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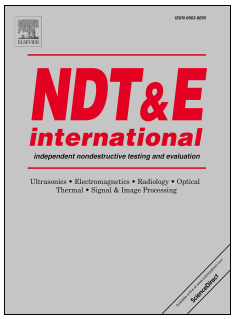


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# Effects of Rebars on the Detectability of Subsurface Defects in Concrete Bridges using Square Pulse Thermography

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**Abstract:** The ability to predict critical conditions on highway concrete bridges is important for the avoidance of unpredictable collapses during the operation period. Potential deteriorations can develop, such as terms of cracks, air voids, and subsurface delaminated areas that are usually detected through nondestructive testing (NDT) techniques together with conventional sounding methods, i.e. hammer sounding and chain dragging. Of these deteriorations, delamination is one of the major indicators of concrete bridge health, i.e., the measurement of the percentage of delaminated area. Due to vehicle loading, changes in weather and environment, and corrosion of reinforcing steel bars, delamination can occur above or even below the rebar layer, and it can be difficult to identify and determine the size and depth of delamination, especially for delamination below the rebars. In this study, two concrete specimens were analyzed in the laboratory as used with a wide range of different concrete covers that are commonly applied in bridge structures, from 2 to 8 cm at near surface. Square Pulse Thermography (SPT), one of the active infrared thermography (IRT) techniques, is used to analyze the specimens in terms of their various heating regimes and environmental conditions. This study aims to comprehensively investigate the effect of steel reinforcement on the detectability of delamination when the delaminations have a width-to-depth ratio equal to or smaller than 2.0. The results show that delamination above the rebars indicates a higher absolute contrast than that below the rebars. In addition, the observation time of delamination below the rebars decreases significantly. As a result, the predicted depth of a delamination will be less than the value of the real depth.

**Keywords:** concrete deterioration; subsurface delamination; square pulse thermography; width-to-depth (w2d) ratio; nondestructive testing; contrast-based method; reinforced concrete bridge

## 1. Introduction

Deteriorations are caused by many factors that occur during the operating period (i.e., vehicle repeated loading), during weather and environmental conditions (i.e. wind loading, freeze-thaw cycle, rain and water flow, and corrosion of rebars) [1], and even during the construction process, due to a lack of compaction energy [2]. Cracks, air voids, and delaminations are the three common deterioration types that develop in concrete bridges, with delaminations or horizontal cracking comprising the majority. Delamination is usually hidden beneath the concrete cover at the upper layer of the reinforcement or even between two layers of rebars, as illustrated in Figure 1. Thus, it is difficult to detect using conventional techniques such as hammer sounding or chain dragging [3]. However, this detection is more accurate and effective when paired with an NDT technique such as impact echo [4], ultrasonic surface waves, ground penetrating radar [5], or active/passive IRT technique [6].

In most bridge structure design guidelines, the required thickness of the concrete cover is considerably greater for bridge decks that directly receive vehicle loads [7]. For example, as required by the American Association of State Highway and Transportation Officials (AASHTO), the required thickness of the concrete cover is at least 50 mm for most cases, while it is at least 75 mm for coastal cases and when cast against earth structures [8].