Detection of Containment Building Defects Through Moisture-Induced Temperature Differences by Infrared Thermography

Ha-Rin Jeong [a], Jun-Hee Park [a], Young Jun Lee[a], Joo-Hyung Kim [a]
[a] Department of Mechanical Engineering, Inha University, Incheon 22212, Republic of Korea
[*]Corresponding author: joohyung.kim@inha.ac.kr

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1. Introduction

Inspecting defects in containment building should be conducted regularly to prevent any leakage and flaws in the concrete structure. Among the prominent non-destructive evaluation (NDE) methods, infrared thermography (IRT) stands out for its non-contact nature and ability to detect defects extensively. Also, the infrared camera module can be conveniently mountable on Unmanned Aerial Vehicle (UAV) because of its compact size [1, 2]. However, the effectiveness of IRT relies on clear temperature differences between the defective and non-defective areas, with larger temperature differences increasing the likelihood of detection. Moisture, such as rain, induces changes in the temperature of the target object through its state transitions [3, 4]. This study aims to quantitatively acquire and verify temperature differences between defect and non-defect regions based on varying moisture levels.

2. Methods and Results

2.1. Experimental Methods

The experiments were carried out while maintaining a constant surrounding environment using an environmental chamber as shown in Figure 1. An infrared camera (FLIR SC600) was used a detector. The halogen lamp was used as a heating source. The distance between the infrared camera and the concrete crack was set to 1 m, and the temperature and humidity inside the chamber were maintained at 20 °C and 30 %, respectively.

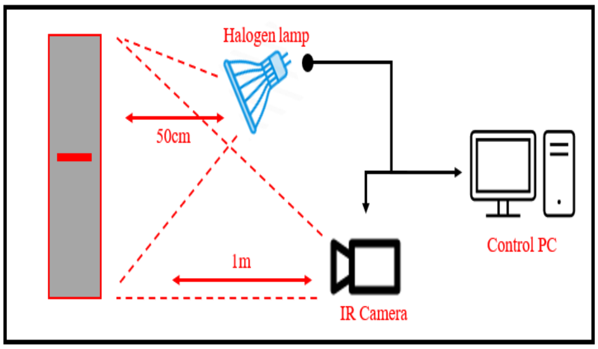

Figure 1. Experimental setup to detect the temperature differences between defect and non-defect regions.

In order to test the defects in the concrete structure, an artificial crack of 10 mm in length, 1.3 mm in width, and 10 mm in depth was made in a concrete structure of 350 x 250 x 50 mm. Then, the temperature distribution between the cracks in the concrete structure was observed. The amount of water to be loaded was fixed at 10 mL. The halogen lamps were used for 10 minutes and the changes in the temperature distribution were observed.

2.2. Results

Figure 2 shows a pattern of the thermal images between cracking and non-cracking during the heating and cooling processes. During the cooling cycle, the non-defective part tends to be 0.6 °C lower than the defective part.

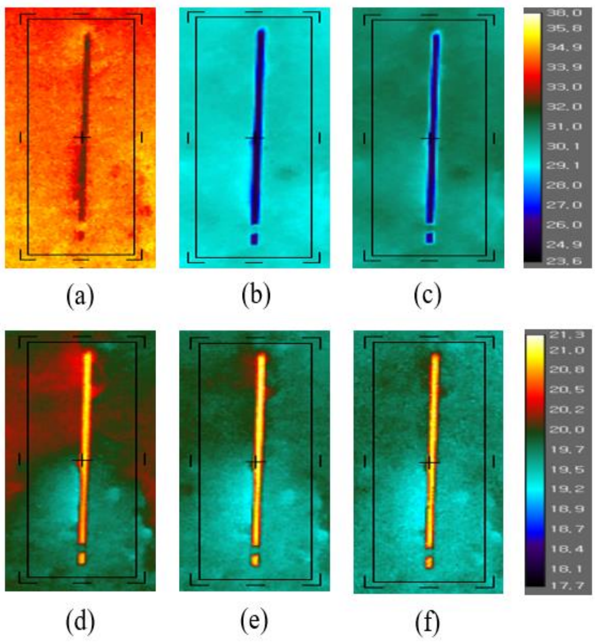

Figure 2. Temperature change of heated crack without moisture (a) Initial heating, (b) After 5 minutes of heating, (c) After 10 minutes of heating, (d) After 15 minutes of cooling, (e) After 30 minutes of cooling, and (f) After 60 minutes of cooling.

Figure 3 shows a thermal images between defects and non-defects in the process of heating and cooling in a state of moisture. During the cooling process, the non-defective part tends to be 1.5 °C lower than the defective part.

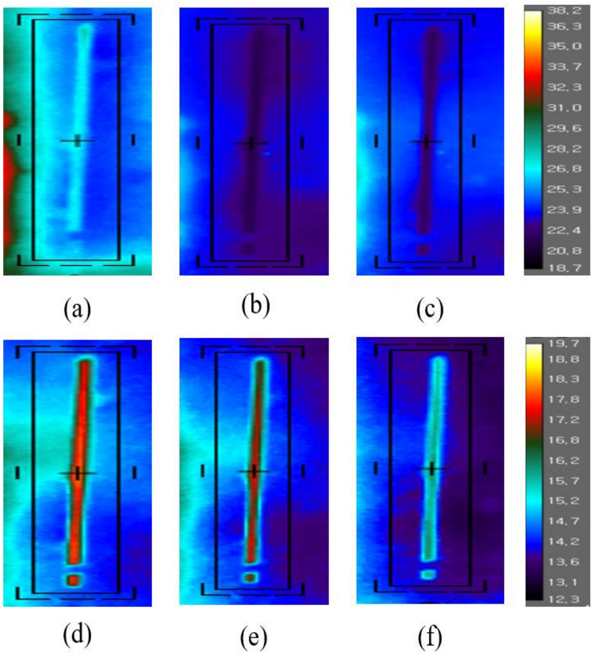

Figure 3. Temperature change of heated crack with moisture (a) Initial heating, (b) After 5 minutes of heating, (c) After 10 minutes of heating, (d) After 15 minutes of cooling, (e) After 30 minutes of cooling, and (f) After 60 minutes of cooling

3. Conclusions

In this study, the thermal behavior of concrete cracks due to moisture effects was analyzed using IRT and focused on the impact of moisture on temperature variations. According to this study, the presence of moisture showed a more pronounced thermal deviation in the analysis of thermal behavior using an infrared camera. During the cooling process, the temperature difference between the non-defective and defective part in the absence of the moisture was about 0.6 °C, whereas the temperature difference in the presence of the moisture was about 1.5 °C.

This study concludes that while monitoring containment cracks using IRT methods, the thermal behavior according to the conditions must be considered.

Also, it employs IRT as a primary tool, emphasizing the importance of distinct temperature contrasts for effective defect detection. The compact and drone-compatible nature of the infrared camera module enhances the convenience of the inspection process.

Acknowledgments

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