

Applicability of Optical Fiber Sensor on Temperature Distribution Estimation and Leakage Detection of Impermeable Liner in Solid Waste Landfill

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1. Introduction

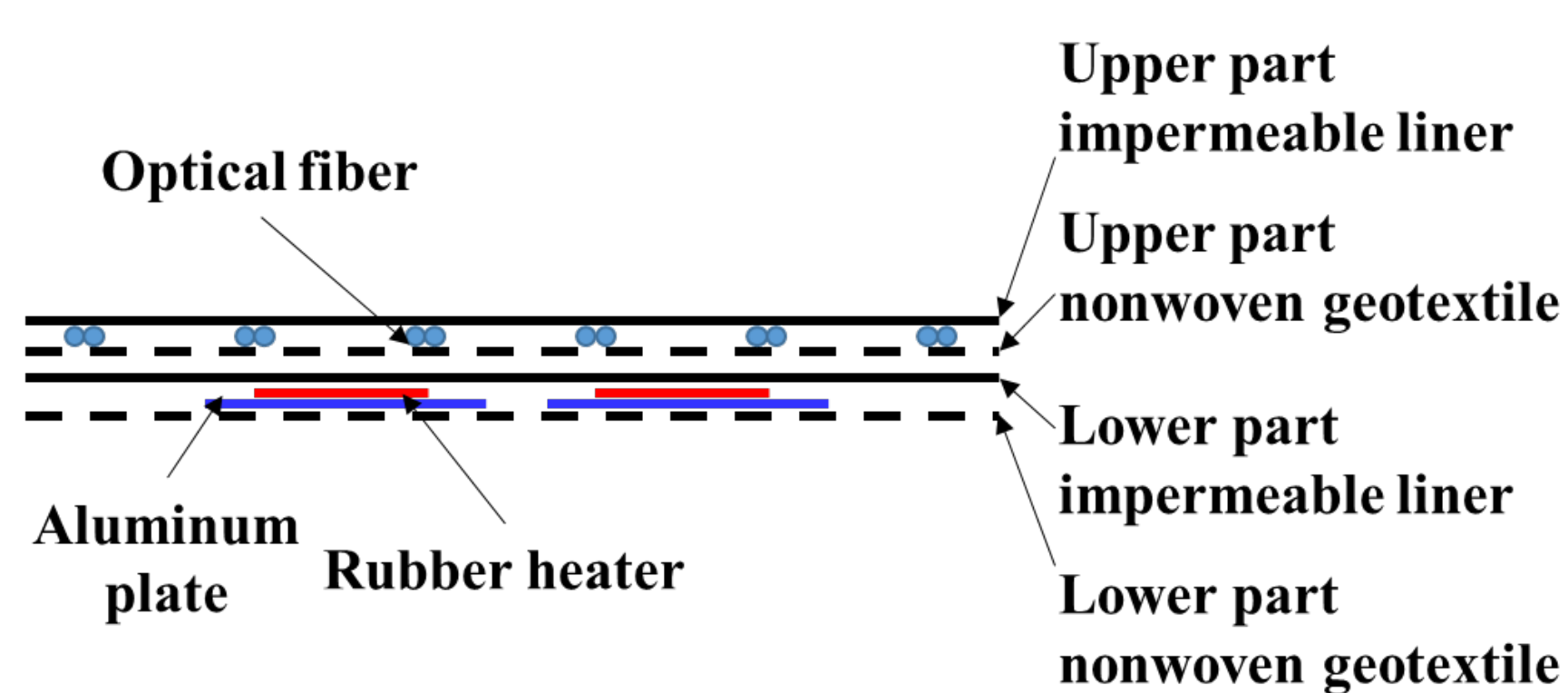
In solid waste landfills, where long-term monitoring is required, the introduction of IoT sensors is expected to lead to significant efficiency and labor savings. Fiber optic sensors are considered to be one of them. Optical fibers can measure physical quantities such as temperature, strain, pressure, and power by using the reflection and scattering of light. They have been used as a monitoring technology in recent years.

In current solid waste landfills, it is difficult to obtain information on the impervious surfaces at the boundary between the waste and the natural environment. Therefore, in this study, a mock-up test was conducted to clarify the possibility of monitoring the impervious wall and its surrounding environment using optical fiber technology. Two types of optical fiber sensors, Brillouin and Raman, were used in the experiment.

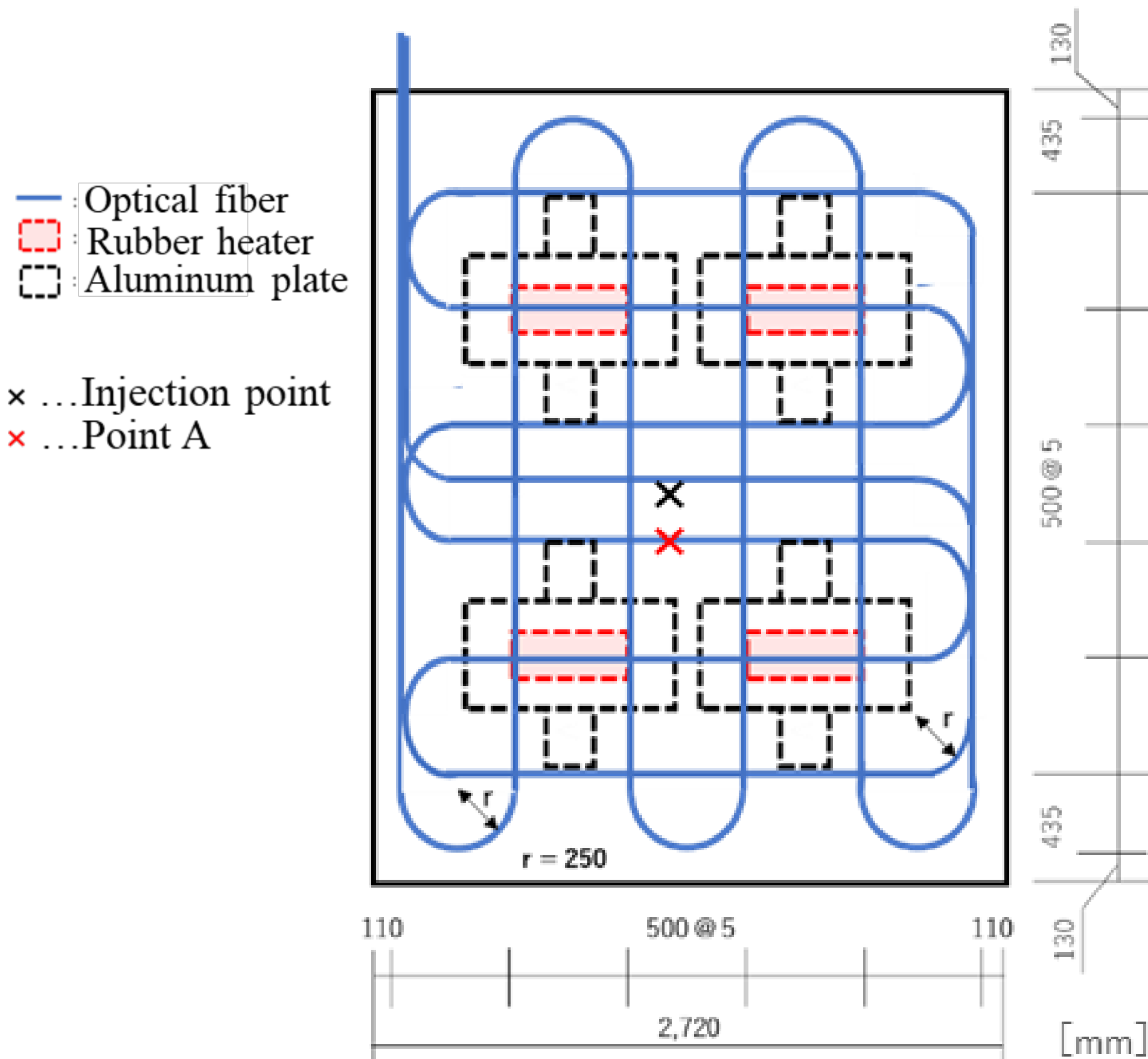
2. Research Methods



Slope Model with Impermeable Liner Laid



Cross-Sectional View of The Slope of The Girders



Schematic of Slope

1. Measurement of temperature distribution

A rubber heater was used to heat the impervious sheet. The purpose is to confirm that the temperature distribution can be monitored by optical fiber.

2. Leak detection

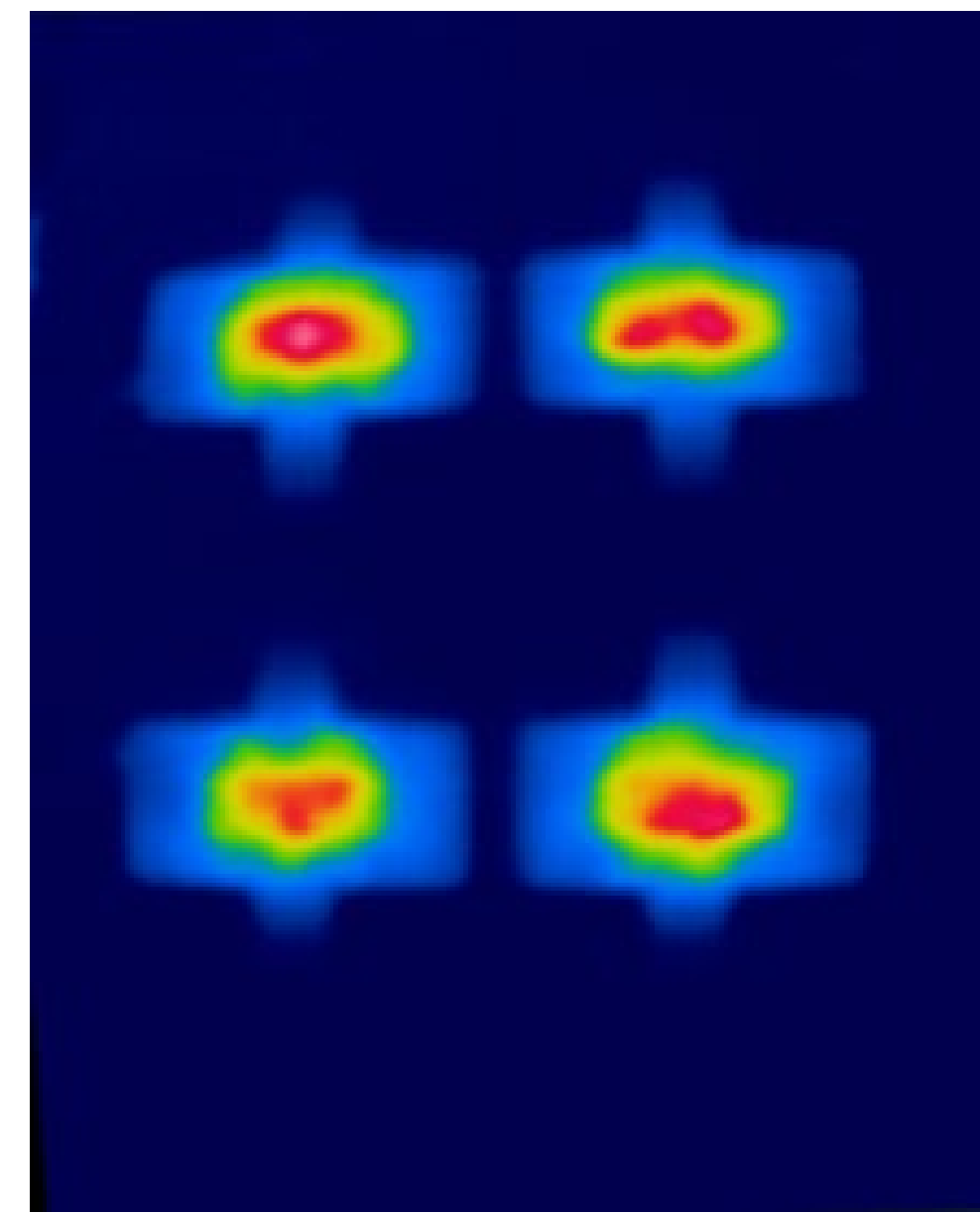
Assuming that the impermeable liner was damaged, water was injected under the sheet. The purpose is to make sure that leaks are detectable.

We examined whether vertical or horizontal placement of optical fibers is more appropriate for detecting leaks.

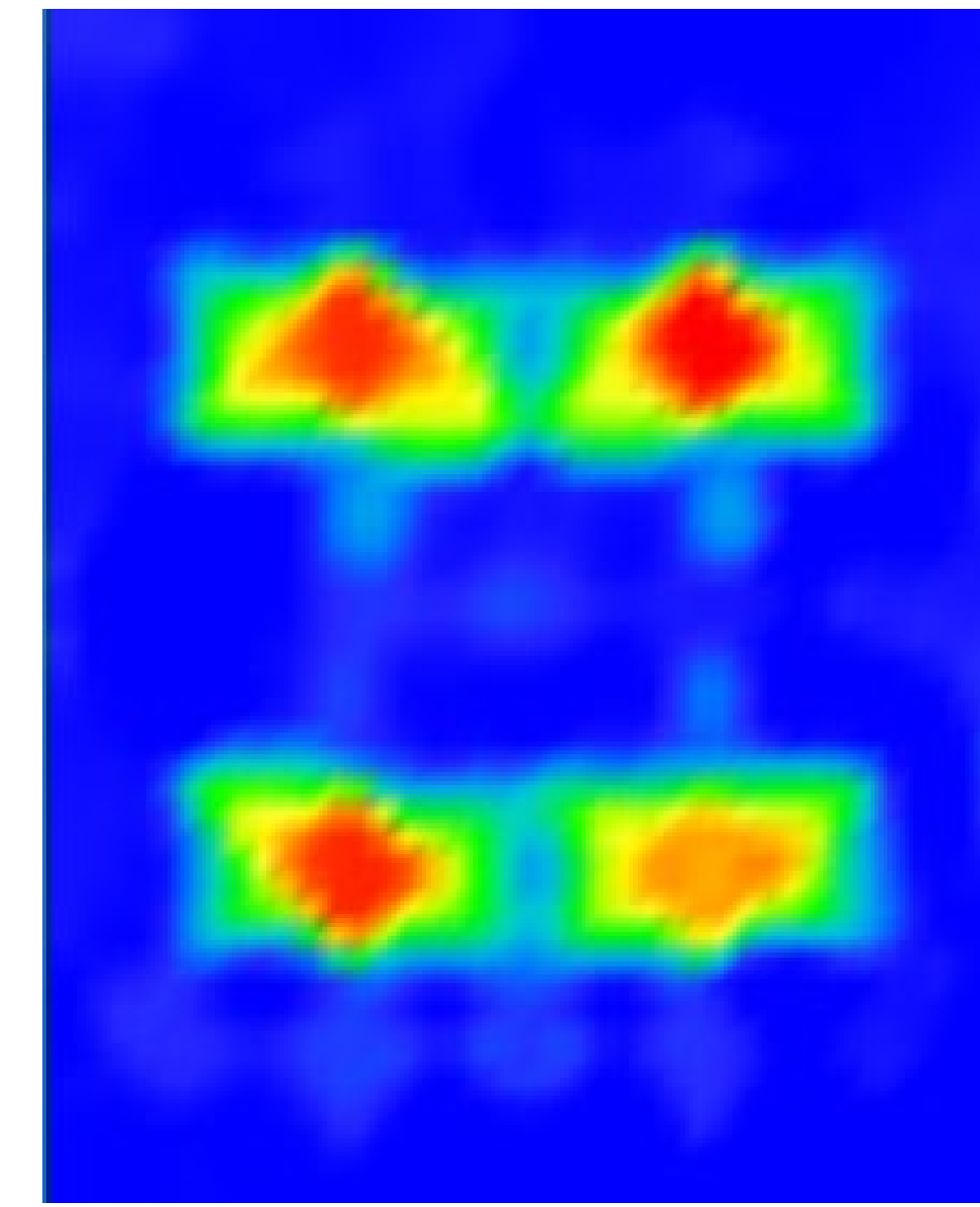
3. Research Results

1. Measurement of Temperature Distribution

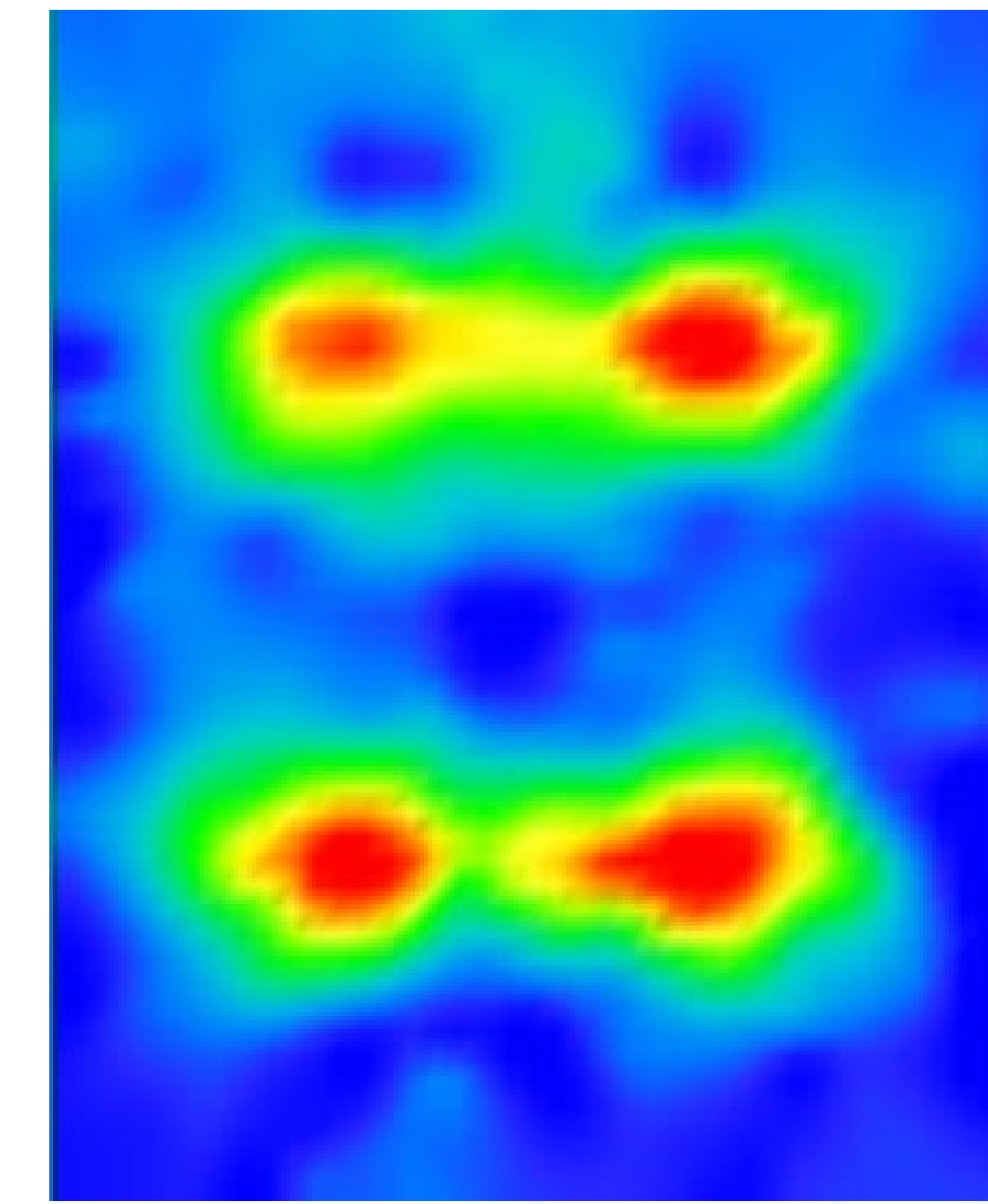
Using visualization software (Visualizer Pro), the one-dimensional temperature obtained by the optical fiber was converted into a two-dimensional temperature distribution.



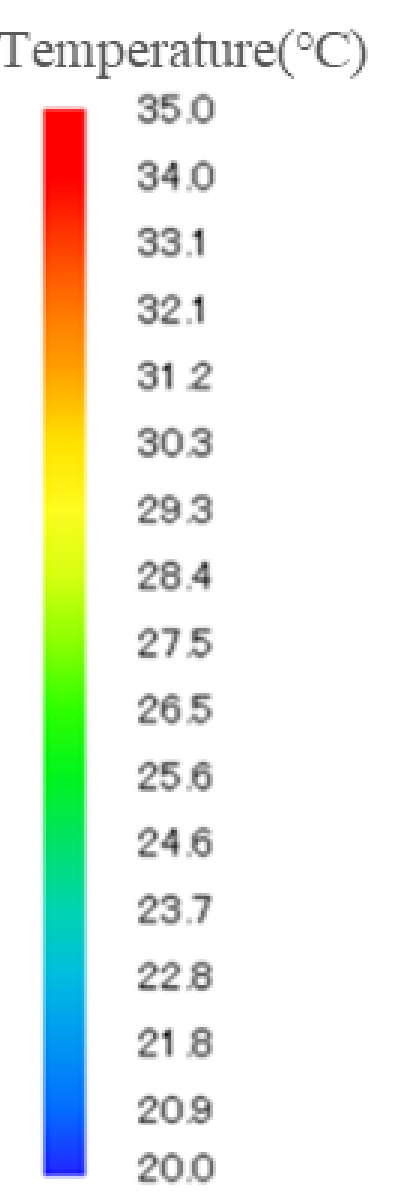
Thermal Infrared Camera



Brillouin Measurement

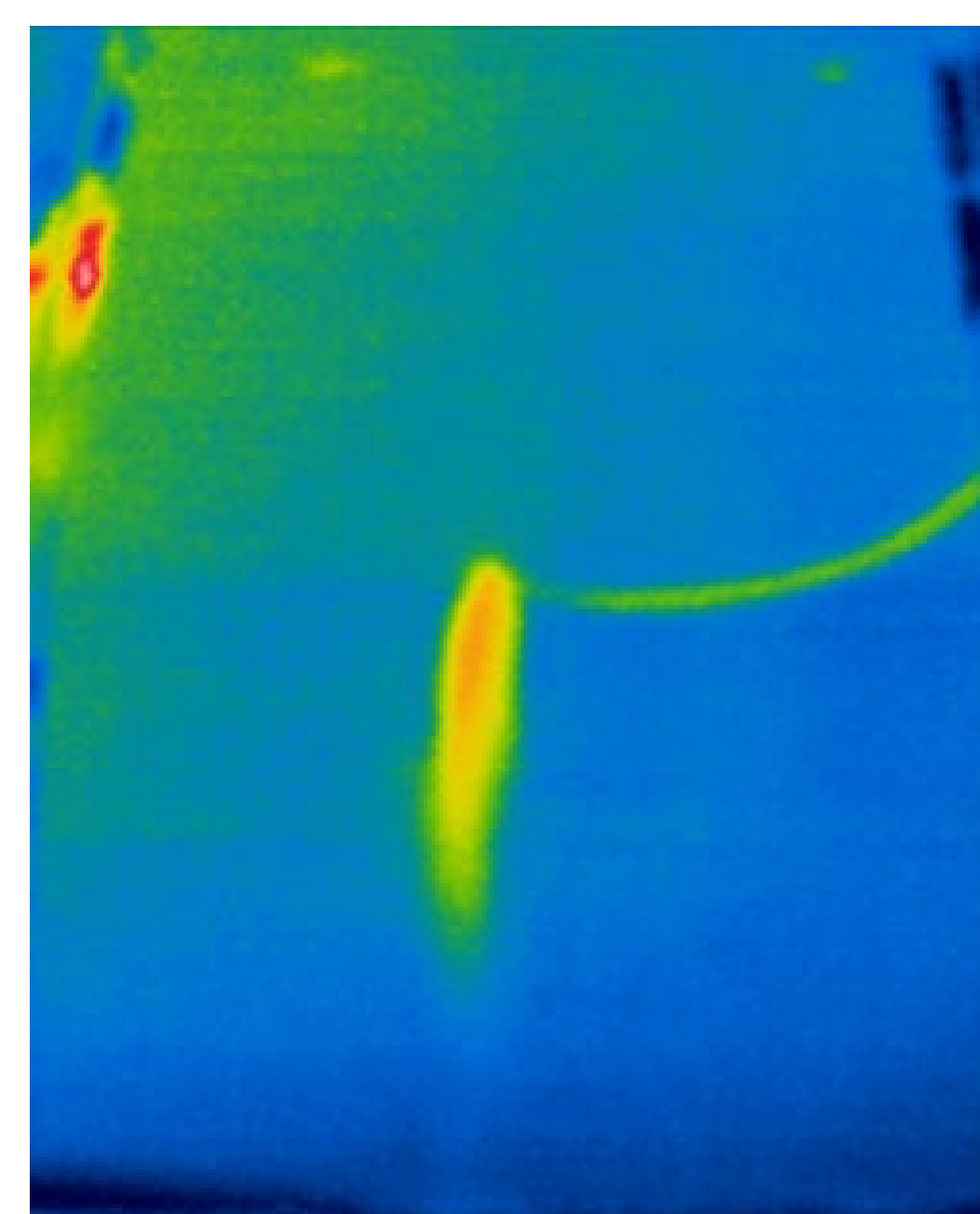


Raman Measurement

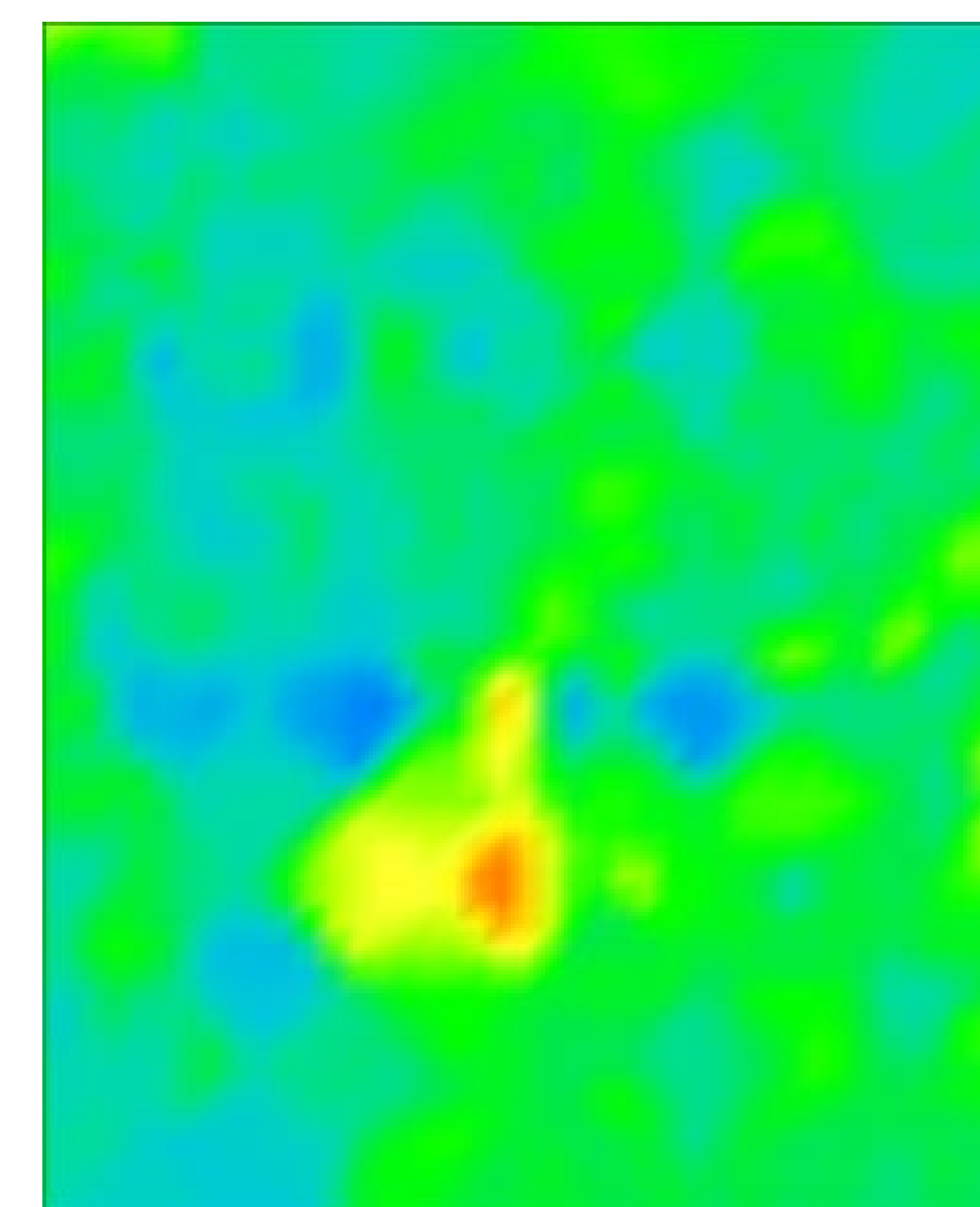


In the Brillouin measurement, the four heat sources were clearly identified, although not as clearly as with the thermal infrared camera. On the other hand, the Raman measurement showed four peaks in the temperature distribution, but the left and right heat sources appeared to be connected. This is thought to be largely due to the difference in spatial resolution.

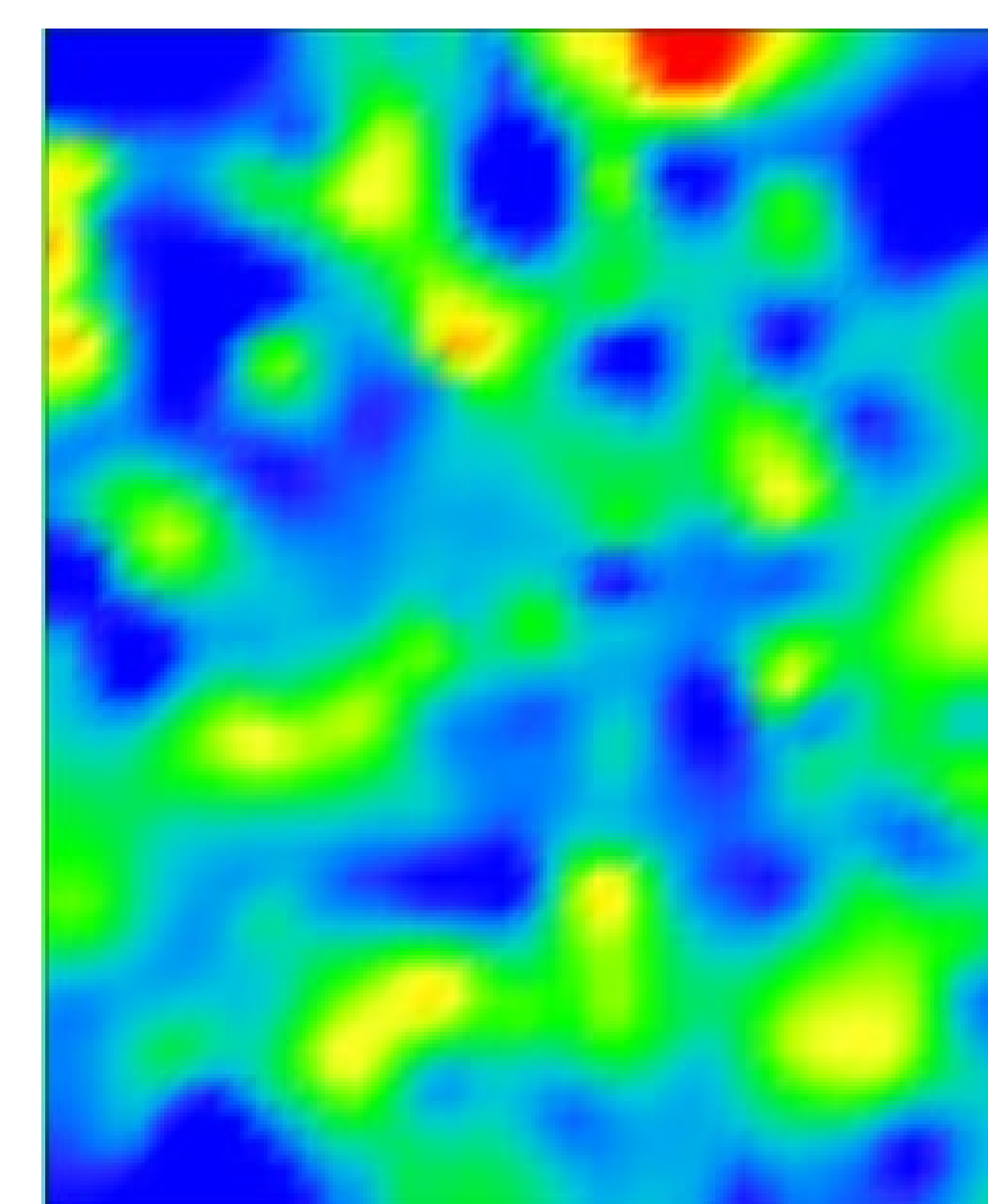
2. Leak Detection



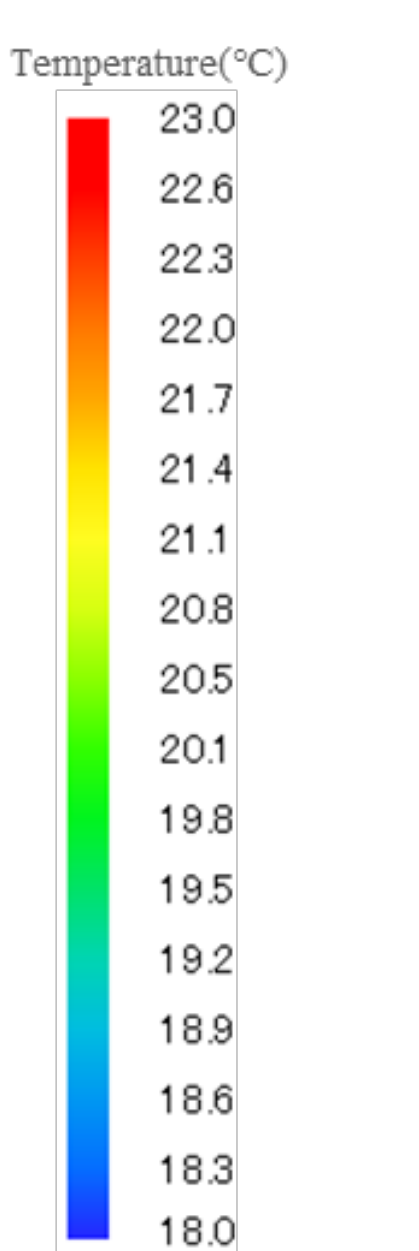
Thermal Infrared Camera



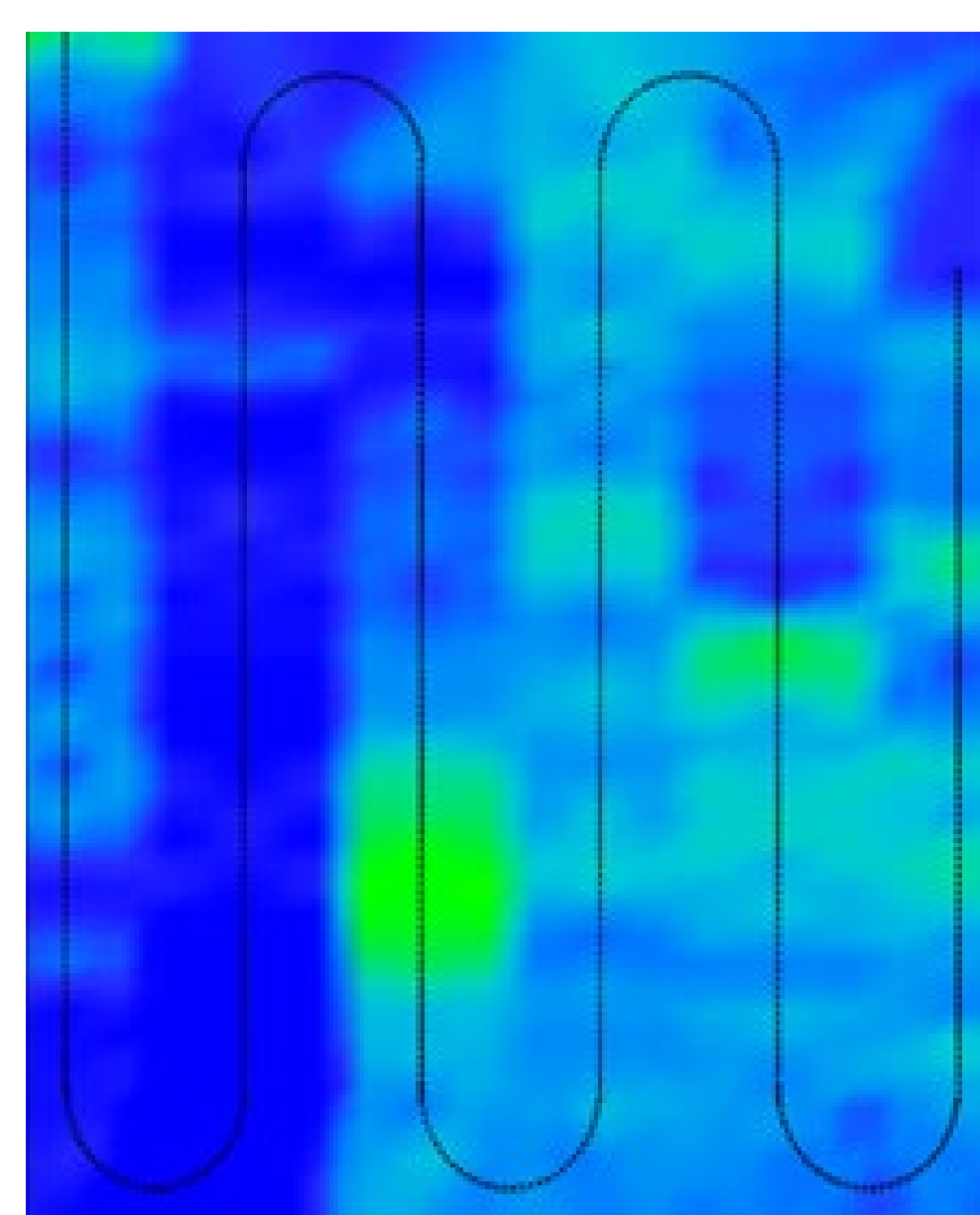
Brillouin Measurement



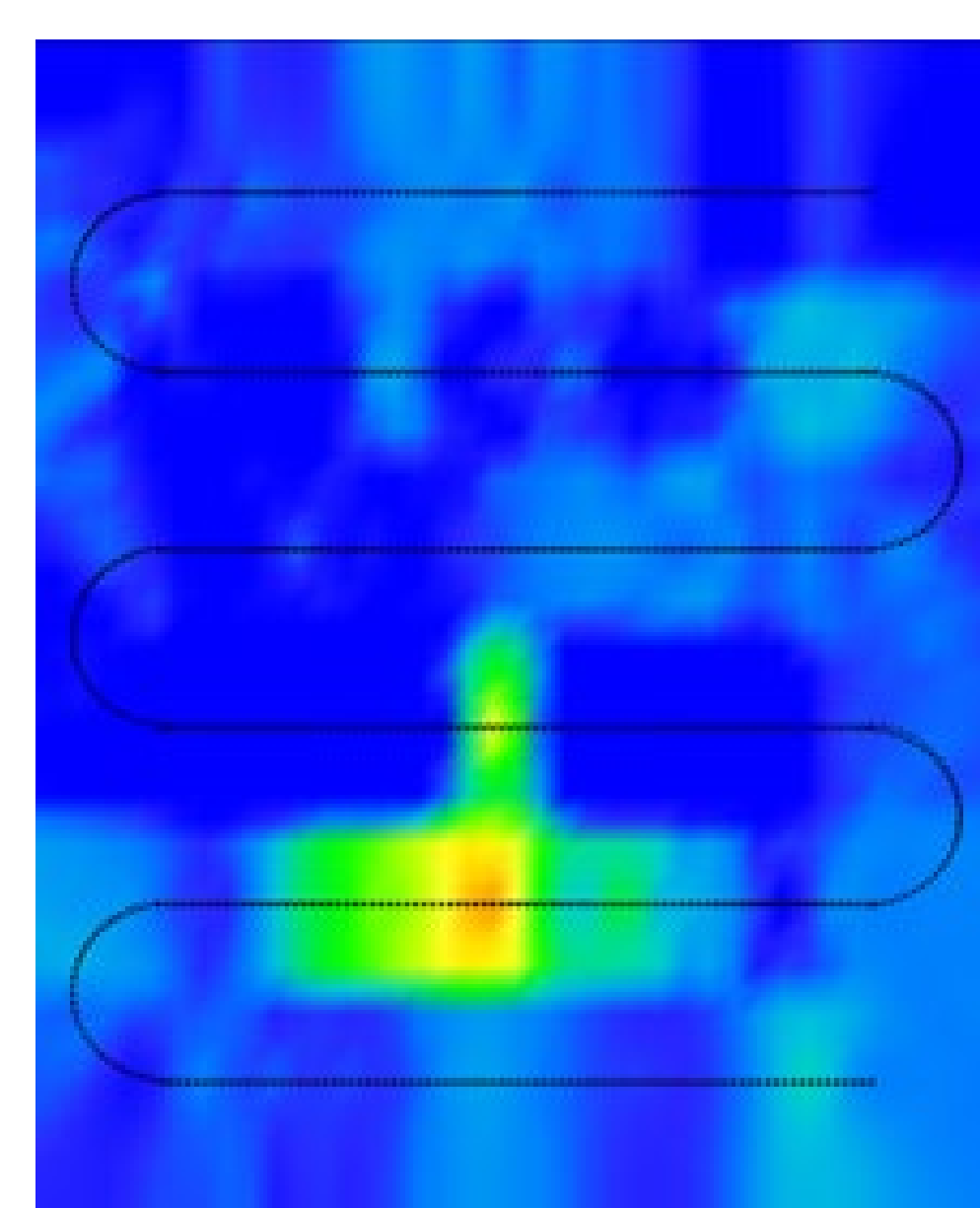
Raman Measurement



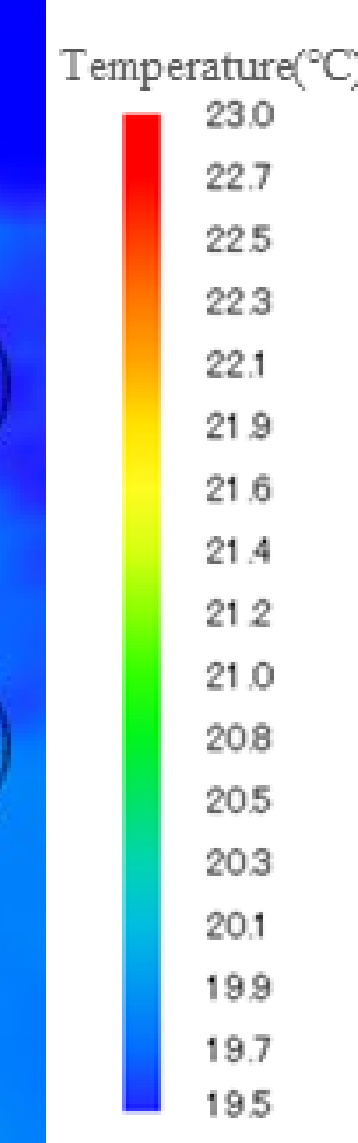
Brillouin measurements showed hot areas similar in shape to the hot areas associated with water injection seen in the thermal infrared images. In the Brillouin measurement, it was shown that if a region of high temperature occurs with the leakage, it may be possible to detect the leakage. Raman measurements could not clearly identify the temperature increase associated with water injection. They are considered unsuitable for leak detection on slopes.



Longitudinal Wiring
(Brillouin Measurement)



Lateral Wiring
(Brillouin Measurement)



In the longitudinal wiring, water injection did not spread widely in the horizontal direction, so the temperature change of the optical fiber due to water injection was limited, and water injection could not be captured clearly. In the lateral wiring, the optical fiber was located in the area where the water injection penetrated, and the temperature change accompanying the water injection could be captured.

4. Conclusion

In this study, optical fibers were wired to a model of a reclaimed land slope with impermeable liners. We examined the reproducibility of temperature distribution and the possibility of leak detection using the measured data from the optical fiber sensor. The findings are as follows.

- 1) The Brillouin measurement reproduces the temperature distribution better than the Raman measurement.
- 2) If a temperature change that can be captured by an optical fiber sensor occurs with a leak, leak detection is considered possible.
- 3) For leak detection on slopes, it is effective to route optical fiber cables orthogonally to the slope direction.