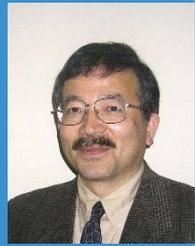
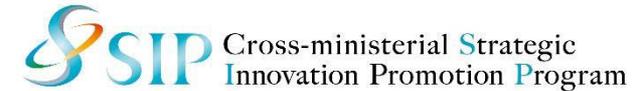


- R&D Topics : Inspection, Monitoring and Diagnostics Technologies
- R&D Theme : Ultrasensitive Magnetic Nondestructive Testing for Deterioration Evaluation and Creating a Preservation Plan of Infrastructures
- Principal Investigator : Keiji Tsukada (Professor, Okayama University)
- Collaborative Research Groups : SUSTERA, JAPEIC, Kyushu University



# R&D Objectives and Subjects



## Objectives

The purpose of this research is to develop a non-destructive testing (NDT) method using highly-sensitive magnetic measurements. Many infrastructural elements, such as bridges, are composed of steel, and the corrosion and cracking of steel can lead to serious problems. Conventional magnetic NDT methods are limited to only surface evaluation of steel structures. Therefore, in this study, we fabricate an inspection instrument that uses a magneto-resistive (MR) sensor and a SQUID sensor, which has the highest sensitivity among magnetic sensors, to realize a new NDT method using magnetic measurement to evaluate corrosion and cracking within and behind steel structures. Comprehensive development of the measurement and analysis method is carried out for detecting changes in magnetic signals due to corrosion and cracking of various steel structures, and a guideline for infrastructure management is established based on the developed NDT method.

## Subjects

- **Basic magnetic inspection system:** To realize quantitative evaluation and visualization of flaws in a way that can be understood by anyone without expertise, a magnetic inspection system was developed that can detect flaws inside steel structures of various shapes, and the method of extraction and display of flaws was examined.
- **Instrument for field inspections and field tests:** Two types of inspection instruments were developed; a portable instrument using an MR sensor and a highly sensitive instrument using SQUID, and the structure of the inspection part and system size, including power supply, were optimized to install the actual device easily. Using these instruments, a field test was performed and the usefulness of these two instruments was clarified.
- **Social implementation:** We spread information about the usefulness of the developed new magnetic inspection method both inside and outside Japan, and promoted standardization for JIS and ISO.

## Portable inspection equipment using magnetic sensors

The magnetic resistive sensor-based non-destructive inspection method can detect not only surface defects but also inner defects because it can analyze magnetic response over a wide range of frequencies from extremely low to high. Furthermore, power consumption of the developed portable inspection equipment is low.

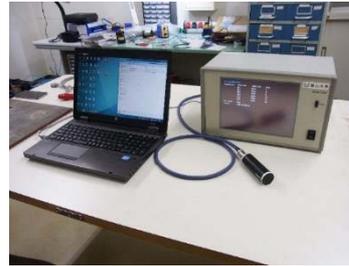
The developed magnetic inspection methods are as follows:

- Extremely low frequency eddy current testing (ELECT)
- Unsaturated AC magnetic flux leakage testing (USAC-MFL)

•**ELECT** can detect thickness changes in corroded iron steel plates. At present, the detection limit is 16 mm in thickness.

•**USAC-MFL** can detect surface and internal cracks in iron steel. Cracks with depths lower than 10 mm can be detected.

These developed magnetic non-destructive testing methods, ELECT and USAC-MFL, can be applied easily to painted and rusted surfaces.



Portable inspection equipment

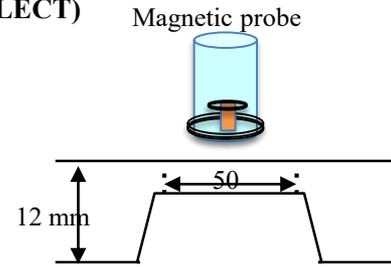


Magnetic probe for corrosion detection

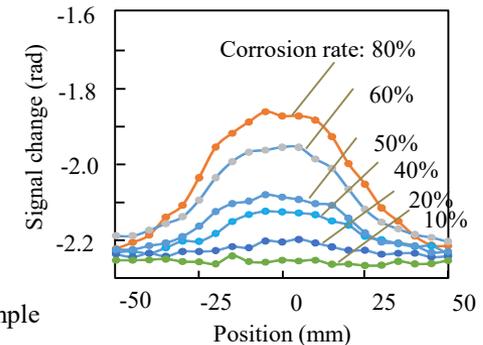


Magnetic probe for crack detection

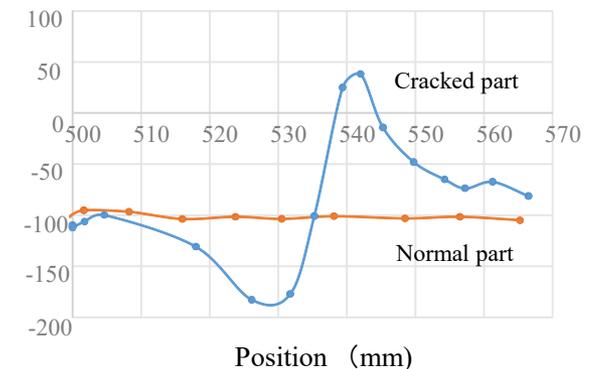
### Ultra low-frequency eddy current testing (ELECT)



Cross sectional structure of corroded test sample

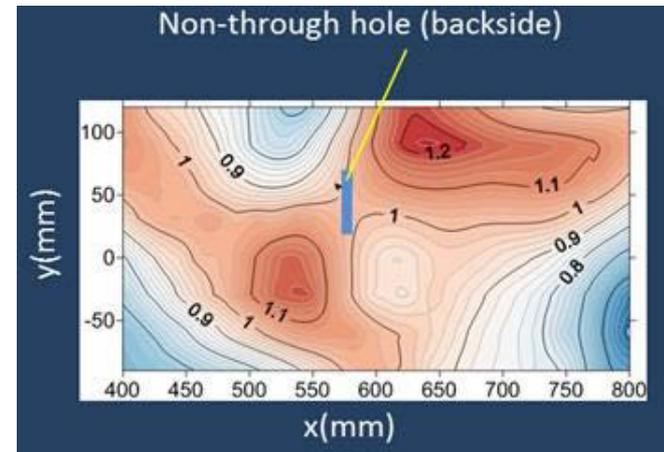


### Unsaturated magnetic flux leakage (USAC)



## Development of NDE system with ultra-high sensitivity

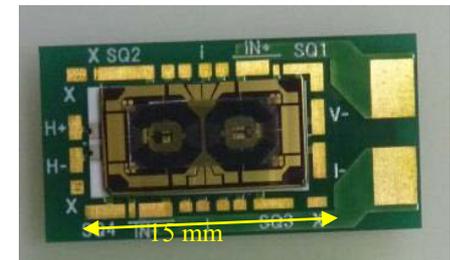
Superconducting quantum interference device (SQUID) magnetic sensors using oxide superconductors have ultra-high sensitivity and can be used by easy cooling with low-cost liquid nitrogen. Recently, fatigue cracks in steel deck plates which originate at the backside welding points have been recognized as a large problem in maintenance of bridges and metropolitan highways. Magnetic particle inspection or ultrasonic testing from the backside of the deck plates are currently used for maintenance. By utilizing a SQUID magnetic sensor which has ultra-high sensitivity even at low frequencies, development of a non-destructive evaluation (NDE) system which enables inspection of small fatigue cracks and further non-through cracks in steel deck plates through an asphalt pavement is expected. So far SQUID magnetic sensors with high tolerance against magnetization in steel plates have been developed, and detection of non-through slit-like defects in test steel plates from the distance comparable to the thickness of asphalt pavement has been demonstrated. Recently, an inspection system which can be applied to inspection on roads has been developed and trial testing on steel deck plates has started.



Example of detection of a non-through slit in a test steel plate

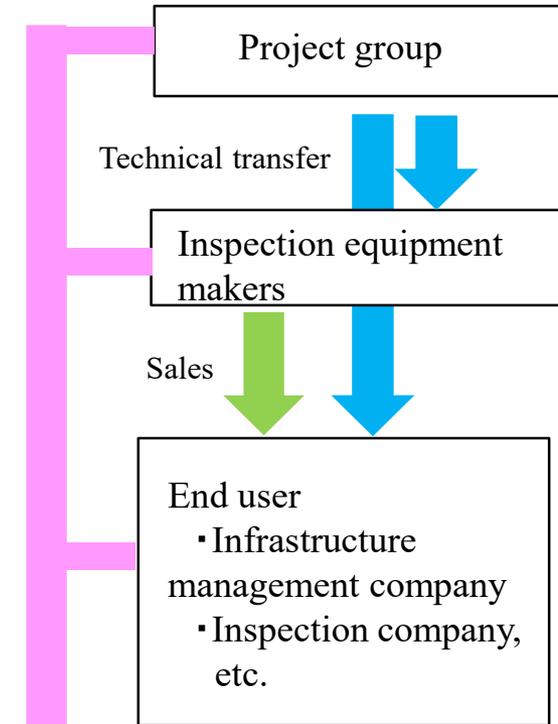


Inspection system for trial use on a road



SQUID magnetic sensor

## Large structure such as dam



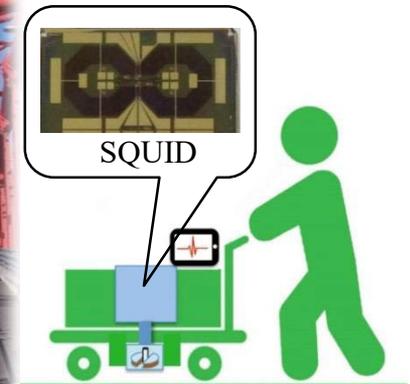
JIS, ISO standardization



Portable equipment



## Bridge



Ultra-high sensitive inspection equipment