Highway PC Bridge Inspection using 950 keV Portable X-ray Source

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Abstract

We developed a 950 keV X-band electron LINAC-based X-ray sources for on-site bridge inspection and visualization of the inner structure of a bridge. The use of X-ray mesh collimators and the highly sensitive flat panel detector makes it possible to understand the grout filling flaws inside the sheath, which leads to a full strength-analysis of the bridge through numerical methodologies.

Keywords: *X-Ray, Nondestructive test, Linear Accelerator, Bridge Inspection, Structural Analysis*

1. Introduction

Many of the bridges built during the economic boom in Japan are approaching their designed life spans. A considerable number of Pre-stressed Concrete (PC) bridges have shown apparent damage even as of now. The degradation of iron wires and their vessel, aka sheath, and grout filling inside a sheath of a PC bridge could be examined onsite through our mobile X-ray source with enhanced flat panel detector. By understanding the grout filling condition, applying a structural analysis becomes possible, which will in turn quantify the degradation of the bridge strength. This technology would be significate for bridge maintenance as 42% and 63% of all bridges will be over 50 years of age by 2021 and 2031 respectively, while a reliable method of examining grout is yet to be developed.

2. Indoor grout filling measurement of a PC bridge sample

The inner structure and the grout flaw are recognizable despite room for improvement. 15mm in diameter of the wire and 40mm of the sheath from the results match the real data. Through MATLAB analysis, it is found that the Al collimators stick to the FPD make images 1.25 times clearer thanks to the reduction of (mostly Compton scattering) noise.

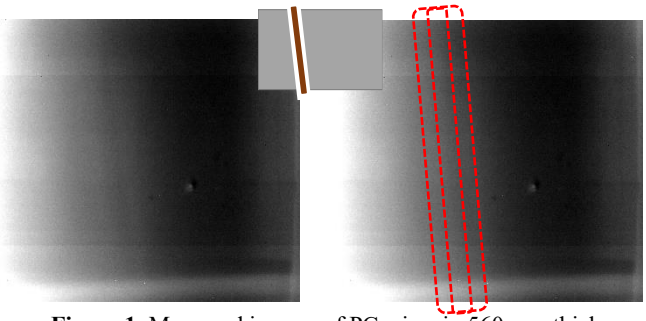

Figure 1. Measured images of PC wires in 560 mm thick
(i) Raw image (ii) Location of PC wires

3. Summary

This technology could be expected in bridge evaluations. We propose the guideline of maintenance consisting of (i) screening by eye and hammering, (ii) X-ray inspection, (iii) structural analysis, and (iv) maintenance planning. We will continue to enhance the detector for higher sensitivity, do the structural analysis, and investigate how moisture inside a sheath affects the overall strength through neutron tests. Meanwhile, longer exposure time to X-ray will be one of our next attempts to make wire & sheath edges more recognizable, along with digital image processing methodologies. Results from another X-ray source with higher energy (up to 3.95MeV) will be compared to judge and improve our efforts.

References

[1] M. Uesaka, Y. Mitsuya, E. Hashimoto, et al., “On-Site Nondestructive Inspection of Bridges Using the 950 keV X-Band Electron Linac X-ray Source,” J. Disaster Res., Vol.12, No.3, pp. 578-584, (2017)