

< AGING INFRASTRUCTURE & RADIATION

– Survey Method Using Cosmic Rays – >

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Fig.1 Aged bridge.

Do you know the problem of “Aging infrastructure” in Japan and other developed countries? Infrastructure includes indispensable basic systems and services, such as transports, waterworks, railways, and power supplies. Many artificial materials, such as metals or concrete, are used for infrastructure equipment. These materials deteriorate over time, and it is known that the probability of accidents or damaging becomes higher when 50 years pass since their construction.

In Japan, the infrastructure was developed during the period of high economic growth since 1954 and before the Tokyo Olympics in 1964. Since so many infrastructures were constructed in a short time at that time, present Japan has a lot of deteriorated infrastructure facilities. It is said that about 40 % of highways and tunnels will be past 50 years after construction in 2023[1]. Since many natural disasters such as typhoons and earthquakes make deterioration faster in Japan, aging infrastructure is a serious problem that needs immediate attention.

Aging infrastructure is treated as a big problem since the traffic disaster in which the tunnel collapse killed nine people at Sasago-tunnel in 2012. But there are still about 60 % of bridges

and tunnels which are not yet repaired though they are at risk of breaking down[2]. As there are many collapses of bridges or roads caused by natural disasters after the 20s, the risks of aging infrastructure are evolving more and more. If we are delay in taking action for the problem of aging infrastructure, the aged equipment may cause not only tragic accidents but also stopping the economy and social life. Though the government started projects for this problem several years, it is very difficult to complete all tasks at once. It is because there are many tasks for total repairings, such as surveys, assessments, and repairs, and they need a large amount of money. Therefore among these tasks, the index and survey method is required to find more deteriorated equipment and judge the priority of mending. A hopeful way for this survey is an application of radiation.

You may think radiation is dangerous and toxic for humans, but actually, it is used in some familiar situations, such as nuclear power generation, treatment for cancer, sterilization of medical equipment, and so on. The radiations have a character that they transmit materials as you can imagine with X-ray inspection in the medical check-up. Using this character, we can detect the difference in density inside the materials by counting the number of penetrated radiations or reflected radiations. When the density is high, the number of penetrated waves decreases, and the number of reflected waves increases. And when the density is low, it means there are some spaces, the opposite phenomena happen. And thus, by detecting penetrated or reflected radiation we can find the cracks or cavities which we cannot detect from outside. Some methods use electromagnetic waves or X-rays to searched inside of the infrastructural equipment at present. In these methods, they use portable X-ray or electromagnetic wave generators and get useful information. But they can only see a few dozen centimeters in-depth and cannot detect fine cracks because of the lack of X-ray power with the current situation. These current methods are developing mainly using artificial radiation. But there are natural radiations that always rain down on the Earth from outside of the solar system, called cosmic rays. Cosmic rays have higher energy than artificial radiation with portable generators, and they include some kinds of radiation particles that have a stronger penetrating power than X-ray and electromagnetic waves. Hence, cosmic rays have the potential to solve the problem of lack of power and sensitivity.

Among the natural radiations, muon has ideal properties for the survey of big facilities. Muon is a kind of secondary cosmic ray that is made from the interaction between the atmosphere and cosmic rays in the sky. Muon has strong penetrating power and has a sensitivity to the density of

penetrating materials. Therefore we can measure the density distribution inside the materials by counting the number of muons that penetrate the materials. This method is called Muography and is used for an internal investigation of volcanoes or pyramids and resource exploration[3]. Muography takes attention these days. For example, at the research of pyramids, researchers found a large room inside the pyramid for the first time and this result gave a big impact on archeology. Muography can measure any target without size restriction and can search without destruction, so it is also useful for the investigation of infrastructure equipment. The detector of data taking system should be small and operating with small electric power to use this method for the survey of infrastructure. Developments of such devices are ongoing for practical use.

If this technic can be used for the survey of aging infrastructure, we can detect serious deterioration which we cannot find from outside early. This is useful in the point of definition of repairing priority. The survey method using natural radiations is under consideration for practical use, but it will be able to make the situation of infrastructure better. I think this new method can make a safe and secure infrastructure that does not have the risk of accidents and failure in social life.

[1] White paper on land, infrastructure, transport and torism in Japan, 2019

[2] MLIT Road Maintenance Annual report (2019)

[3] K. Suzuki, Journal of AESJ, 57. 5(2015)

(Fig.1 is taken from <https://www.photo-ac.com/main/detail/22041176>)