Detection of Concrete Exfoliation by Active Infrared Thermography

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As a means of detecting exfoliation of the concrete covering of a tunnel, viaduct, etc., infrared thermography that measures the difference of temperature at the concrete surface by using an infrared camera is attracting attention. There are two types of infrared thermography: passive infrared thermography that measures a temperature difference caused by meteorological conditions, and active infrared thermography that measures a temperature difference caused artificially by using a heating apparatus (Fig. 1). Although active infrared thermography requires a heating device, it permits measuring the difference of temperature at the concrete surface without being influenced by weather conditions and hence it has been applied to inspect concrete tunnels. In the case of an elevated concrete bridge, however, it is necessary to irradiate the heat onto the concrete surface from the surface of the ground since the heat source can hardly be set close to the concrete surface. For that purpose, we developed a new heat source using a xenon arc lamp and subjected it to laboratory and field tests.

Unlike the tungsten halogen lamp, the xenon arc lamp is a point source, the light-emitting part of which is a small spot offering a highly condensed beam of light (Fig. 2). With the xenon arc lamp, therefore, it is possible to secure a large irradiation energy density even for an object located at a considerable distance. The irradiation energy density measured at a point 10 m away from the xenon arc lamp was 15kW/m^2, about three times that of distant infrared irradiation equipment.

Specimens having an artificial void prepared for active infrared thermography using a xenon arc lamp were subjected to a laboratory test. Each of the specimens embedded with a styrene foam block simulating a void in concrete produced by exfoliation was heated by the xenon arc lamp and photographed by an infrared camera. The test results are shown in Fig. 3. The specimens, from left to right, had a simulative void depth of 10 mm, 20 mm and 30 mm, respectively. From the test results, it can be judged that active infrared thermography using a xenon arc lamp permits detecting exfoliation of concrete up to about 30 mm in depth which is a common design concrete covering depth of viaducts.

With the aim of confirming the applicability of the method to actual viaducts, a special inspection vehicle (Fig. 4) was prepared and a field test was carried out by using it (Fig. 5). Examples of the infrared images obtained are shown in Fig. 6. In the passive infrared thermographic image before irradiation by the xenon arc lamp (Fig. 6 (a)), several high-temperature parts which were considered due to exfoliation were observed. In the active infrared thermographic image after irradiation by the xenon arc lamp (Fig. 6 (b)), the exfoliated parts that were observed in the passive infrared thermographic image were observed more clearly. In addition, a high-temperature part which could not be observed in Fig. 6 (a) could be observed in Fig. 6 (b) (the part that is indicated by an arrow). From these results, it was confirmed that active infrared thermography permits detecting concrete exfoliation more accurately than passive infrared thermography. In the future, we have plans to study a technique to judge the soundness of concrete covering using detection results.

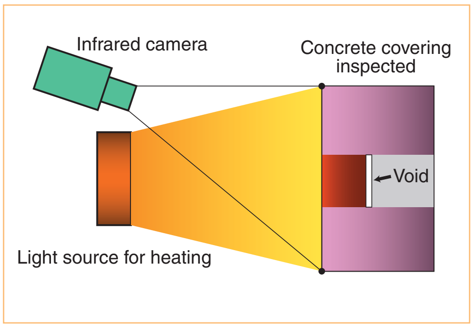

Figure 1. Principle of concrete exfoliation detection by active infrared thermography

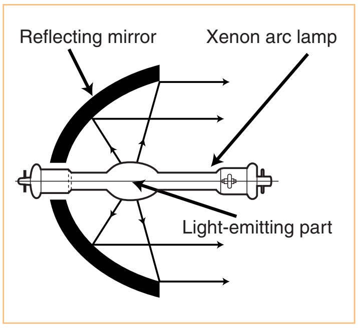

Figure 2. Xenon arc lamp used as light source for heating

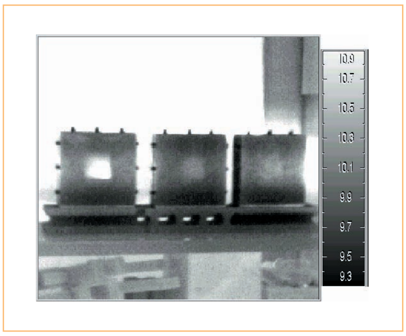

Figure 3. Laboratory test using specimens having simulative void

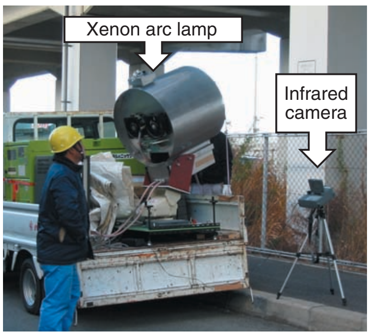

Figure 4. Inspection vehicle

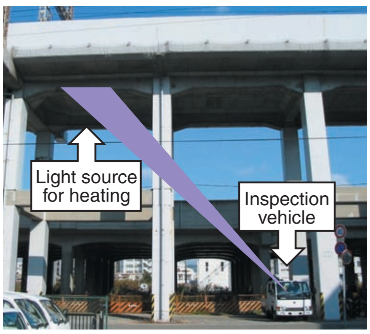

Figure 5. Scene of field test

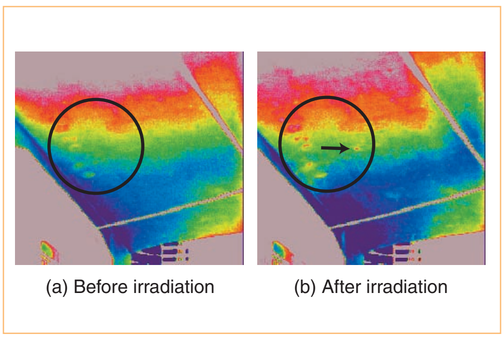

Figure 6. Infrared thermographic images