Non-Destructive Techniques for Bridge Inspection in United Arab Emirates

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Summary

This paper presents an investigation of the combined defect detectability of Ground Penetrating Radar (GPR) and Infrared Thermography (IRT) in concrete bridges taking into considerations variations in concrete mix proportioning. This variation will exist due to the difference in mix ingredients, aggregate gradations, w/c ratio, and aggregate type. Therefore, four concrete mixes; high strength, normal strength, lightweight and self-consolidated concrete are used in the investigation. The goal is to evaluate the effect of concrete mix variation on the signals and images of the GPR and IRT techniques. Sixteen 1.2m x 1.2m x0.2m slabs with common bridge defects, cracks, voids, delaminations, honeycombing, and corrosion were prepared. Parameters included in the investigation are concrete type, defects type, size, and location. Furthermore, effects of the environmental conditions on the images, such as temperature changes, solar radiation at different times of the day, and will also be assessed. Results and findings will be discussed and presented.

Keywords: bridges, defects, ground penetrating radar, infrared thermography.

1. Introduction

Rapid growth of infrastructure in the United Arab Emirates has caused a proportional growth in the transportation system. Therefore, it is important to maintain the nation's valuable asset to insure serviceability and infrastructure integrity, hence, protecting public safety. Bridges are considered as main elements in the transportation systems that require continuous monitoring and maintenance throughout the years. Concrete bridge decks are prone to deterioration that requires assessment of its condition from time to time. Due to the lack of a defined inspection system in UAE, there is a great urge to adopt an effective technology to be used in UAE. Replacement of bridges is expensive; hence it is desirable to assess damage using a cost effective maintenance strategy. The unseen deterioration of bridge decks impacts maintenance and repair schedules which can eventually cause failure. Therefore, the adoption of appropriate non-destructive techniques can greatly minimize the repair cost of structural elements and avoid the need to replace these elements which is very costly.

Visual inspection should not be the primary method used for bridge inspection since most of the bridge defects form at subsurface locations. Visual inspection is a common method that is used in UAE for bridge maintenance and repair. Repair is done mainly whenever it is obvious that it is needed. Consequently, there is a need to adopt other inspection techniques for bridge inspection in UAE. As a result, this research will help introduce Ground penetrating radar (GPR) and Infrared thermography (IRT) as non-destructive techniques which could be used to improve bridge

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inspection in UAE. The purpose of this research is to evaluate the effectiveness of GPR and IRTdetection to be used in the assessment of reinforced concrete bridge deck condition.

2. Experimental program

The objective of the experimental study is to investigate the ability of GPR and IR thermography to accurately detect bridge deck defects in different concrete mixtures. Small-scale specimens with three concrete mixtures were prepared and tested using GPR and IRT equipment. Each of the specimens contained simulated defects and different concrete mix. The differences in the dielectric properties due to the different concrete mixes in each specimen were studied.

3. Results

3.1 IRT

The three slabs were placed under the same environmental conditions after casting. The range of the ambient temperature was 26 to 37° C with a relative humidity 70±10%. Several images were taken for each of the specimens at different timings during the day. A temperature difference range of 3-5° C was enough to reveal the defects.

3.2 GPR

At the beginning, the IR camera was used to have an indication about the approximate location of defects. Based on the collected data, a 30 cm x 30 cm grid was placed at the center of each specimen. Consequently, GPR data were collected in 3D mode; the defects that were placed in the specimens were clearly detected. The size and shape of the defects in the images were clearly influenced by the mix variation. The results showed that delamination size was best detected in LWC specimens.

4. Concluding Remarks

The initial results presented in this paper showed that GPR and IR images are affected by the variation in the concrete mixes. Further investigation is required to clearly identify the impact of materials and environmental variations on the accuracy of both techniques. For GPR technique, the dielectric constant for each mix shall be investigated and calibrated for more accurate results. For infrared thermography, the early day investigation will be carried out and compared to early evening results to provide inspectors with extra timing options.