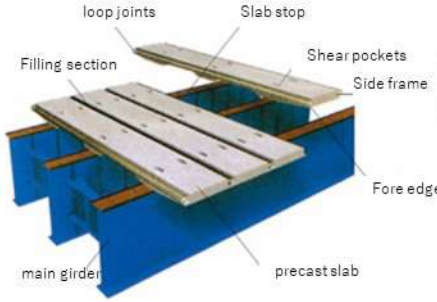
3. Cost Considerations and Implementation Examples

- 3.1 Cost Considerations
- 3.2 Implementation Examples

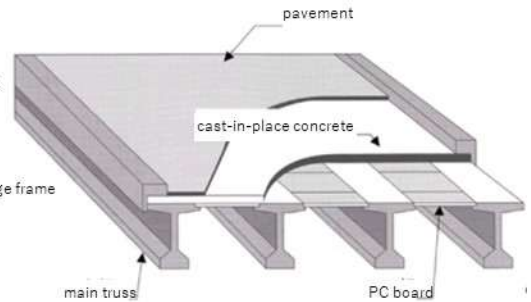
CH. 2 Monitoring of Concrete Slabs

- **Target structures and damages**

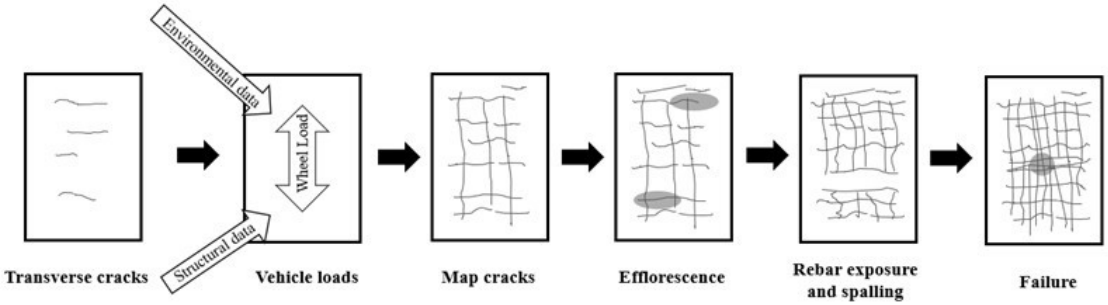
CIP Concrete Slab



Precast Concrete Slab



PC composite slab

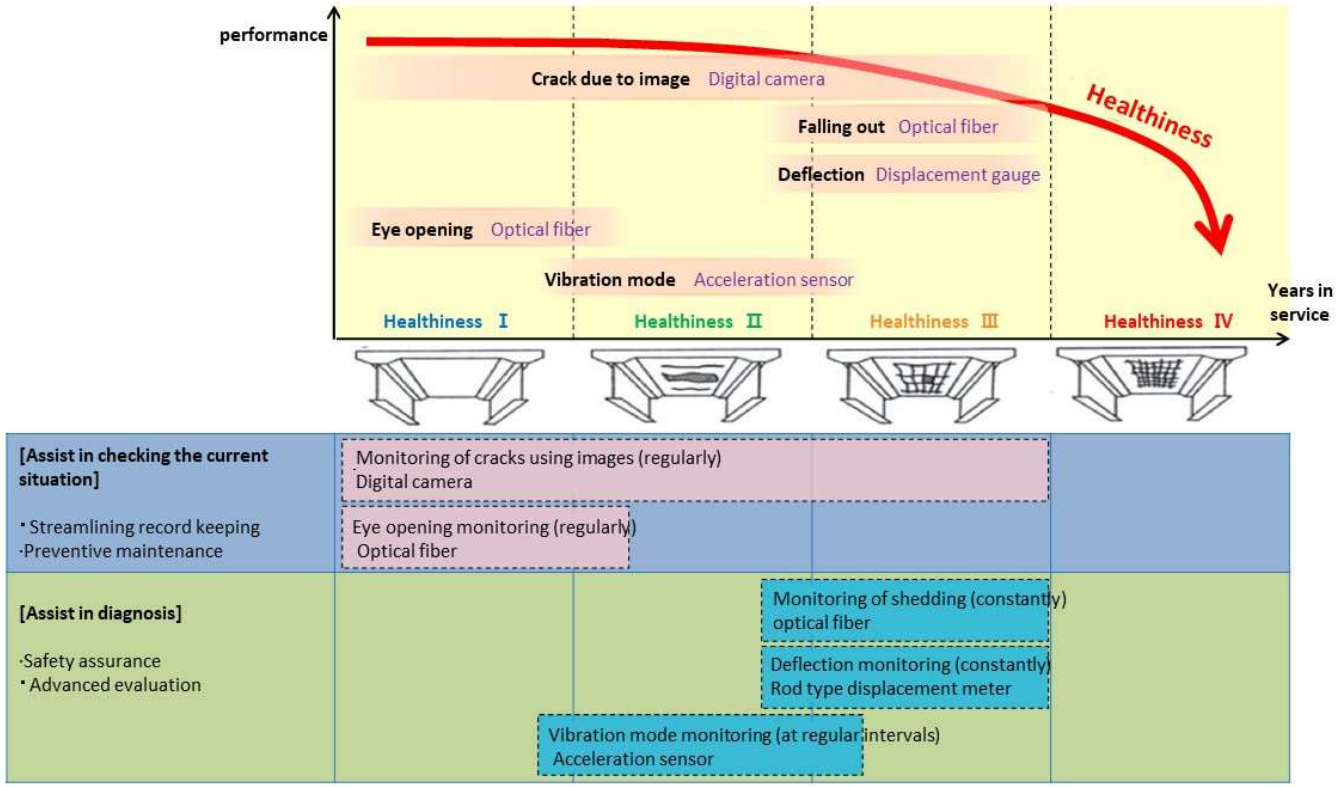


(a) Cracks in slabs (b) Falling out

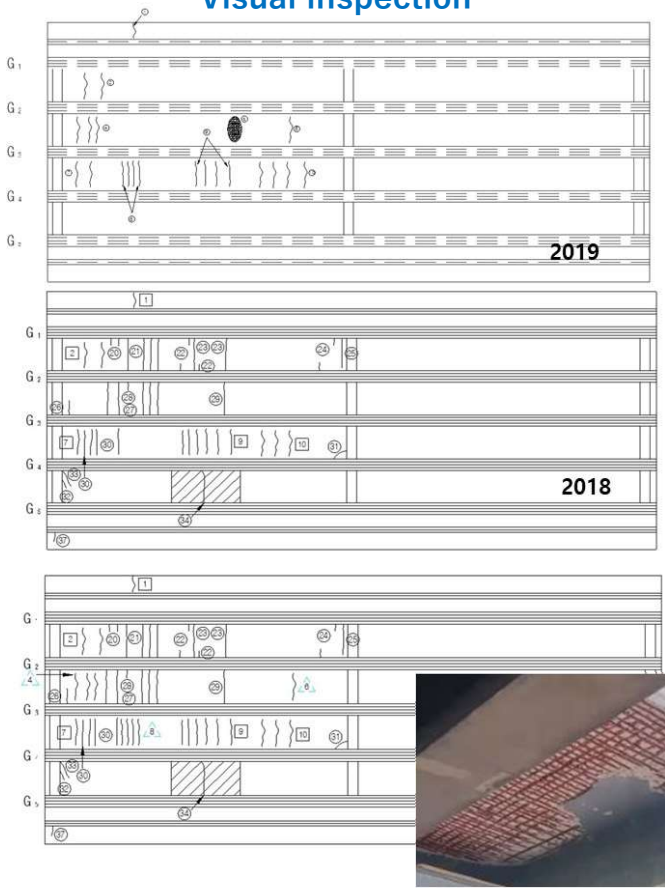
(c) Delamination and rebar exposure (d) Water leakage and free lime

CH. 2 Monitoring of Concrete Slabs

- Types and roles of monitoring in the maintenance of concrete slabs



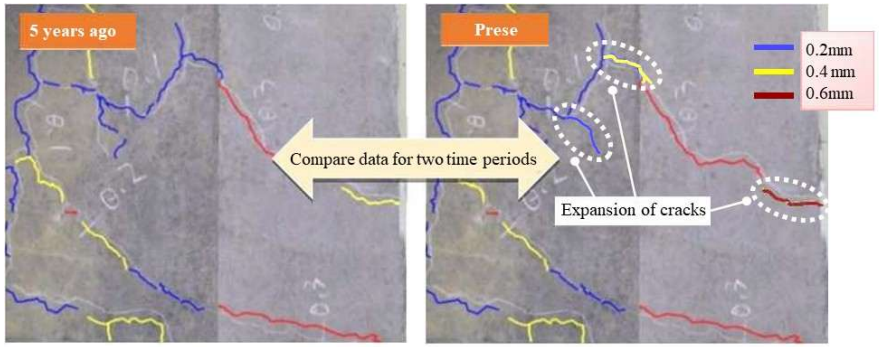
Visual inspection



CH. 2 Monitoring of Concrete Slabs

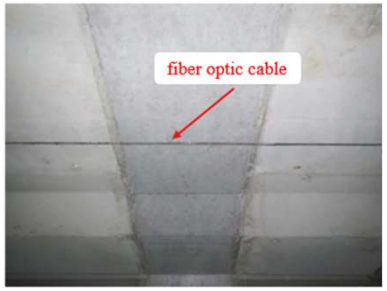
- **Types and Purposes of Monitoring Techniques**

Image-based Crack Monitoring Technology



Comparison example based on crack distribution maps for two time periods

Monitoring technology for precast slab joints using optical fiber



Underside of floor slab

Deflection monitoring by displacement gauge

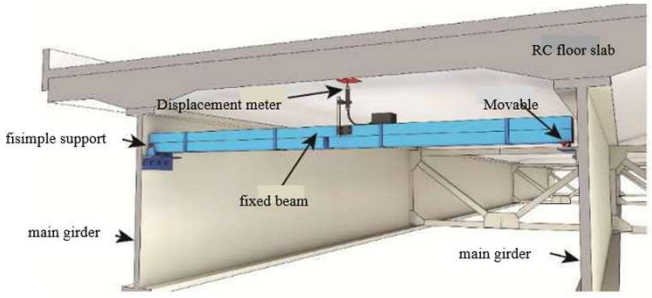
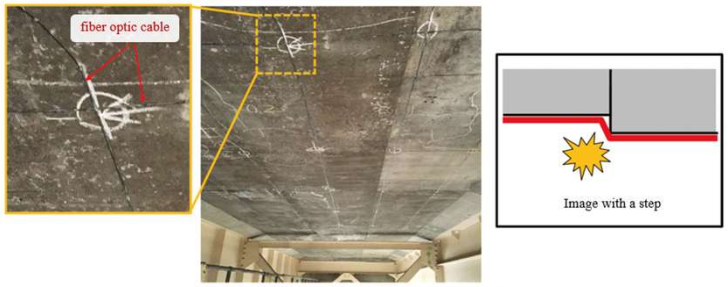


Image of floor slab deflection measurement

Monitoring technology for concrete delamination via optical fiber



Installation of optical fiber to the underside of floor slab and image of step occurrence

CH. 2 Monitoring of Concrete Slabs

- **Concept of Management Criteria in Monitoring**

① In the monitoring of cracks in slabs (including delamination, exposed rebar, water leakage, and free lime), the management criteria includes the current status and the degree of deterioration of the cracks.

② In the monitoring of falling out, continuous and periodic monitoring is carried out from the beginning. The management criteria should be considered by confirming abnormal values and sudden changes, with reference to past cases.

③ In the monitoring of deflection, continuous and periodic monitoring is carried out from the beginning. The management criteria should be considered by confirming abnormal values and sudden changes, with reference to past cases.

④ In the monitoring of gaps at precast slab joints, continuous and periodic monitoring is carried out from the beginning. The management criteria should be considered by confirming abnormal values and sudden changes, with reference to past cases.

⑤ In monitoring abnormal vibrations, the management criteria are considered based on comparisons between pre-analysis of vibration modes and actual measurements.

CH. 2 Monitoring of Concrete Slabs

- Cost Concept and Examples of implementation

① Preliminary work costs

② Measurement costs

③ Data processing costs

④ Other expenses (data storage costs and other indirect costs)

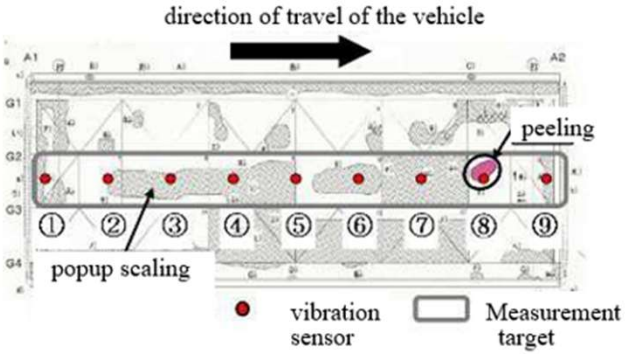


Image of Accelerometer Installation and Damage

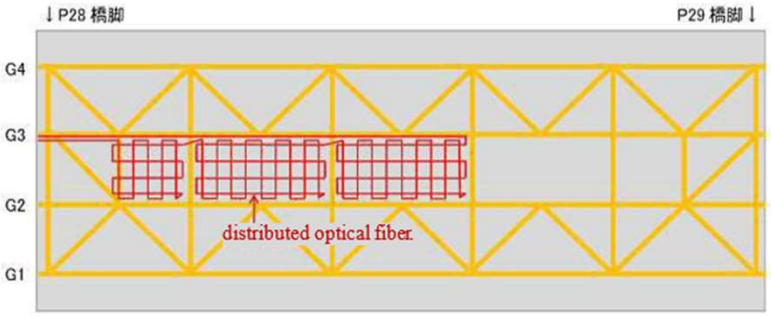
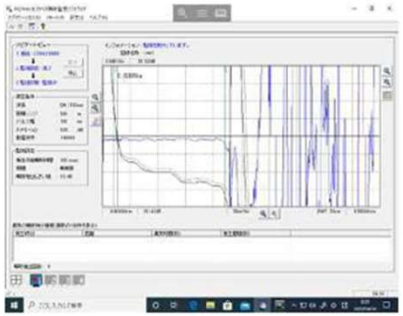
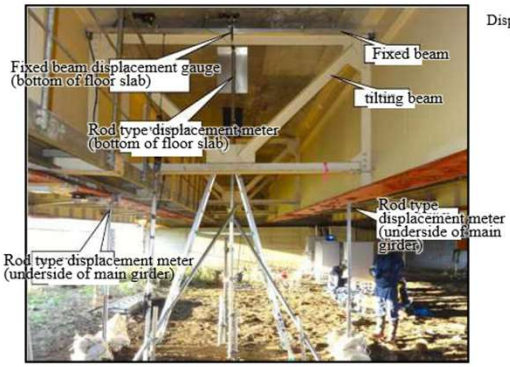
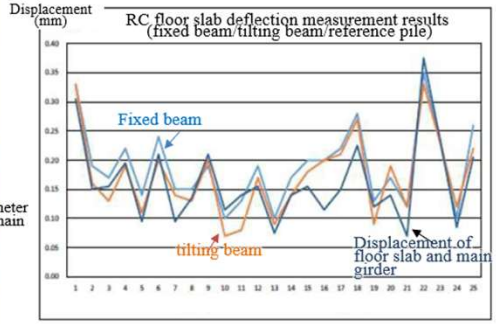


Image of optical fiber installation



Example of monitoring results





CH. 3 Monitoring of Concrete Girders

1. Purpose and Types of Monitoring

- 1.1 Target Structures and Deformations
- 1.2 Current Status and Issues in Inspecting Concrete Girders
- 1.3 Purpose of Monitoring and Assumed Scenarios

2. Concept of Monitoring Technology and Management Standards

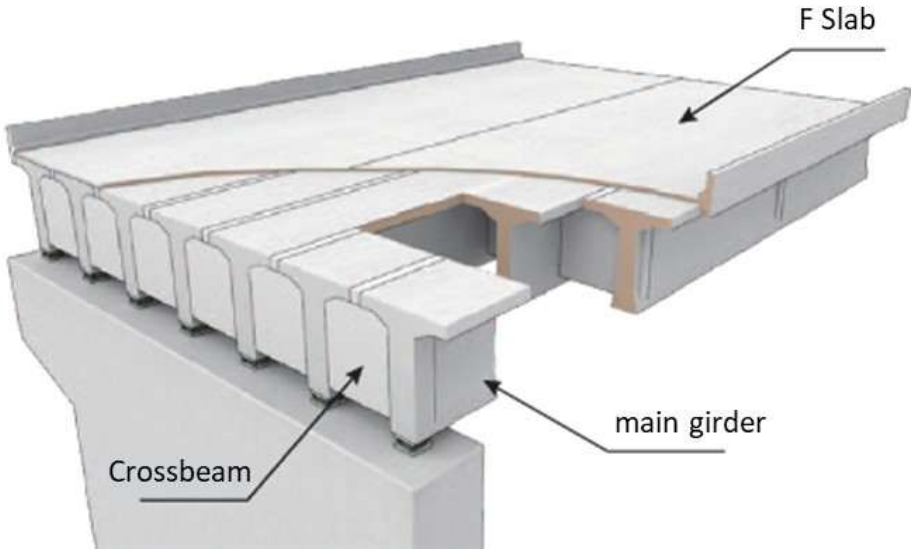
- 2.1 Types and Purpose of Monitoring Techniques
- 2.2 Criteria for Implementation of Monitoring Technology
- 2.3 Concept of Co Criteria in Monitoring

3. Cost Concept and Implementation Examples

- 3.1 Cost Concept
- 3.2 Examples of Implementation

CH. 3 Monitoring of Concrete Girders

- Target structures and damages



• Visible

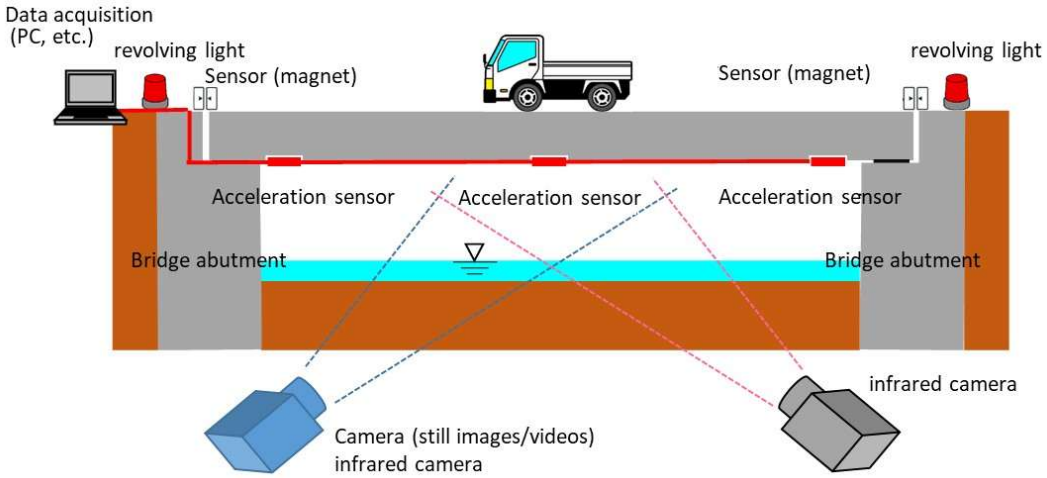
cracks, delamination, rebar exposure, water leakage, efflorescence , deformation of repair and reinforcement materials, abnormality in the fixing unit, discoloration, deterioration, defect, and abnormal displacement of girder ends that are visible on the exterior

• Invisible

concrete delamination, the harmfulness of crack, internal corrosion and the reduction in rigidity due to fatigue damage

CH. 3 Monitoring of Concrete Girders

- **Types and Purposes of Monitoring**



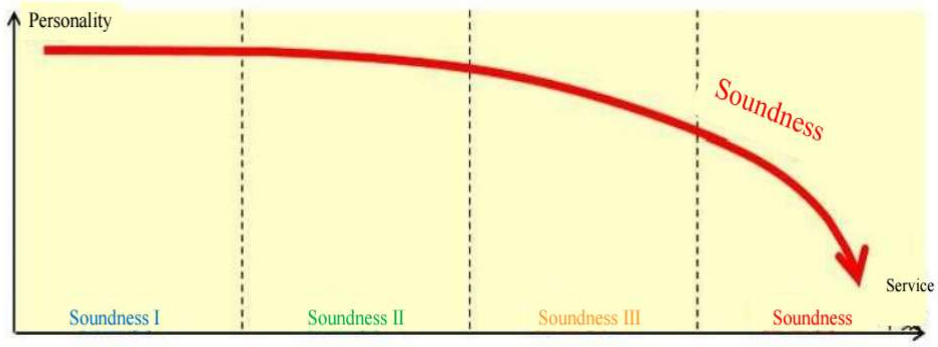
Target Deformation	Type of monitoring	Purpose of Monitoring*.								
		Inspection assistance		Diagnostic assistance					Verification of effectiveness of repair and reinforcement	Emergency response
		A	B	C	D	E	F	G	H	I
Separation and delimitation	Floating and delamination monitoring using infrared thermography method (periodic measurement)	○	○							
General appear acne deformation	Deformation by image processing Monitoring (periodic measurement)	○		○						
Crack	Monitoring of crack by video processing (periodic measurement)					○				
Change in rigidity	By 3-axis acceleration sensor Diagnosis of soundness (periodic and constant measurements)		○ Periodic			○ Normal				
Abnormal displacement of the end of girder	Abnormality detection monitoring of girder ends (Constant measurement)	○								○

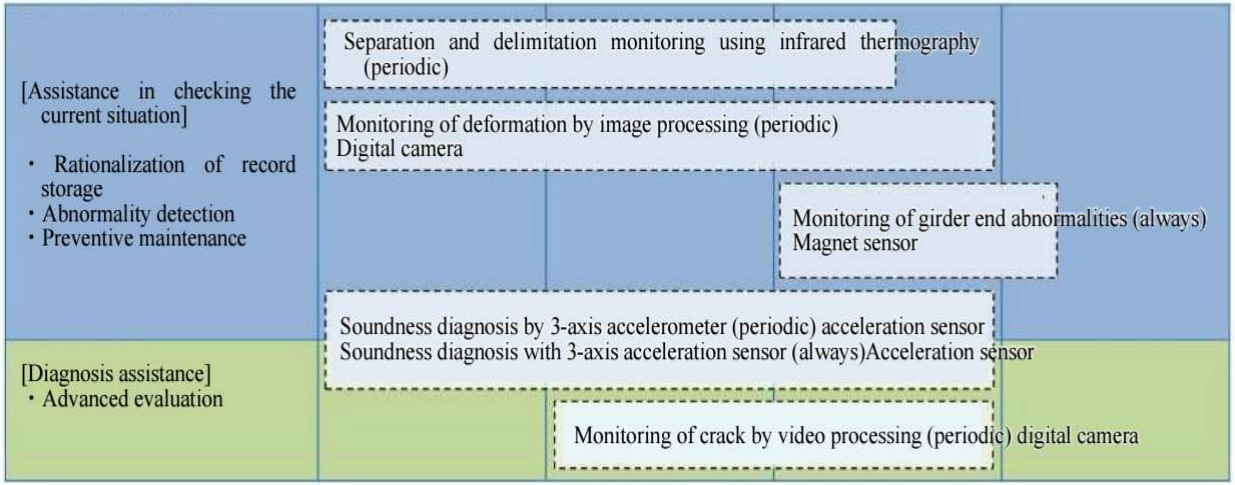
Legendary explanation of monitoring objectives

A Identify where abnormality occurred.
B Determine the sound range or the range requiring monitoring.
C Obtain the information necessary to determine the implementation of preventive maintenance.
D Obtain and compare quantitative data.
E Obtain qualitative and quantitative data to assess soundness.
F Confirm that conditions have not reached a state requiring traffic control or closure.
G Check the condition until measures such as repair and reinforcement are taken.
H Verify the effectiveness and sustainability of the measures.
I Identify areas where bridge collapse is predicted.

CH. 3 Monitoring of Concrete Girders

- **Types and roles of monitoring in the maintenance of concrete girders**





	Assumed scene	Purpose of Monitoring
Scenario 1	When it is difficult to approach a structure or it is necessary to implement large-scale restrictions, infrared thermography can replace the close visual inspection to monitor separation and delamination. Thus, the screening is performed reliably and efficiently.	Assistance in inspections (ensuring inspection accuracy and efficiency in locations that are difficult to visually inspect or access)
Scenario 2	Monitoring of deformation by image processing improves the efficiency of field work in visual inspection and recording of cracks in the main girder, as well as determining the location of the deformation.	Assistance in inspections (ensuring inspection accuracy and efficiency in locations that are difficult to visually inspect or access) Assist in diagnosis (obtain information necessary to determine implementation of preventive maintenance)
Scenario 3	When cracks in the main girder are found during periodic inspections, the crack can be monitored by video processing.	Assist in diagnosis (obtain qualitative and quantitative data for soundness assessment).
Scenario 4	For bridges that are difficult to determine by visual inspection alone, the structural integrity of the main girder and other structures is confirmed by evaluating changes in rigidity through vibration analysis using a 3- axis acceleration sensor.	Assist in inspections (determine the healthy range or the range that needs monitoring). Diagnostic assistance (obtain qualitative and quantitative data for soundness assessment)
Scenario 5	For bridges whose condition is difficult to be determined by periodic inspections, monitoring to detect abnormalities at the end of girders can be used to immediately determine the occurrence of abnormalities. It also can determine whether the bridge should be closed or require traffic control.	Assist in inspections (identify any abnormality) Assistance in emergency response (identify locations where bridge collapse is predicted)

CH. 3 Monitoring of Concrete Girders

- **Types and Purposes of Monitoring Techniques**

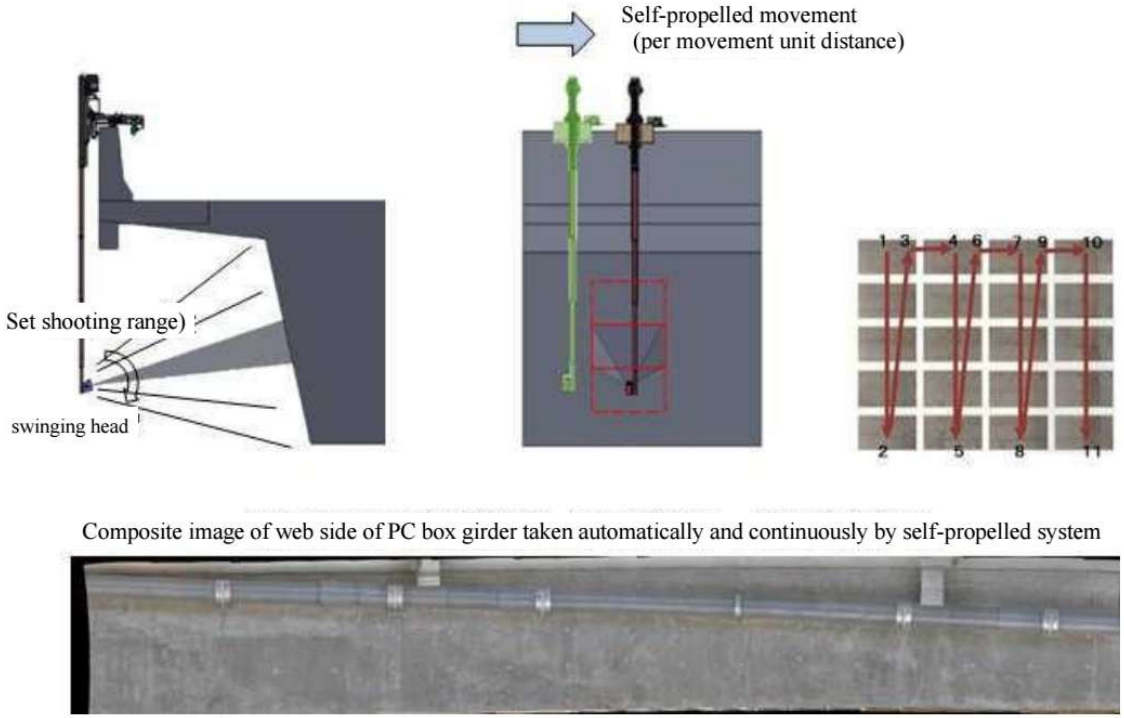


Figure 3.2.1. Example of monitoring deformation using image processing with a self-propelled bridge inspection camera

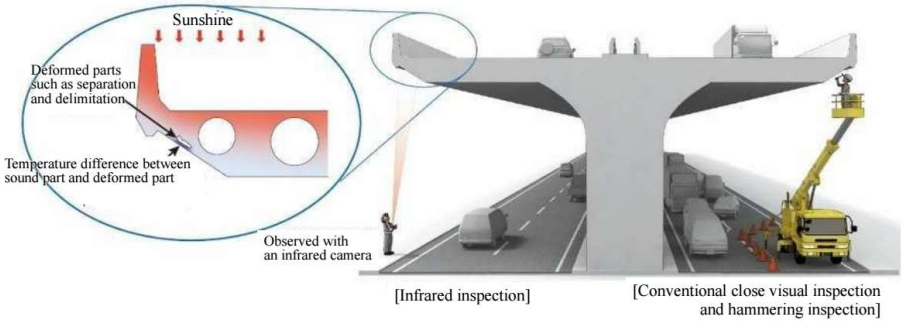


Figure 3.2.2 Inspection using infrared method

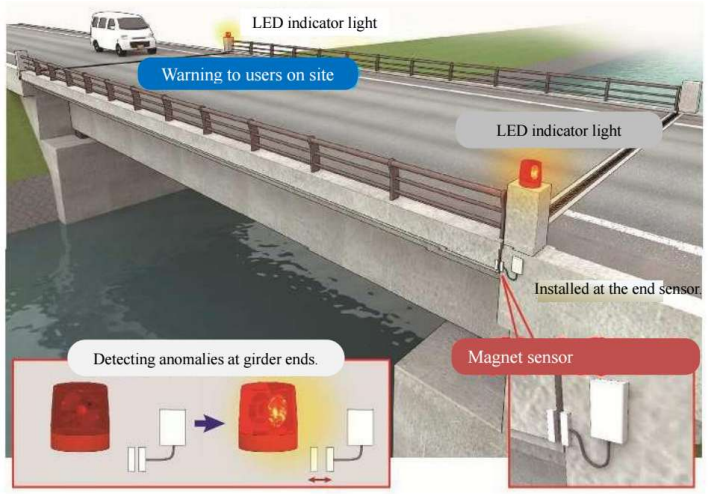
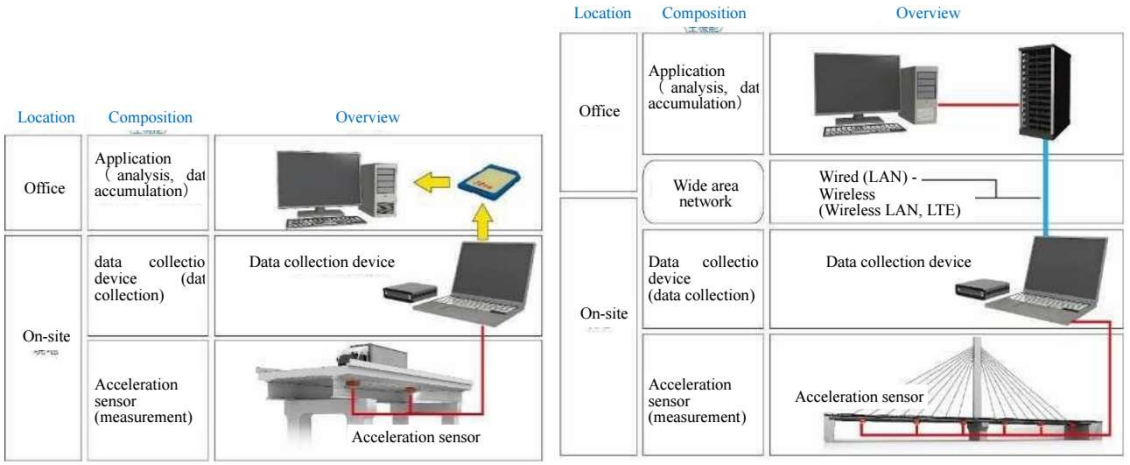


Figure 3.2.3. Example of Monitoring for Detecting Abnormality at Girder Ends

CH. 3 Monitoring of Concrete Girders

- **Types and Purposes of Monitoring Techniques**

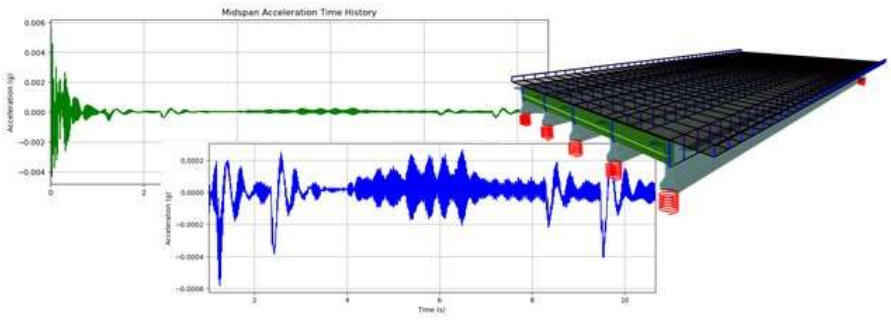
Figure 3.2.4. Monitoring of Crack Using Video Processing



Offline type system

On-line type system

Figure 3.2.5 Soundness Diagnosis System Using Acceleration Sensors



CH. 3 Monitoring of Concrete Girders

- Concept of Management Criteria in Monitoring

(1) For monitoring of separation and delamination, the depth of the condition is classified in stages, and the change in the range of the condition compared to past results is used as the standard for management.

(2) For monitoring of cracks, the width of the cracks, the temporal change in the range of the cracks, and particularly sudden changes, are used as the standard for management.

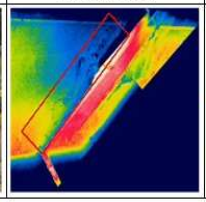
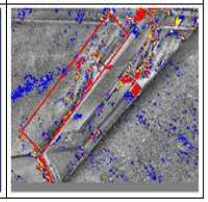
(3) In vibration analysis using an accelerometer, management standard values are estimated from both preliminary analysis and actual measurements regarding the natural frequency and frequency spectrum. Damping vibrations and deflection angles are considered for management standards, with reference to the values described in design documents and road bridge instructions.

(4) In the detection of abnormal displacement at the girder ends, the measurement accuracy of the device is taken into account, and past disaster cases, etc. are referred to when considering management standards.

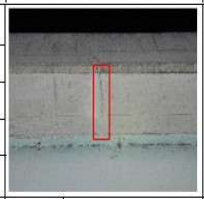
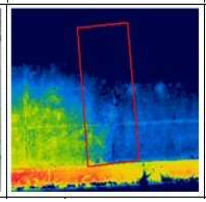
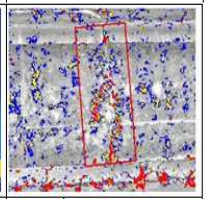
CH. 3 Monitoring of Concrete Girders

- **Cost Concept and Implementation Examples**
  - **① Preliminary Work Cost**
  - **② Measurement Cost**
  - **③ Data Organizing Cost**
  - **④ Other Costs (data storage and indirect cost)**

Results of the critical assessment for rust juice (end of the girder)

Damage Detection Status		Visible image	Close-up visible image	Infrared imaging	Support system image
Location of injury	Overhang (Running)				
Damage extent(m)	1.36 × 0.25				
Appearance findings	Rust juice				
remarks					
judgment result	Be careful				

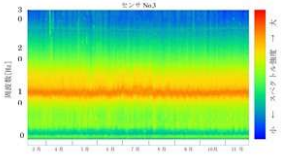
The critical judgement results of the cracked (protruding floor plate).

Damage Detection Status		Visible image	Close-up visible image	Infrared imaging	Support system image
Location of injury	Overhang (passing)				
Damage extent(m)	1.06 × 0.47				
Appearance findings	crack				
remarks					
judgment result	Be careful				

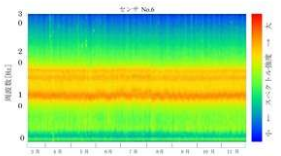
Full View of Load Testing

Sensor Installation Status

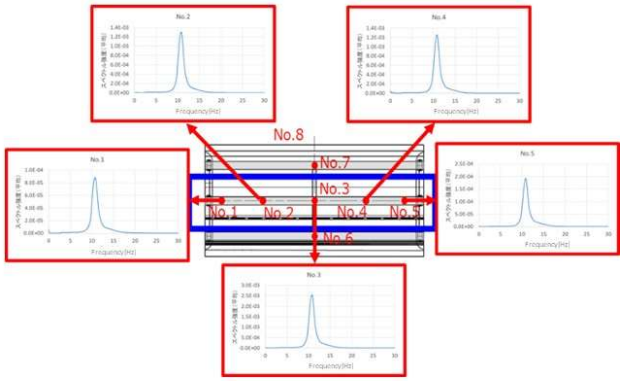
Sensor Installation Status



Spectrogram
Central column (central part)



Spectrogram
Roadside Girder (Central Part)

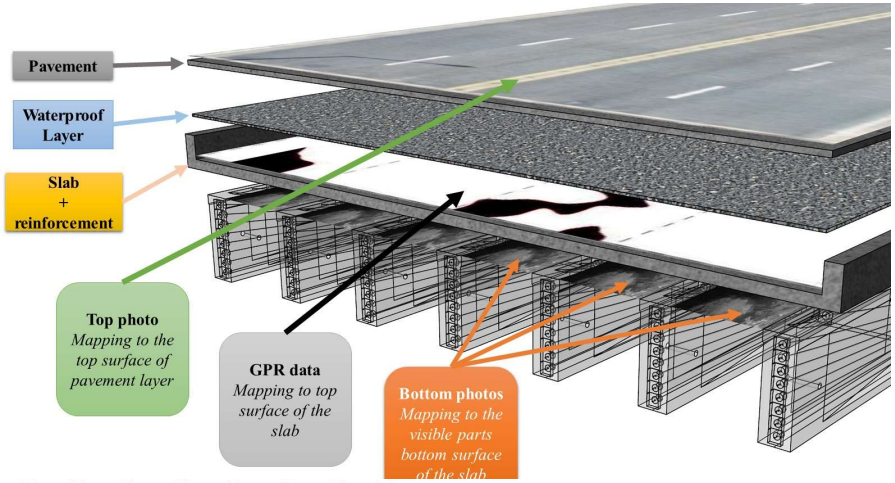


Power Spectrum in the Bridge Axial Direction

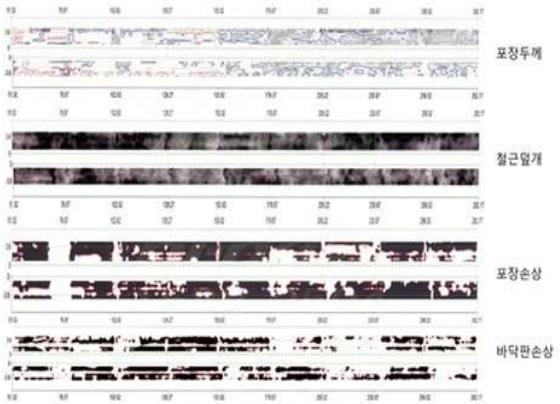
Vibration Analysis Technique of Main Structures using Low-Frequency 3-Axis Acceleration Sensor

Improvement

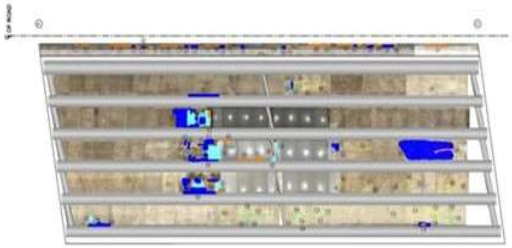
- **Data Standard for international Collaborative Research on Data-driven Assessment**

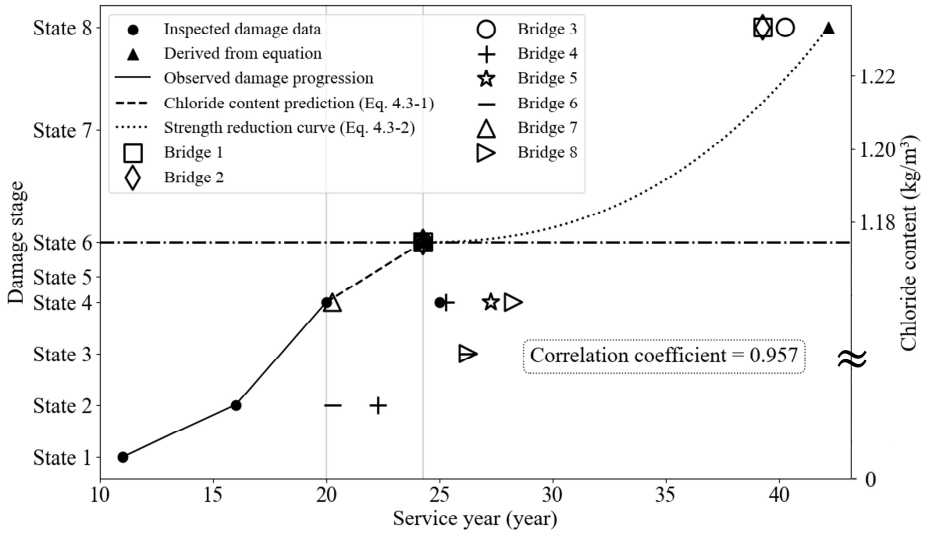


GPR



Vision inspection





Assessment of future performance based on Data

- **KPI : key performance indicator**
- **Visual and sensing data**
- **AI service**