

Bridge Deck Condition Evaluations

Structures: A4294 & A5045

Job Number: J6S3488

FINAL REPORT

submitted to

Missouri Department of Transportation

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by

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1. Introduction

The objective of this project was to evaluate the condition of the bridge decks outlined in Table 1. . The overall purpose of the survey was to quantify and map rebar-level delamination, concrete deterioration, patching, and spalling to facilitate upcoming planning and rehabilitation efforts. The condition evaluations were carried out using ground penetrating radar (GPR), infrared thermography (IR), and high-resolution video (HRV) equipment mounted to a survey vehicle and collected at driving speed. This report provides a description of the GPR, IR, and HRV data collection and analysis procedures, and includes the resulting quantities and maps in Attachment A.

Table 1 – Bridge List

Bridge ID	County	Feature On	Feature Under	Deck Area (sf)
A4294	St. Charles	MO 79	I-70	21,216
A5045	St. Charles	Bryan Road	I-70	21,730

2. Data Collection

The GPR data collection was carried out on May 13th, 2020 with temperatures in the high 50s (°F). The HRV and IR data collection was carried out on June 17th, 2020 during mostly sunny weather conditions with temperatures in the mid to high 80s (°F). The equipment used for this project is shown in Figure 1.



Figure 1 – Infrasense Survey Vehicle

The GPR surveys were carried out according to ASTM D 6087-08 using a dual 1-GHz horn antenna vehicle-based system. The GPR data was collected in a series of lines spaced at a maximum of 3 feet transversely across the width of each deck at normal driving speeds. The DMI distance data was continuously recorded into each GPR record, so that each GPR data scan has an associated distance.

The IR/HRV surveys were carried out according to ASTM D 4788 – 03 (2013) using a 640 x 512-pixel FLIR Systems Model A6701sc infrared camera and a Sony – Alpha a7sii 4K resolution visual camera, both mounted to an elevated platform on top of the survey vehicle and operated remotely from within the vehicle.

The IR and HRV data were collected in a series of passes across each deck; one for each driving lane and shoulder. Each pass covers a deck width of 15 feet. The IR and HRV cameras are connected to an electronic distance measuring instrument (DMI) for accurate location referencing.

3. Data Processing and Analysis

3.1 GPR Processing and Analysis

The GPR analysis is carried out with Infrasense's proprietary software *winDECAR*® using the following steps:

- (1) Identification of the beginning and the end of each deck in each radar file, and check of the radar distance measurement against the known length and other features within each deck;
- (2) Identification of reinforcing steel that appears as a dielectric discontinuity in the GPR data (see example data, Figure 2);
- (3) Setup of the analysis for all the passes for each deck, computation of concrete dielectric constant, rebar depth, and concrete attenuation at rebar-level.

The analyzed GPR data is presented in the form of contour plots. The potential areas of deteriorated concrete are identified by a threshold. Figure 2 shows a sample of GPR data. The weakening of the reflection (attenuation) from the top rebar layer is an indication of corrosion, chloride contamination, and possible delamination.

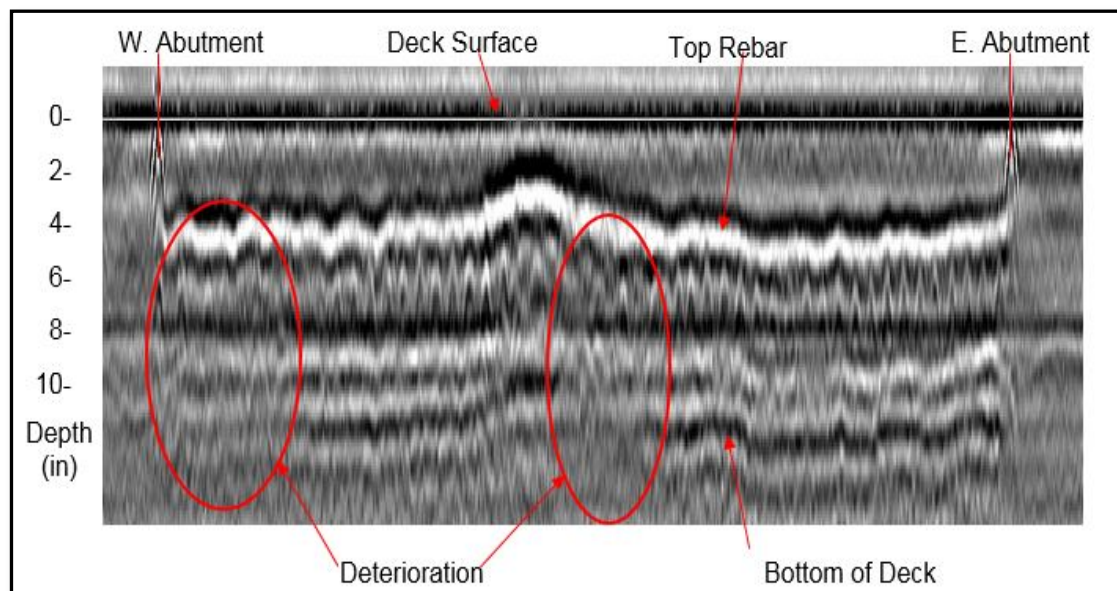


Figure 2 – Sample GPR data showing typical signs of deterioration.

3.2 IR and HRV Processing and Analysis

The infrared data was reviewed simultaneously with the video data to differentiate delaminated areas from surface features (discoloration, oil stains, sand and rust deposits, etc.) that appear in the infrared, but are unrelated to subsurface conditions. Figure 3 shows an example of delaminated areas as they appear in a single image of infrared data and in the corresponding visual data. A “snip” is taken from each image, calibrated so that it captures an area that is 1 foot in the direction of travel and 12 feet across; sequential snips are then stitched together to create a single strip image for each pass. The individual strip images are aligned to produce composite thermal images of each deck area. Figure 4 shows a sample composite thermal image.



Figure 3 – Example of side-by-side infrared and visual images

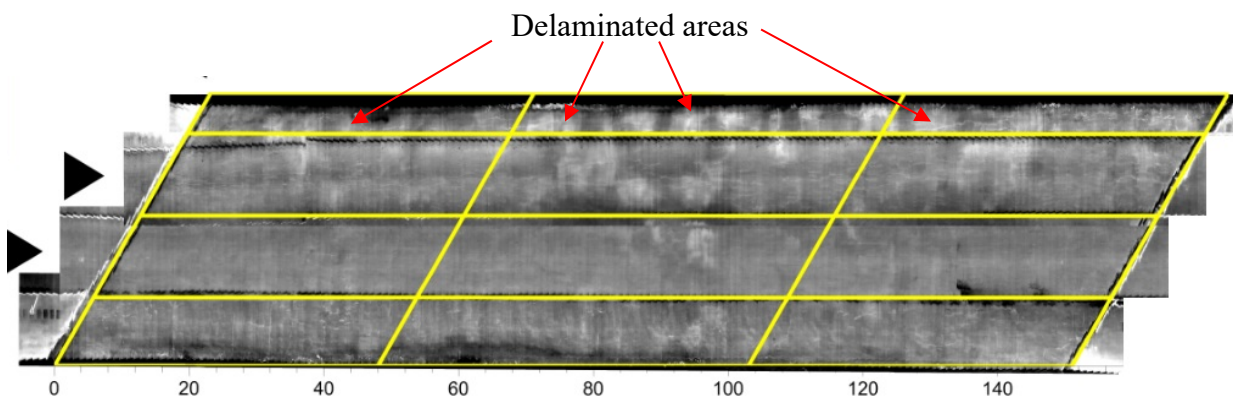


Figure 4 – Sample composite infrared image

4. Results

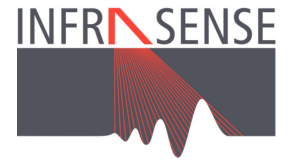
The results of the GPR, IR, and HRV condition evaluations include the overall quantities in Table 2 below, as well as the condition maps provided as Attachment A.

Table 2 – Quantities Summary

Bridge ID	GPR Concrete Deterioration %	IR Concrete Delamination %	Patching %	Spalling %
A4294	7.5	4.0	0.0	0.0
A5045	7.9	0.6	0.0	0.0

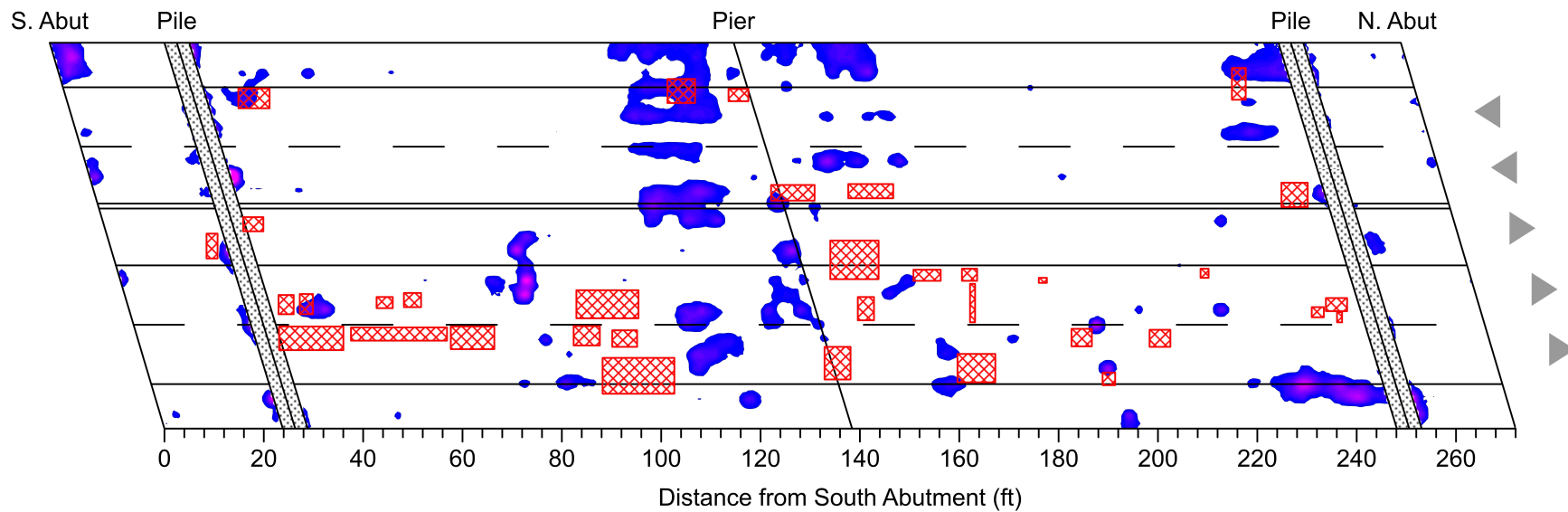
5. References






- ASTM, “Standard Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar” Designation D 6087-08, ASTM International, West Conshohocken, PA, 2008.
- ASTM, “Standard Test Method for Detecting Delamination in Bridge Decks Using Infrared Thermography,” ASTM, Annual Book of ASTM Standards, Vol 04.03, Designation: D4788-03 (2013), 2013.
- SHRP C-101, “Condition Evaluation of Concrete Bridges Relative to Reinforcement Corrosion – Volume 3: Method of Evaluating the Condition of Asphalt-Covered Decks”, Strategic Highway Research Program Report SHRP-S-325, Washington, DC, 1993.

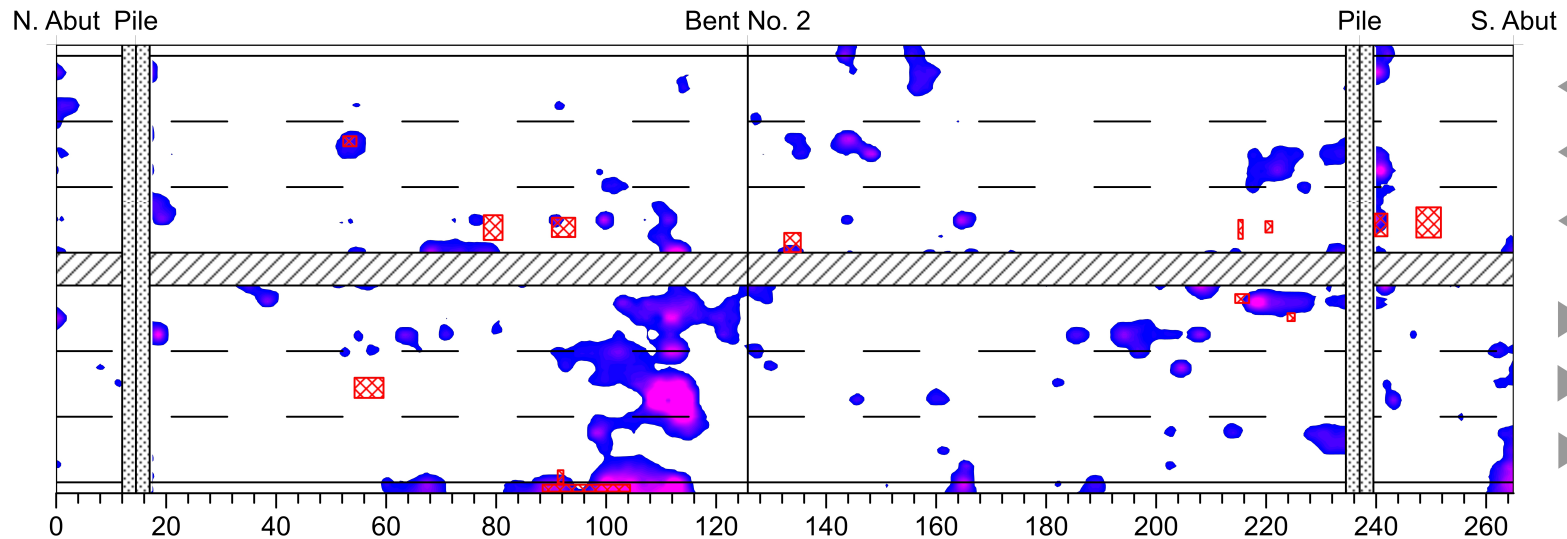


ATTACHMENT A

DECK CONDITION MAPS



Conditions Legend	Orientation	Quantity Summary			General Information
Rebar-level deterioration detected by GPR		Condition Quantities	sq. ft.	%	Bridge ID: A4294 MO 79 over I-70
Increasing severity -->		GPR Deterioration	1520.0	7.5	Analyzed by: STB Reviewed by: AJC Completed: 7/27/2020
 Delamination detected by IR		Delaminations	845.3	4.0	Sheet 1 of 1
 Patching		Patching	0.0	0.0	
 Spalling		Spalling	0.0	0.0	
 Condition not detectable by GPR					



Conditions Legend			Orientation	Quantity Summary			General Information	
<div>Rebar-level deterioration detected by GPR</div> <div>Increasing severity --></div> <div></div> <div>Condition not detectable by GPR</div>	<div></div>	Delamination detected by IR	<div></div> <div>Direction of traffic</div>	Condition Quantities	sq. ft.	%	Bridge ID: A5045 Bryan Rd. over I-70	
	<div></div>	Patching		GPR Deterioration	1531.8	7.9		
	<div></div>	Spalling		Delaminations	132.8	0.6	Analyzed by: STB Reviewed by: AJC Completed: 7/23/2020	
				Patching	0.0	0.0		
				Spalling	0.0	0.0	Sheet 1 of 1	

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