



# R&D of monitoring system including a detection of river levee deformation



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## R&D Objectives and Subjects

### Objectives

#### Conventional levee inspection

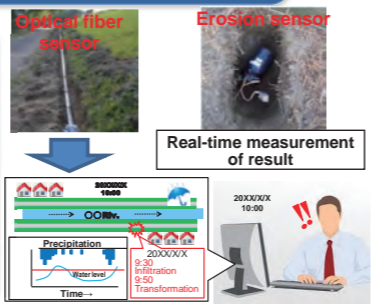


- Identify deformation by visual inspection on foot.
- Issues
  - Difficulty in detecting deformation depending on the frequency of weeding or weather conditions.
  - Securing personnel for inspection, which is likely to become more challenging from now on

#### Development of new inspection technology

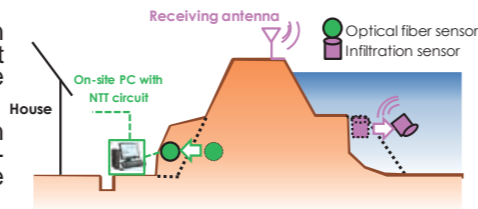
- Identify levee deformation with optical sensor or erosion sensor

- Merits
  - Available to identify minute deformation of a levee body quantitatively
  - Available to measure the result in real time with a monitoring system



### Subjects (2014-2018)

- If part of levee transfers or transforms at a position where an optical fiber sensor is installed, the sensor follows the movement and measures the location having the deformation and the damage level of the levee in real time.
- Detect erosion and corrosion by a posture change of an erosion sensor, and notify it from underground/water in real time by a low-frequency electromagnetic wave. Conduct measurement of the location of erosion in real time.



While not requiring visual inspection, realize a monitoring system that allows measurement of levee deformation due to infiltration or erosion.

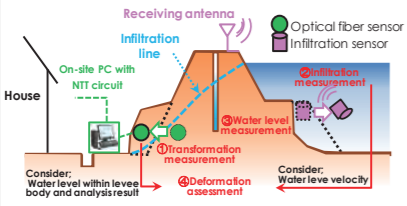
## Current Accomplishments (1/2)

(2014-2016)

### 1. Developing Monitoring System for Levee Deformation with Sensor Devices

Operations undertaken at a levee along the Shonai-River;

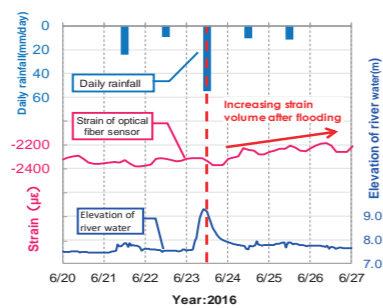
- Measurement/organization with an optical fiber sensor
- Measurement/organization with an erosion sensor
- Measurement of water level within levee body
- Evaluation of deformation identified with sensor devices
- Development of system



- Realized the monitoring of levee deformation with an optical fiber sensor and an erosion sensor

### 2. Measuring Levee Deformation with Optical Fiber Sensor

Conducted measurement of levee deformation (strain) with the optical fiber sensor. The strain grew in a compressed direction accompanying an increase in precipitation or water level.

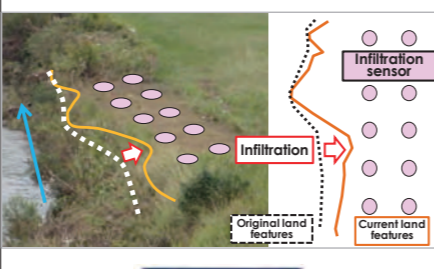


- Realized identification of the transformation of levee body (transfer of the levee body) accompanying flooding with the optical fiber sensor

### 3. Measuring Levee Deformation with Erosion Sensor

Conducted measurement of the levee deformation (the presence of erosion) with the erosion sensor.

Accompanying flooding, the water level increased by exceeding the height of the erosion sensor installed. The erosion extended to a length of approx. 50 cm around the sensor. (Stopped just in front of the sensor location)



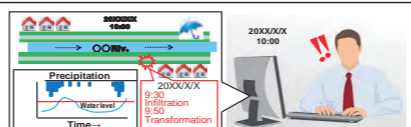
- Realized detection of erosion that occurred underwater with a wireless signal from the sensor device

- #### Utilization example
- Formerly: Patroller detects the deformation due to infiltration by visual inspection.
  - Formerly: Impossible for patroller to detect the erosion because it occurs under water.



Utilize to improve a certainty of river management and save work in terms of the following operations.

- Quantitatively identify the deformation due to infiltration with the optical fiber sensor.
- Identify the erosion phenomena caused under water with the erosion sensor.
- Possible for administrator to identify the above deformation in real

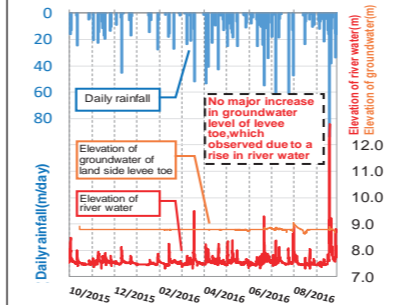


## Current Accomplishments (2/2)

(2014-2016)

### 4. Measuring Water Level within Levee Body

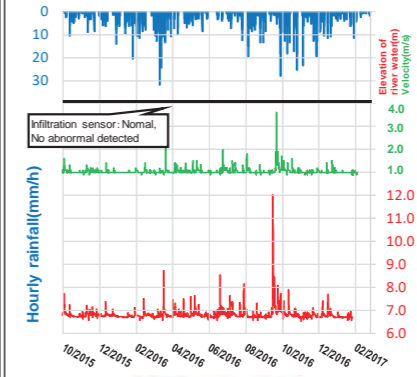
Conducted the measurement of water level within the levee body. Focused on the phenomenon that levee deformation grows according to the water level within the levee body.



- No escalation of water level up to a saturated extent of levee as far as the flooding of this scale type

### 5. Evaluating Deformation Identified by Analysis Model

- Assessment of deformation due to erosion



- In Sep 2016, the velocity was around 3.6 m/s and the erosion caused at that time was approx. 50 cm. While the erosion sensor was running properly, nothing was detected.

Assessment of deformation due to infiltration. With seepage analysis, trace a time history of growth of the infiltration line within the levee body by taking the precipitation and the river level when flooding as external forces.

Analysis item	Max value of local hydraulic grade		Heaving
	Vertical direction	Horizontal direction	
Review criterion value	<0.5	<0.5	>1.0
Result	0.300	0.447	-
Judgment	O.K.	O.K.	-



Compare with the measurement result of deformation/water level by optical fiber sensor and the analysis result.

- By developing the correlation diagram between the volume of strain measured with the optical fiber sensor as well as the water level within the levee body, we can identify the moisture condition inside of the levee body, which affects the levee deformation.

## Practical Process Flow of Outcomes

- Developing Monitoring System for Levee deformation with Sensor Devices
- Measuring Levee Deformation with Optical Fiber Sensor
- Measuring Levee Deformation with Erosion Sensor
- Measuring Water Level within Levee Body

## 5. Comparative Verification of Measurement Results Derived from Analysis Model

Realize real-time and quantitative monitoring of levee deformation with an optical fiber sensor and an erosion sensor.

## Goals

### Numerical targets

Realize a cost reduction by 60% compared to that of the conventional visual inspection for the following flood fighting points:

- Critical flood fighting point A (38.6 km) against infiltration
- Critical flood fighting point A (84.0 km) against erosion (For the case of LCC 10 years later)

### users

- Administrators of rivers under Ministry of Land, Infrastructure, Transport and Tourism
- Administrators of Class B rivers under prefectures
- Embankment administrators of railways or roads, etc.
- Observers of slope deformation, etc.

### how to use/Places of use

- In order to monitor the deformation due to infiltration/erosion at rivers under direct control and Class B rivers under prefectures, install sensors at estimated critical flood fighting points.

### Services to Offer

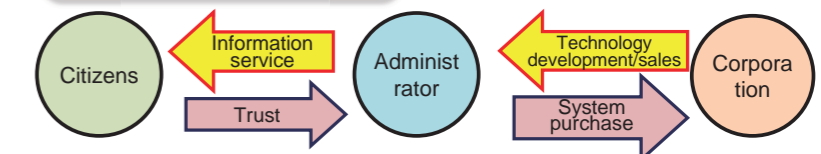
Instead of the conventional qualitative levee management by visual inspection, obtain quantitative real-time information at site office

By utilizing the real-time information and promptly providing information to protect people's lives and property, contribute to "No failure to escape" and "Minimization of damage on socio-economy."

### Cost comparison list

	Visual inspection	Optical fiber sensor	Erosion sensor
Position installed	---	Three units	Single unit
Installation cost	---	¥112 mill	¥38 mill
Maintenance cost/yr	¥16 mill	¥3 mill	¥3 mill
LCC of 5 yrs later	¥82 mill/5yrs	¥126 mill/5yrs	¥53 mill/5yrs
LCC of 10 yrs later	¥164 mill/10yrs	¥141 mill/10 yrs	¥66 mill/10 yrs
Cost items	Labor cost	Materials + Construction + Labor cost	Materials + Construction + Labor cost
Availability of measurement	Impossible: At night or when covered with flourish vegetation	24 hrs, 365 days available	24 hrs, 365 days available

### Sales method



On the basis of the new technology developed, the administrator provides the information to citizens. By providing high quality information, the administrator earns the citizens' trust, and furthermore, the system is manufactured/procured. This enables generation of profits.

