■ R&D Topics : Inspection, Monitoring and Diagnostics Technologies
■ R&D Theme : Improvement for More Advanced and Efficient Road Structure Maintenance using Monitoring Technology
■ Principal Investigator : Atsushi Homma (Research Association for Infrastructure Monitoring System)

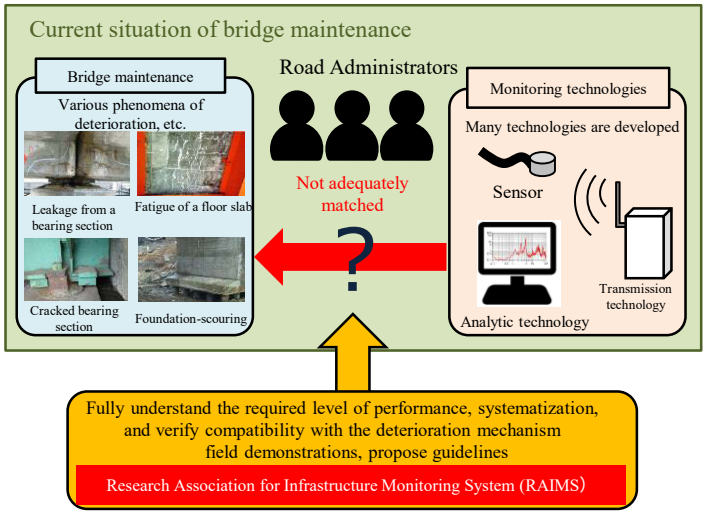
R&D Objectives and Subjects

SIP Cross-ministerial Strategic Innovation Promotion Program

R&D Objectives

Current situation: Although a lot of monitoring technologies and products for bridges are developed, the road administrators cannot choose technologies and how it should be applied since the practical specifications are not standardized.

To make the maintenance cycle more sophisticated and more efficient, propose guidelines to introduce the most advanced monitoring systems to bridge management based on experiments, analysis, and field demonstrations in accordance with the needs of the actual road administrators.



R&D Subjects (FY2014 to FY2018)

- Classify and analyze road administrators' needs for monitoring technologies
- Examine the relationship between measurement data, which are obtained from monitoring technologies, and damage to structures by conducting laboratory experiments and field demonstration experiments
- Develop scenarios for introducing monitoring technologies to bridge maintenance works, and make guidelines for monitoring systems

Achieve more advanced and more efficient bridge maintenance works through facilitating the introduction of monitoring technologies by guidelines for road administrators.

Current Accomplishments (1/2) (Implemented between FY2014 and FY2016)

1.Study the needs of road administrators and the required performance of roads and bridges

Collect and classify information about monitoring technologies based on road administrators' request.

(1) Classify road administrators' needs (documentary survey, discussion with experts, etc.)
(2) Classify the adaptation status of monitoring for bridge maintenance (conduct interviews with road administrators of local public bodies)
(3) Examine the required monitoring performance

Classification	Objectives of administrators	Needs of maintenance	Objectives of monitoring
Monitoring to support inspection	Reduce the number of failures to notice deformations during routine inspections (screening)	Improved efficiency	Understand the section where some kind of abnormality occurred (it does not matter whether the phenomenon is identified or not)
	Reduce inspection time and cost by narrowing the range of regular inspection	Improved efficiency	Understand the range where soundness has been confirmed (inspection is considered unnecessary)
Monitoring to support diagnosis	Prevent aggravation of deterioration and damage by taking preventive maintenance measures	Sophistication	Understand when it has reached the point where preventive maintenance measures should be taken.
	Prioritize actions	Improved efficiency	Obtain quantitative data to conduct an objective evaluation
	Maintain the service status	Improved efficiency	Check if it has reached the point where traffic restrictions or road closures should be carried out
Monitoring to confirm the effects of repairs and reinforcement	Confirm appropriateness of the measures	Sophistication	Confirm the effectiveness and durability of the measures
Monitoring to support measures during an emergency	Shorten the time until traffic restrictions are removed (express highway)	Improved efficiency	Understand the section where the risk of bridge collapse is predicted
	Shorten the time that dangerous spots for traffic are left unaddressed (ordinary roads)		

Particularly important needs of road administrators

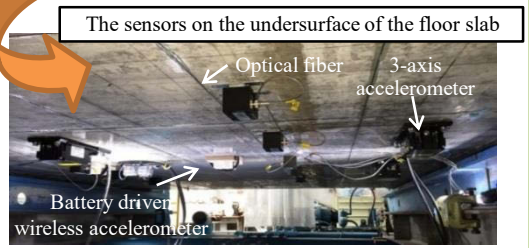
- Deal with the growing burden caused by mandatory close visual inspections
- Support the inspection of areas which are difficult to approach, such as an overpass
- Monitor bridges that need measures but they cannot be taken for a while
- Monitor important regional bridges at low cost

- **Matching the applicable situation with the applicable monitoring technology required by road administrators**

2. Floor slab monitoring experiments / RC girder monitoring experiments

Laboratory experiments (2015)

To confirm the applicability of the sensors, deflection and cracks were monitored while replicating fatigue failures of the floor slab with a wheel-load running test using a specimen. The applicability of the sensors for each phase of deterioration was confirmed.

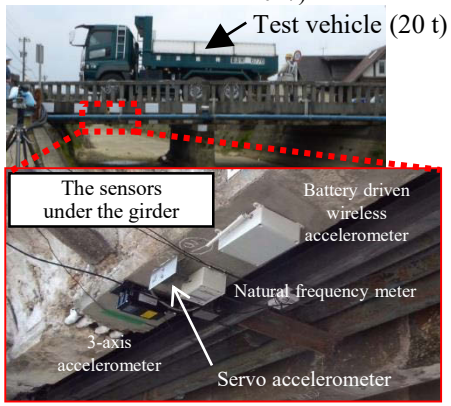


Performed mapping of deterioration phenomenon that should be noticed and monitoring technologies that can catch the phenomenon in accordance with the soundness of the bridge.

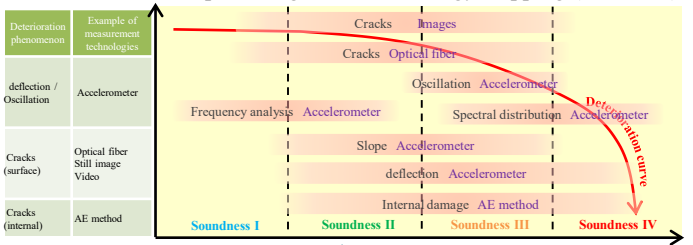
- **Develop guidelines for practicable and effective monitoring methods based on the soundness of the floor slab and girder.**

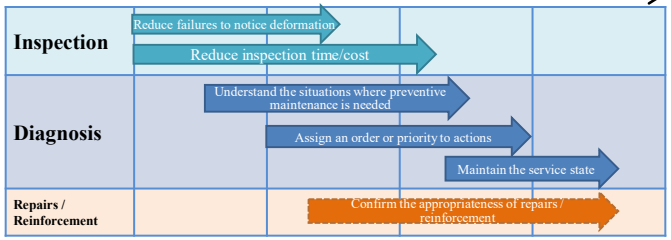
Field demonstration experiments (2016)

Deflection and cracks were monitored at actual bridges mainly using the sensors whose usability was confirmed during the laboratory experiments. The applicability of the sensors in an outdoor environment was confirmed. (Some measurements will continue until 2017)



Conceptual diagram of technology mapping (floor slab)





Current Accomplishments (2/2) (Implemented from FY2014 to FY2016)

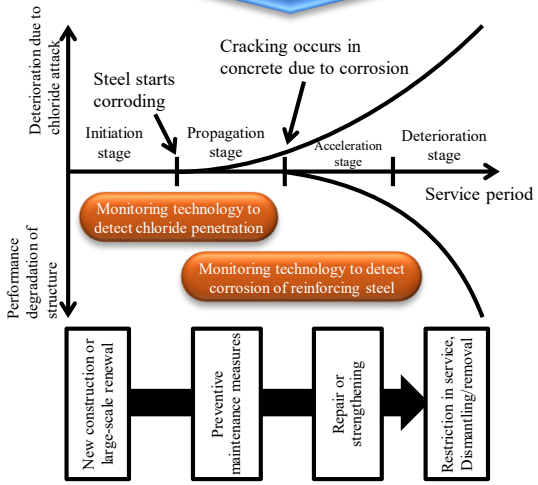
3. Monitoring system for concrete structures under chloride attack

Accelerating tests on RC beam specimens (2015)

Performed accelerating tests by salt water immersion and electrolytic corrosion using RC beam specimens, in which 6 sensors were installed for monitoring re-bar corrosion and chloride penetration. Performance of the sensors was evaluated focusing on applicability for existing bridges.

Verification tests on existing bridges(2016)

Installed sensors to monitor the progress of deterioration due to chloride attack to existing bridges and verify their applicability in on-site environment.
(Measurements will continue until 2017)



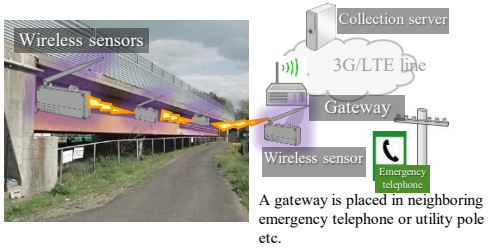
Mapped applicable monitoring technologies based on the progress of deterioration.

- **Develop guidelines for practicable and effective monitoring methods based on the state of deterioration due to chloride attack.**

4. Evaluate wireless communication methods

Field experiment of wireless method assuming collection of monitoring data.

(1) Fixed-point collection type monitoring
To confirm the possibility of multi-hop wireless communication among sensor installation points, the range of communication at various locations of the bridge were measured.



An image of fixed point collection type monitoring system

(2) Patrol collection type monitoring
Focused on a technology that wirelessly collects sensor data using vehicles running at 80 km/h, we confirmed that a routine inspection patrol vehicle doing other work is able to collect the data.

- **Develop guidelines for specific methods to collect monitoring data using wireless communication.**

Utilization Flow of Results

1. Examine road administrators' needs and required performance

Demonstrate bridge monitoring systems

2. Floor slab monitoring RC girder monitoring

3. Monitoring for chloride attack

4. Evaluate wireless communication methods

Other monitoring Data storage, etc.

Make guidelines to introduce monitoring systems

Bridge maintenance works are able to become more sophisticated and more efficient as the monitoring system becomes easier to use.

Goals

Final target value

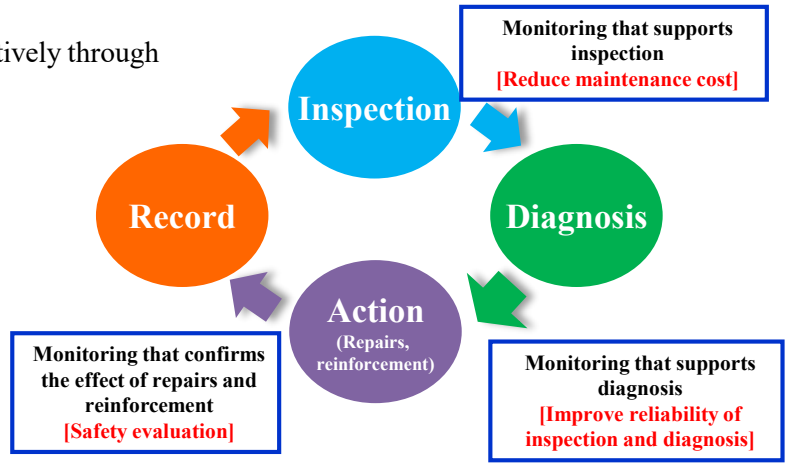
Aim to achieve a service life of 100 years by maintaining bridges appropriately and effectively through the facilitation of the use of monitoring in accordance with the guidelines.

Target users

All road administrators (the state, local public bodies, expressway companies, etc.)

Usage method, locations to use, etc.

Introduce monitoring systems in accordance with the objectives, target bridges, management systems, etc. to the inspection guides etc. for each road administrator based on the guidelines.



Flow of spreading the guidelines

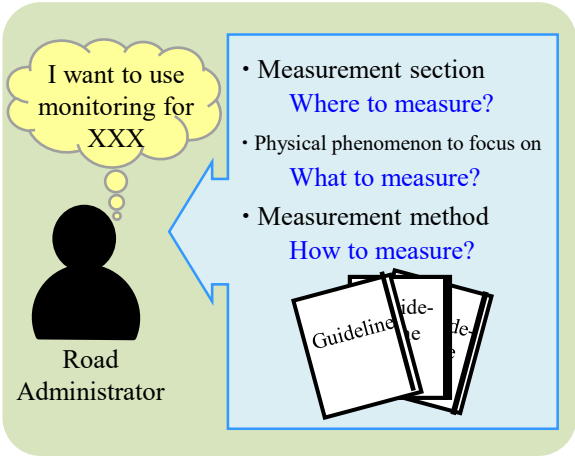
Share the results at lectures, technology exhibitions, etc.
Cooperation with local public bodies

Promote the use of monitoring for national roads, expressways
Send information/give advice to local public bodies

Outline the service provided

Propose utilization methods of monitoring systems for bridge maintenance using guidelines
[Examples of expected use]

- Improve the efficiency of inspection works by making more effective inspection plans based on regular monitoring data.
- Improve the accuracy of inspections and reduce the number of failures to notice damage by carrying out monitoring to help to inspect spots that are difficult to access.
- Improve safety by introducing monitoring to damaged structures.
- Devise reasonable repair and reinforcement methods by confirming the effects after any repairs and reinforcement through monitoring



It's possible to introduce a monitoring system that matches the objectives of road administrators

→ Achieve more advanced and more efficient bridge maintenance works