Deterioration of road infrastructure has been a serious worldwide problem. In the USA, degradation of concrete bridge decks is a widespread problem among several bridge components. Traditionally, qualified engineers implemented sounding and visual inspections for concrete bridge deck evaluations, yet these methods require substantial field labor and lane closures. Under these circumstances, Non-Destructive Evaluation (NDE) techniques such as infrared thermography (IRT) have been developed to inspect and monitor deteriorating structures rapidly and effectively. This research presents the potential to reduce a burden of bridge deck inspections in place of traditional methods by IRT. However, there were still several challenges and uncertainties in using IRT. This study revealed them and explored those solutions and ideal conditions for applying IRT in order to enhance the usability, reliability and accuracy.

Firstly, three infrared (IR) cameras were compared under active IRT conditions in the laboratory to examine the effect of photography angle along with the specifications of cameras. The results showed that when IR images are taken from a certain angle, each camera shows different temperature readings. However, since each IR camera can capture temperature differences between sound and delaminated areas, they have a potential to detect delaminated areas under a given condition in spite of camera specifications even when they are utilized from a certain angle. Secondly, finite element (FE) models were developed and analyzed to explore sensitive factors of delamination detectability were explored. This study presents that the area of delamination is much more influential in the detectability than thickness and volume. Then, FE modeling was used to obtain the temperature differences between sound and delaminated areas in order to process IR data. By using this method, delaminated areas of concrete slabs could be detected more objectively than by judging the color contrast of IR images. After that, the favorable time windows for IRT were explored through field experiment and FE model simulations. Higher temperature differences in the day were observed from both results around noontime and nighttime. However, considering the results that IRT is strongly affected by sun loading during the daytime heating cycle resulting in possible misdetections, the nighttime cooling effect is preferable to reduce the possibility of misdetection. Moreover, it can be assumed that the maximum effect occurs at night, and the temperature difference decreases gradually from that time to a few hours after sunrise on the next day. Thus, it can be concluded that the nighttime application of IRT is the most suitable time window. Furthermore, three IR cameras with different specifications were compared to explore several factors affecting the utilization of IRT, specifically when the IRT is utilized for high-speed bridge deck scanning at normal driving speeds under field laboratory conditions. After that, a real bridge was scanned by three IR cameras and the results were compared with other NDE technologies that were implemented by other researchers on the same bridge. These comparative studies revealed two important factors of camera specifications for high-speed scanning of bridge decks by IRT as shorter integration time and higher pixel resolution.

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