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“Technical Research and Development for Road Policy Quality Improvement” Study Summary

No.	Title	Principal Researcher
2020 - 9	Study for non-destructive inspection technology of concrete salt damage using neutron	RIKEN, Team Leader, Yoshie Otake

Many infra-structure concrete structures such as bridges are exposed to salt damage, in which rebars are corroded due to the penetration of salt contained in sea breezes and anti-icing agents. It is extremely important to measure the salt concentration with the required accuracy of 1.2 kg/m3, which is the salinity concentration at which steel corrosion starts. In this study, a portable (installable on a bridge inspection vehicle) non-destructive on-site quantitative evaluation of salt concentration is possible using a Californium neutron beam source and neutron-induced prompt gamma-ray elemental analysis.) This study is aimed at developing a neutron salt meter for practical use, such as performing measurement work on actual bridges.

1. Backgrounds and Objects

Many infra-structure concrete structures such as bridges are suffering from salt damage, corroding reinforcing bars due to the penetration of salt contained in sea breezes and anti-icing agents, causing extensive damage overseas. Serious accidents such as collapsed bridges are also a concern in Japan. Therefore, it is extremely important to measure the salt concentration in concrete, which is directly linked to rebar corrosion, with the required accuracy of 1.2 kg/m3, which is the salt concentration at which steel corrosion starts. There are problems such as damage to objects, restrictions on sampling locations, and inability to analyze on the spot. In this study, to solve these problems, a non-destructive, portable (bridge inspection) that can quantitatively evaluate the salt concentration on site using a Californium neutron (Cf) source and neutron-induced gamma-ray elemental analysis. The purpose is to develop a neutron salinity meter (hereafter, salinity meter) that can be mounted on a vehicle. During the period of this research (R2-R4), we used a Cf radiation source of 3.7 MBq or less for an actual bridge, and the salinity concentration that can be detected at a depth of 7 cm from the surface of 1.0±0.2 kg /m3 in 1 hour. The goal is to achieve.

2. Activities in Research Period

To achieve the goal, we performed (1)the development of Cf source and anti-Compton shield method to improve S/N ratio in gamma-ray measurement by optimization of Cf source shield structure and to reduce size and weight in salt measurement system, (2)the production of the prototype of a neutron salt meter that can be mounted on a bridge inspection vehicle, (3)the development of the method to estimate salt concentration in concrete, (4)the publication to the inspection support technology performance catalog, and (5)the discussion with road administrators.

3. Study Results

Validation experiment of salt detection sensitivity combining concrete plates with adjusted salt concentration, shielding structure calculation for chlorine gamma-ray yield and Cf source for optimization of S/N ratio using radiation transport simulation code, Fukushima Robot Test Field, we carried out a mounting test on a bridge inspection vehicle using a salt-meter mock model. After that, as an outdoor salt measurement test, a salt measurement test was performed on a salt damage removal bridge installed in an outdoor facility at the Public Works Research Institute, and a concrete plate with adjusted salt concentration was pasted on a test bridge at the Fukushima Robot Test Field, and a bucket A measurement test was conducted using a bridge inspection vehicle. To compare the measurement results of the salt meter with those of the conventional technique, drill powder sampling and potentiometric titration were also performed on the area measured by the salinity meter, and consistent results were obtained.

After testing at outdoor facilities, aerial work vehicles and bucket-type bridge inspections were conducted on actual bridges, such as the Tsunaki Overpass (Route 48) in Sendai City and the Akka Ohashi Bridge (Route 45) in Kunohe District, Iwate Prefecture. A measurement test using a car was carried out. The area measured by the salinity meter was compared with the salinity concentration measurement by the conventional technology of drill powder sampling and potentiometric titration, and consistent results were obtained, and the salinity was successfully detected non-destructively using the salinity meter on the actual bridge. bottom.

However, regarding the numerical target, since there were no cases where the actual bridge measured had a salt concentration of 1.kg/m3 at a depth of 7 cm, verification was carried out through laboratory tests of combinations of concrete plates with an adjusted salt concentration that simulated the concentration distribution. It was confirmed that a salinity concentration of 1.0 kg/m3 at 7.5±1.5 cm (equivalent to a depth of 7 cm) can be detected in 1 hour. Based on these measurement results, the inspection support technology performance catalog (bridges/tunnels) applied for in 2022 was selected for 2023 and was published on March 31, 2023. In addition, RANS View Corporation (RIKEN Venture) was established on April 3, 2023, and by preparing a system for performing measurement work on actual bridges, the operation and practical application of salinity meters will start from FY2023.

4. Papers for Presentation

①Y. Wakabayashi, M. Yan, M. Takamura, R. Ooishi, H. Watase, Y. Ikeda, and Y. Otake, “Development of neutron salt-meter RANS-μ for non-destructive inspection of concrete structure at on-site use”, Journal of Neutron Research 24, pp. 441-449, (2022).
②Y. Wakabayashi, M. Yan, M. Takamura, R. Ooishi, H. Watase, Y. Ikeda and Y. Otake, “Conceptual study of salt-meter with 252Cf neutron source for on-site inspection of bridge structure”, Journal of Neutron Research, Vol. 23, No. 2-3, pp.207-213, (2021).
③Yasuo Wakabayashi, Yan Mingfei, Chihiro Iwamoto, Kunihiro Fujita, Maki Mizuta, Masato Takamura, Ryutaro Oishi, Hiroshi Watase, Yujiro Ikeda, Yoshie Ohtake, ``Salt damage of concrete structures using small neutron sources RANS and californium radiation sources. Development of non-destructive inspection equipment”, Japan Concrete Institute “Symposium on Inspection and Diagnosis of Concrete Using Neutron Beam”, pp.202-209, (2021).

5. Study Development and Future Issues

We succeeded to measure salinity using a bucket inspection vehicle at the real bridge, and achieved to publish the inspection support technology performance catalog on March 31, 2023. In addition, to perform the practical application of salt measurement at actual bridge, RANS View Corporation (RIKEN Venture) on April 3, 2023 has been established.

In the future, we will increase the results of salt content measurement on actual bridges, and with the cooperation of the Neutron Next-Generation System Technology Research Association, we will make further efforts to contribute to preventive maintenance of roads while comparing measurement results with conventional technology. We plan to improve measurement accuracy (depth resolution and salinity detection sensitivity), improve ease of use, improve all-weather type by waterproofing and dustproofing, and improve development according to on-site needs. As future prospects, we plan to continue research and development aimed at non-destructive detection of sedimentation of RC floorboards using neutrons and visualization of deterioration and damage inside concrete structures, and practical application.

6. Contribution to Road Policy Quality Improvement

By establishing a non-destructive inspection method for salinity concentration and developing practical equipment such as the salinity meter developed in this research, infrastructure structures that are destructively inspected by the conventional core drill method will not be damaged, and there will be no restrictions on the measurement location. The salinity concentration of each part of the bridge can be measured, the inspection time is greatly shortened, and safe, efficient and effective countermeasures against salt damage can be realized. Furthermore, at present, salinity concentration inspections are destructive inspections, so salinity concentration inspections are rarely conducted, and measures are generally taken after salt damage has occurred, which is an after-the-fact maintenance measure. By using a salinity meter, this situation can be converted to preventive maintenance measures to take measures before salt damage occurs. By doing so, it is possible to prevent bridges from collapsing due to salt damage, extend the service life of bridges, and significantly reduce maintenance costs.

7. References, Websites, etc.

① Ministry of Land, Infrastructure, Transport and Tourism "Inspection support technology performance catalog" https://www.mlit.go.jp/road/sisaku/inspection-support/pdf/06.pdf
② RANS View Corporation https://ransview.co.jp/