New Way to Check the Health of Concrete Using Light

"Concrete View" : A quick and non-destructive concrete diagnostic system

Until now, in order to quantitatively measure the state of deterioration of concrete, the only method available was coring, in which internal samples were collected. IHI Infrastructure Systems Co., Ltd. has developed an innovative non-destructive diagnostic system for deterioration of concrete by applying the same spectroscopic analysis technology that is used to measure the sugar content of fruit.

Measurement using "Concrete View"

Salt — the nemesis of concrete structures

In the 1980s, many instances of surprisingly early deterioration of concrete structures believed to be semi-permanent structures occurred, and as the situation gained attention, it became known as the "concrete crisis." The cause of this deterioration was salt damage, an unfamiliar term that only increased the uneasy feeling people had.

Salt damage is a phenomenon that occurs when salt permeates concrete, causing the internal reinforcing steel inside a concrete structure to corrode and causing the concrete to crack and peel. Deterioration due to salt damage makes up a large percentage of the deterioration of bridges and viaducts and is a major problem. In structures near the coastline, salt that is carried by the wind from the ocean is the cause of salt damage, while in cold areas, the salt comes from antifreeze agents and snow-melting agents. To handle this problem, measures such as the refinement of concrete structures, protection of reinforcing steel using rust-proofing agents, coating concrete surfaces and the like are being taken. However, preventing salt damage completely is difficult, and particularly in coastal areas or cold regions, degradation diagnosis of concrete continues to be an important issue.

In order to diagnose the occurrence of salt damage, it is necessary to measure the chloride ion concentration on the surface and inside the concrete. Because of this, the accuracy of non-destructive examination methods such as visual diagnosis or the conventional half-cell potential method was insufficient, so often times coring was used. Coring is a diagnosis method in which internal concrete samples are

collected from the structure. The problems with this method are the time it takes to analyze the concrete sample and the fact that the structure has to be repaired. Furthermore, coring is a type of point sampling, and so is not suitable for diagnosing an entire structure. Therefore, there was a need to develop a method that would be able to easily screen an entire concrete structure, and diagnose the degree of salt damage.

At IHI Infrastructure Systems Co., Ltd. (IIS), we have developed a system called "Concrete View" to do just that. "Concrete View" measures the chloride ion concentration by scanning a concrete surface using light. We have been providing this system since 2012.

Measuring the salt content of concrete using spectroscopy — Examining concrete in a manner similar to examining fruit using a sugar content meter —

The sugar content of fruit is measured by taking advantage of the property that sugar absorbs a specific wavelength of near infrared light. By shining near infrared light on fruit, and analyzing how much of the wavelength that is absorbed by sugar, it is possible to calculate the sugar content of the fruit. This method is called spectroscopy, and has an advantage in that the sugar content can be measured without cutting the fruit.

The same principle is used to measure the salt concentration on a concrete surface. The difference is that a wavelength that is absorbed by salt is used. To measure salt content, a halogen lamp is used as the light source to shine near infrared light onto the concrete surface, and the reflected light is analyzed to measure the absorbance of a specific wavelength by chloride ions. However, in the case of concrete, it is known that the chemical composition and deterioration over time (neutralization) also has an effect on the absorbance. Therefore, in order to obtain accurate measurement results of the chloride ion concentration, it was necessary to devise a method that eliminates these effects.

In order to overcome this problem, the absorbance spectrum was examined in detail, and as a result, a method was found for dealing with this problem by statistically processing peaks of multiple wavelengths.

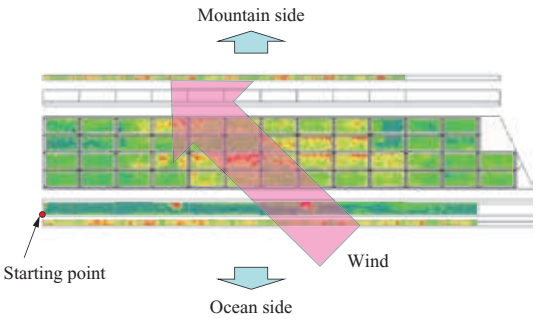
By measuring the chloride ion concentration on the concrete surface, it is possible to estimate the chloride ion concentration in the depth direction by using a diffusion equation.

At IHI, we have a record of technical development in this area such as the development and implementation of an exhaust gas detection system for a thermal power station, an automatic sorting machine for plastic bottles, and even a fruit sugar content meter. Creating a non-destructive diagnostic system for concrete by combining technology from different fields such as bridge technology and spectroscopy technology, could only be brought about by the IHI group where engineers from various fields work together.

Development of "Concrete View"

The non-destructive diagnostic system for concrete we developed called "Concrete View," is capable of measuring approximately 200 m^2 of concrete per day. Expectations for this method are high as a screening technology for detailed examinations following visual checks.

Photo of a probe head



Example of a contour diagram

At a weight of 1 kg, the probe head that houses a light source and spectroscope is compact and lightweight, so even the measurement of narrow areas can be performed easily. There are also scanning type, flat type and stethoscope type probe heads, so measurement is possible in a variety of areas large or small.

By using "Concrete View," it is possible to visually display the concentration distribution of chloride ions on the surface of a concrete structure using a contour diagram (isoline diagram). As a result, it is possible to infer the degree of deterioration per bridge, site, or measurement location, and inspection or repair methods can be selected based on the degree of deterioration.

Over 30 structures have already been diagnosed using "Concrete View," and with the aim of further spreading this technology, we are planning for the development of a self-propelled probe head and a system for automatically determining the area to be repaired based on the obtained results.

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