Use of Hand-Held Thermographic Camera for Condition TPF-5(152)

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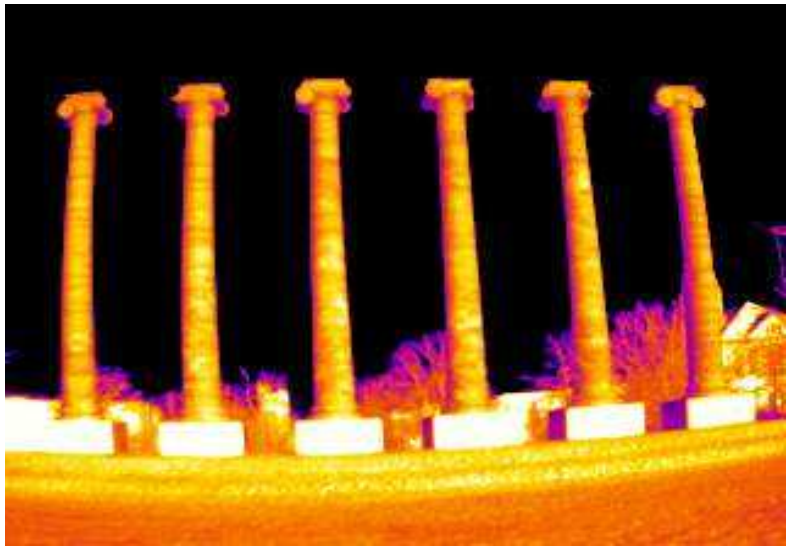
Midwest Bridge Preservation Partnership 2010

Agenda

- Goals and Objective
- Background
- Guidelines
- Field examples
- Conclusions



Goals and Objective
Pooled fund TPF-5(152)


- Goal: Improve technology and methods for the condition assessment of civil infrastructure
- Objectives: Develop thermal imaging technology for detecting subsurface damage in concrete
  - Provide a practical tool for routine inspection and maintenance

Risk of Soffit Damage

OKLAHOMA CITY (AP) - In 2004, a football-sized piece of concrete fell from a bridge and crashed through Yvonna Osborn's windshield while she was driving home on Interstate 35.

All Headlines

A chunk falls off bridge over 35E, striking two cars — but bridge deemed sound

By Mara H. Gottfried
mgottfried@pioneerpress.com
Article Last Updated: 07/27/2008 12:18:02 AM CDT

Falling concrete hits car on I-70

Darla McFarland
the Examiner

A Kansas City man narrowly escaped serious injury Wednesday when a 20-pound chunk of concrete dropped from the Noland Road bridge on to Interstate 70 and smashed through his windshield.

"i'm glad I was paying attention."

Jim Neal

The Washington Post

A hard rain and then some on Second St.

Concrete falls off bridge, but woman says concern fell on deaf ears

Concrete falls from I-77 bridge

RICK STILLION/The Daily Jeffersonian
December 18, 2009

State inspectors to examine bridge where concrete fell
Posted: 02/01/2010 11:50 AM

Concrete chunk falls off bridge and smashes a car

Updated: 10/31/2009 3:46:13 PM

Concrete from bridge falls onto Chicago st

Saturday, January 23, 2010

Tags:

BOSTON & BEYOND. NOW.
METRODESK

< Back to front page Text size – +

Chunk of concrete falls from Somerville bridge

January 15, 2010 07:10 PM E-mail | Link | Comments (8)

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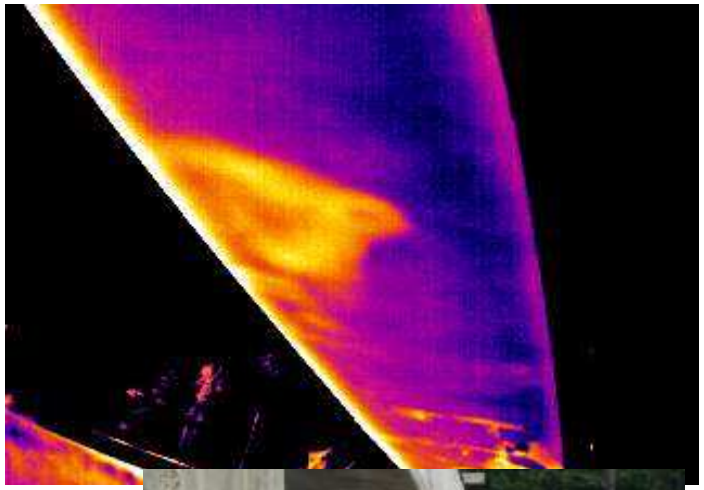
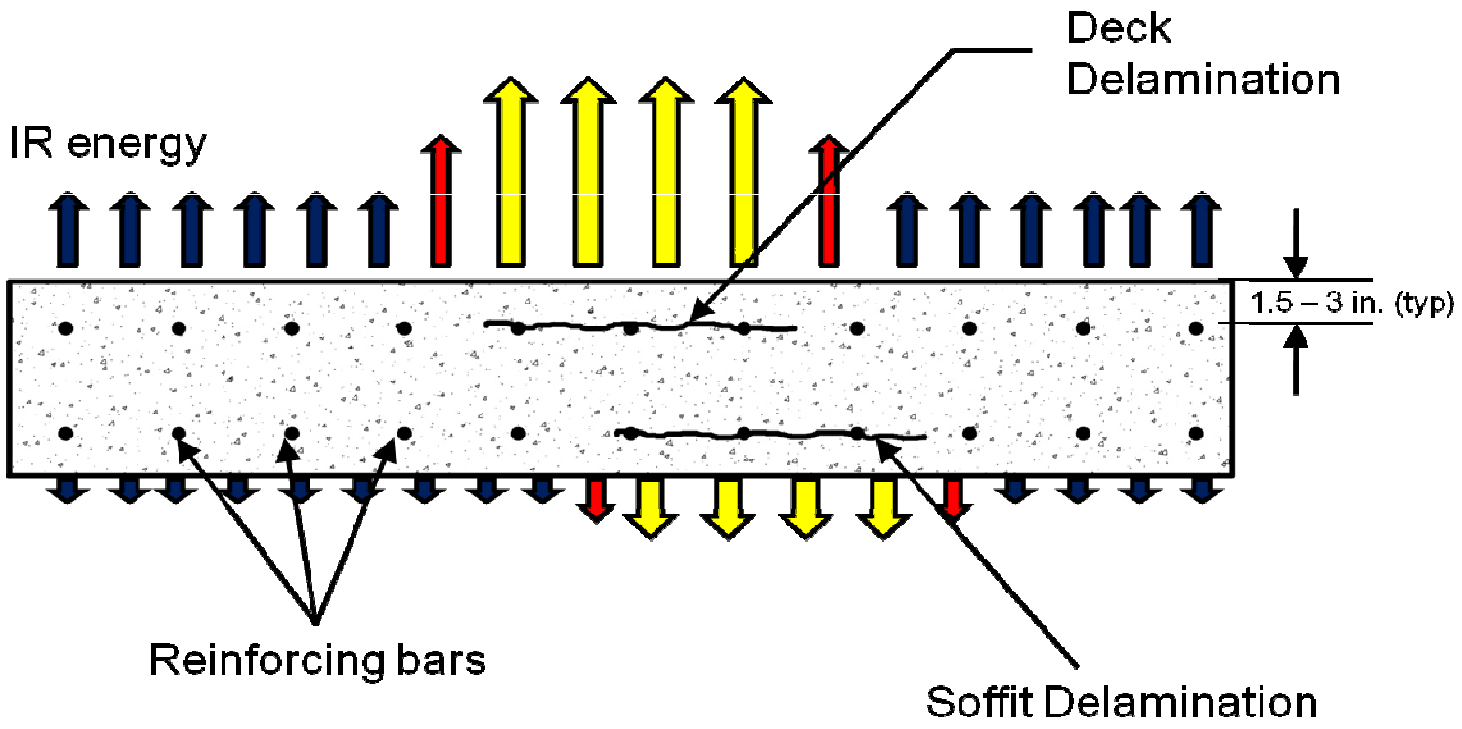
Approach

- Subsurface delaminations create a perturbation in heat transfer through the concrete
  - As a result, a the loose/delaminated concrete heats and cools at a different rate than surrounding concrete
  - The loose/delaminated concrete is at a slightly different temperature than the intact concrete, which heats and cools slowly due to its mass



Background

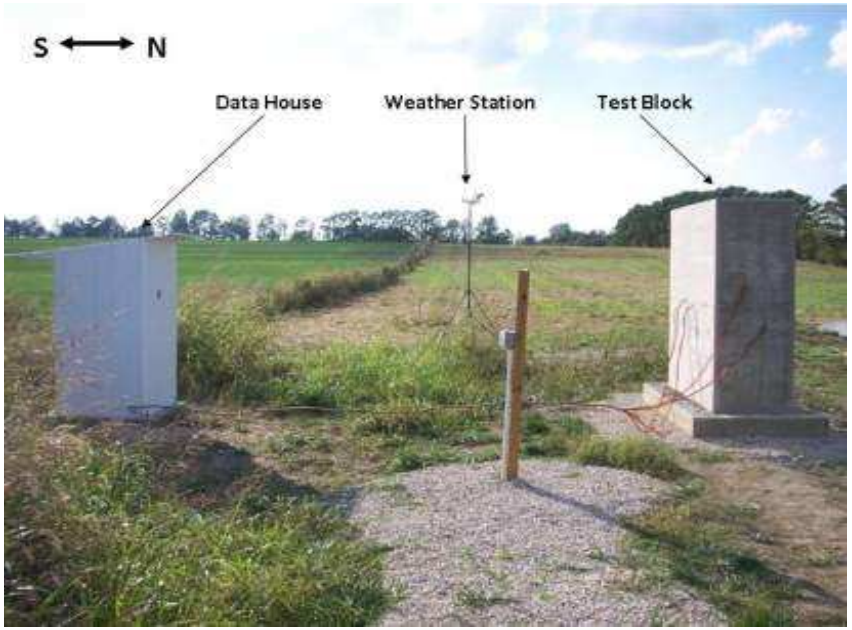

Deck
Delamination
IR energy
1.5 – 3 in. (typ)
Reinforcing bars
Soffit Delamination

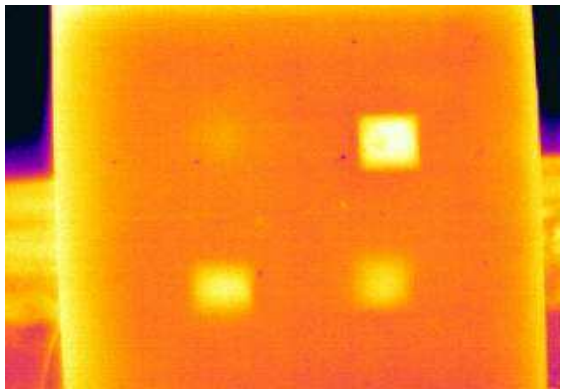
Approach

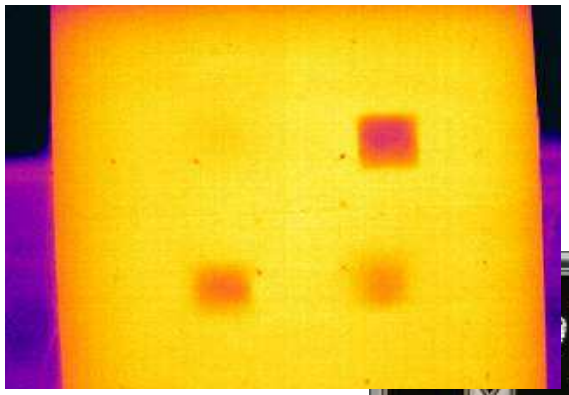
- IR cameras can be used to detect loose/delaminated concrete from a stand-off distance
  - From an embankment or breakdown lane, or standing next to the parapet
- IR cameras are available in rugged, fieldable systems
  - Carry in a truck
- Minimal training required to operate
- ~$15 k and dropping

Research

- The detection of the subsurface delaminations depends on the environmental conditions at the bridge
  - Effects:
    - Ambient Temperature Changes: Temperature variations during the day
      - Warming in the daytime, cooling at night
    - Wind speed: Convective heat transfer from the environment
    - Depth of defect
    - Time delay
    - Solar exposure







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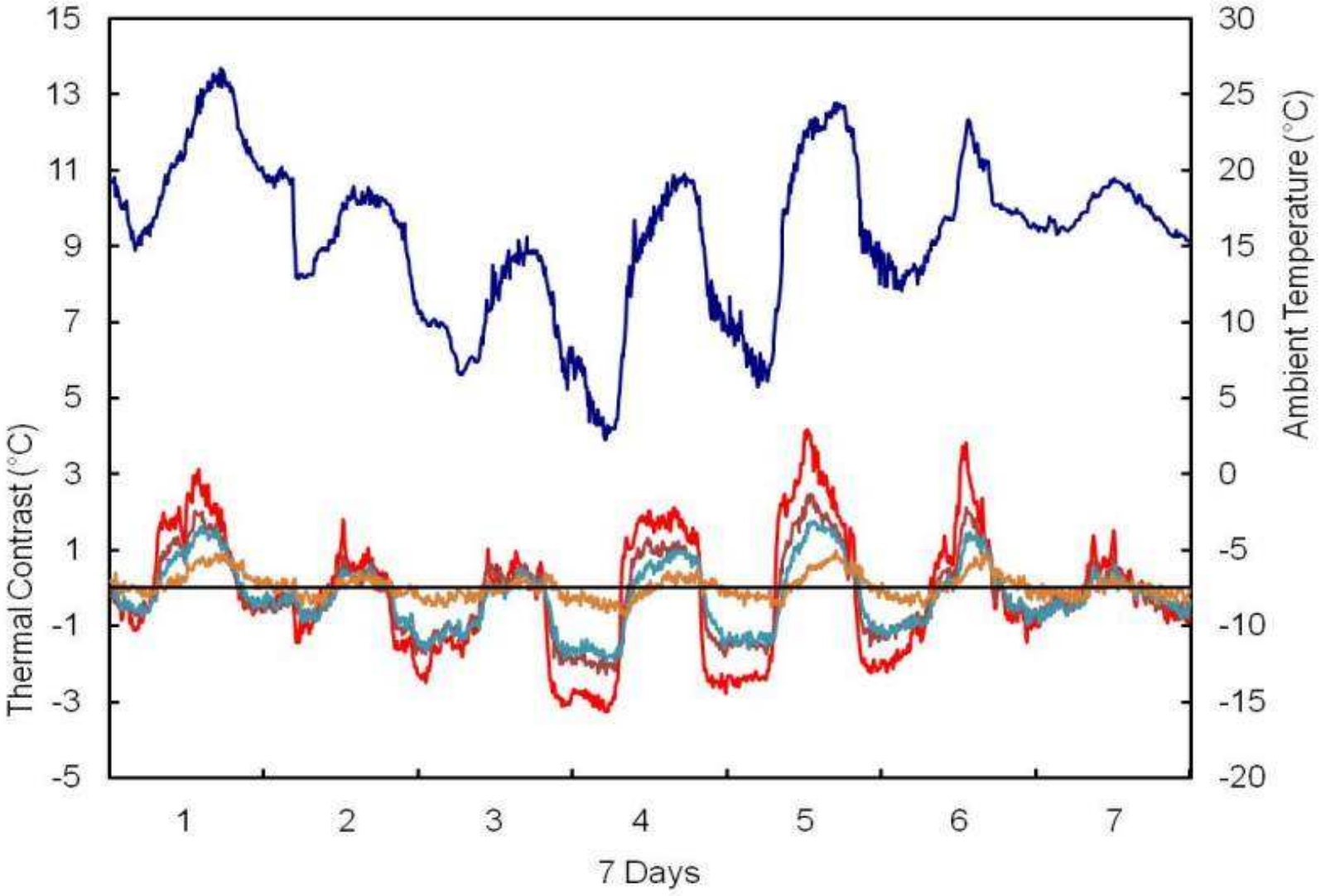
Ambient Temperature vs. Thermal Contrast (North side)



Guidelines

- Simple guidelines (3 pages, both sunny side and shady side)
- Guidelines include:
  - Ambient temperature change requirements
  - Rate of change of temperature
  - Wind conditions
  - Time of day (relative to sunrise)
  - Camera setting
  - Approach angle
- Coupled with 1 day training course

Field Examples

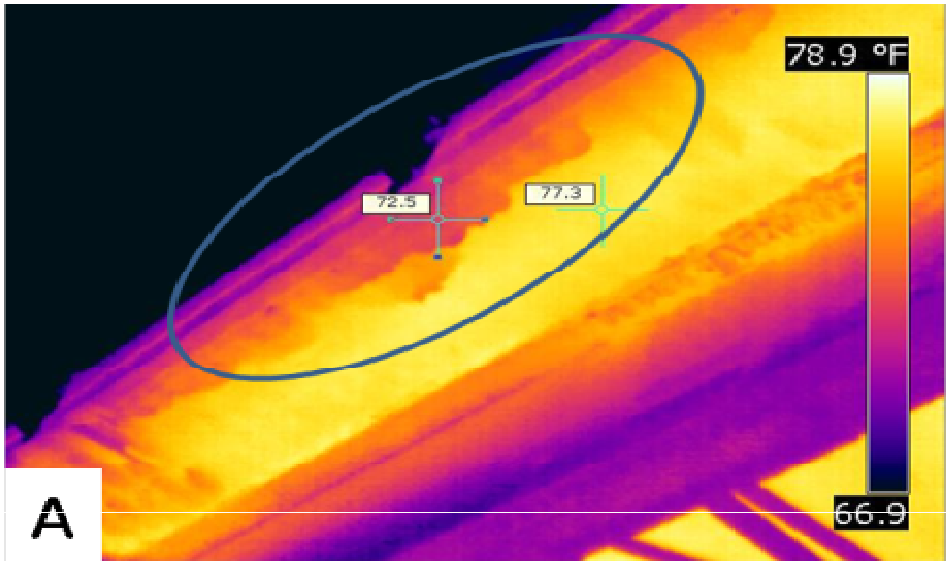
- Voided slab bridge
- Corrosion damage and patching

Note: All data collected from roadside without traffic control

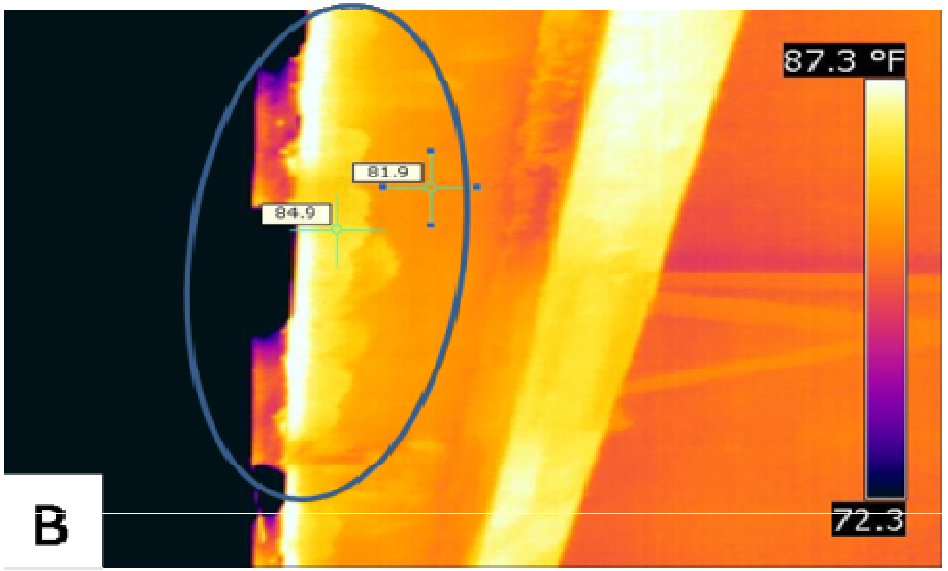

51.7
24.1
FLIR
Before
2 months later

Example: Typical Overpass
I-70, Columbia

Soffit Example



A



B

C

D

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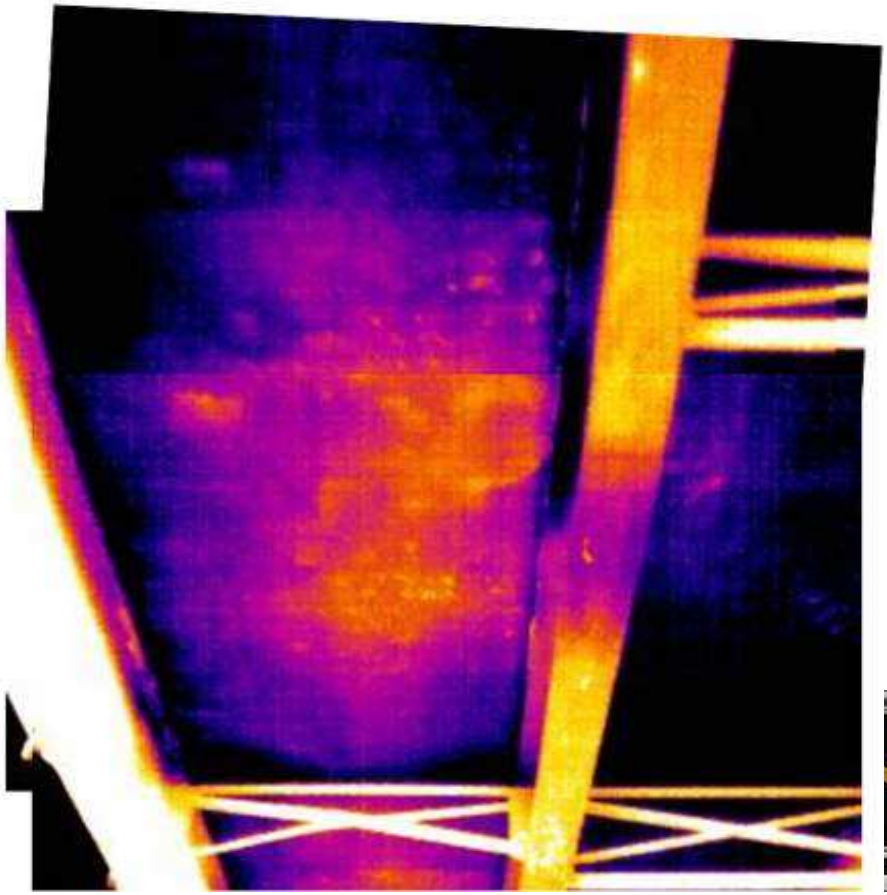
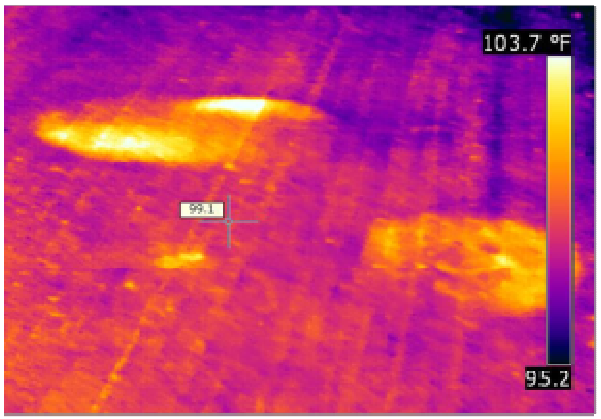
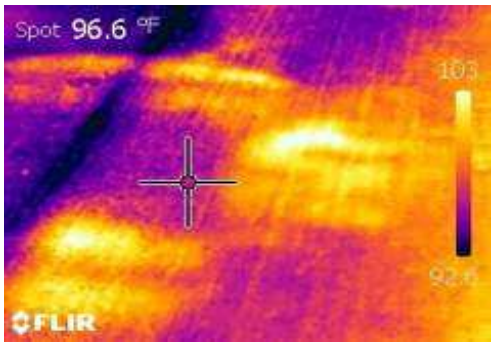
Soffit – inner bay

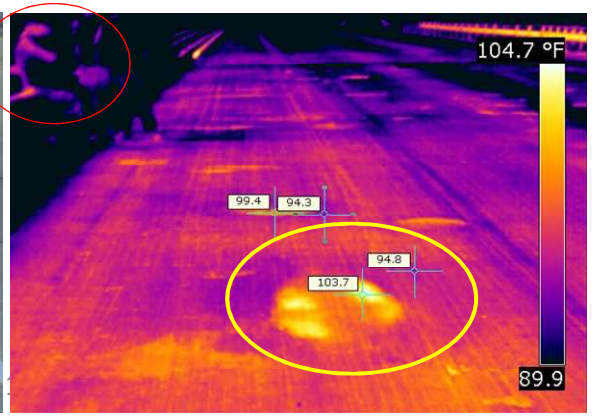
- Over I-70 E



Overlay Delaminations -TX







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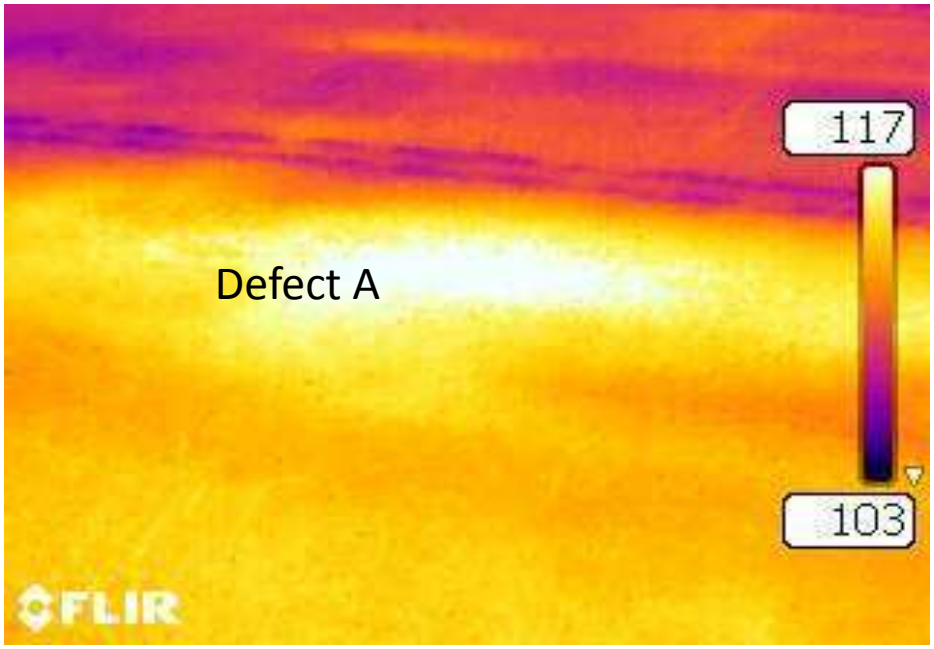
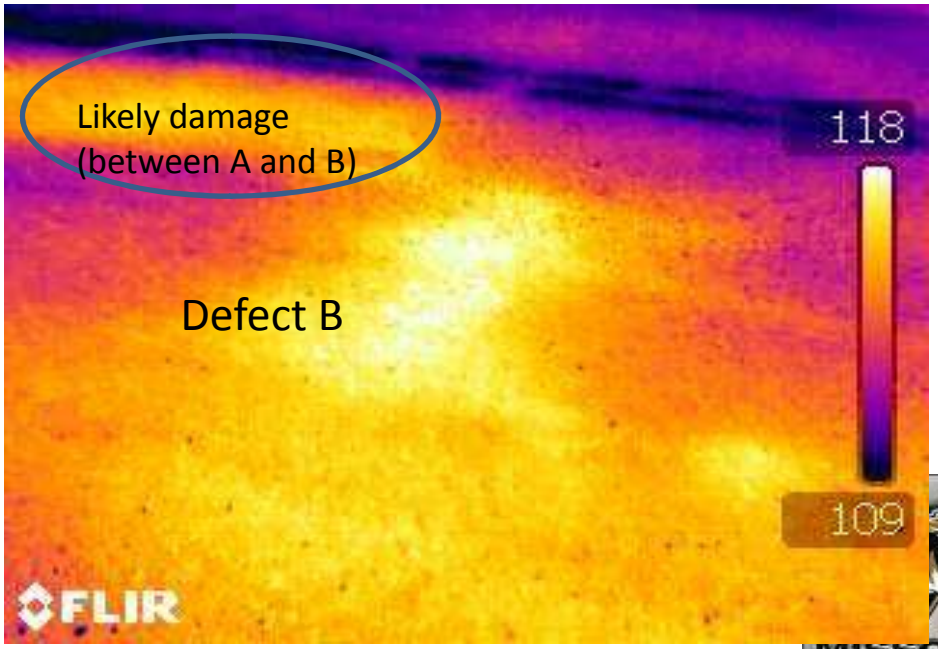
Two different defects in asphalt covered bridge deck from shoulder





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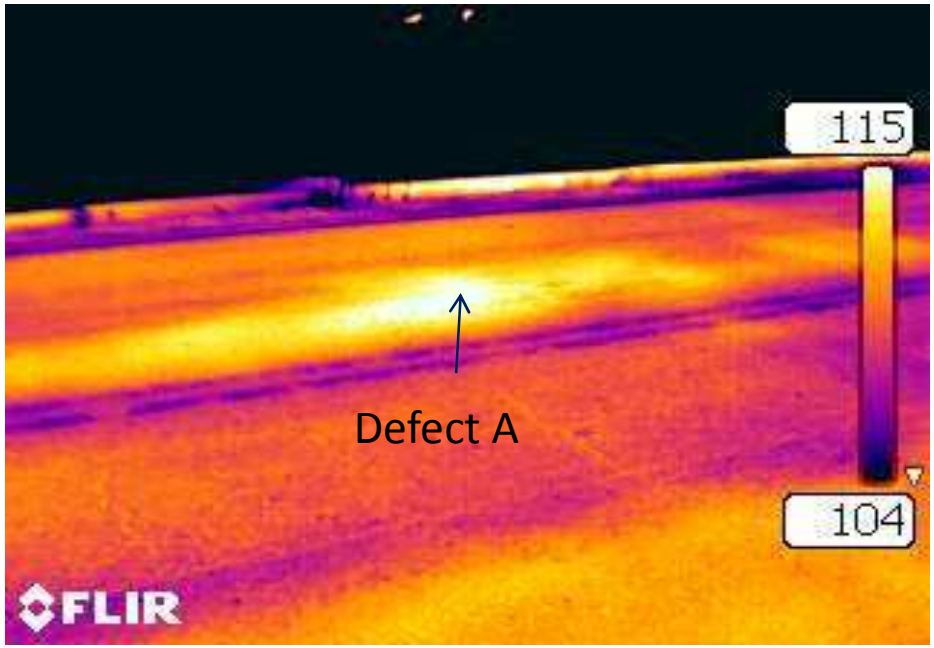
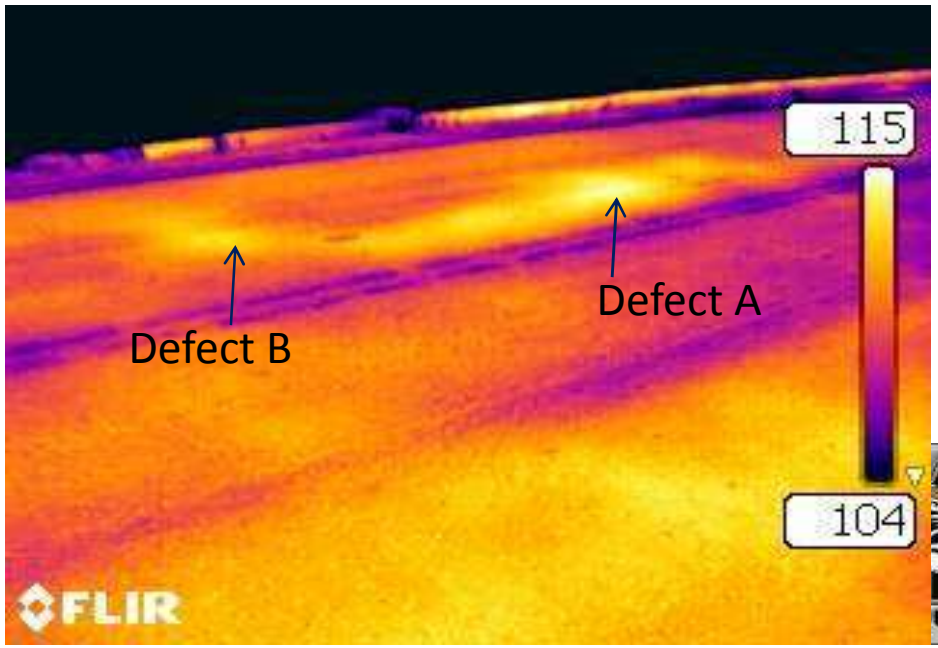
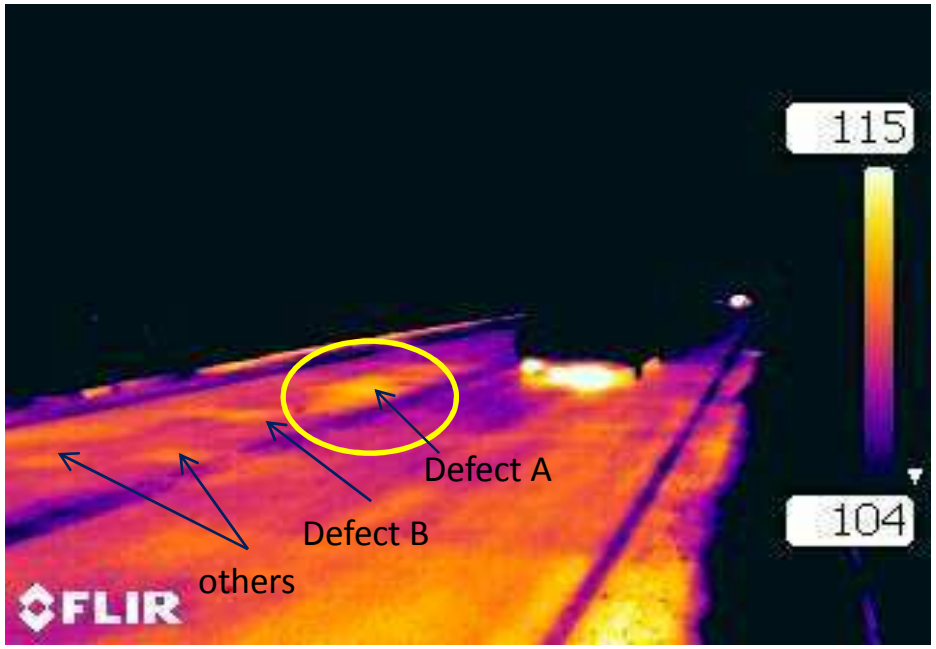
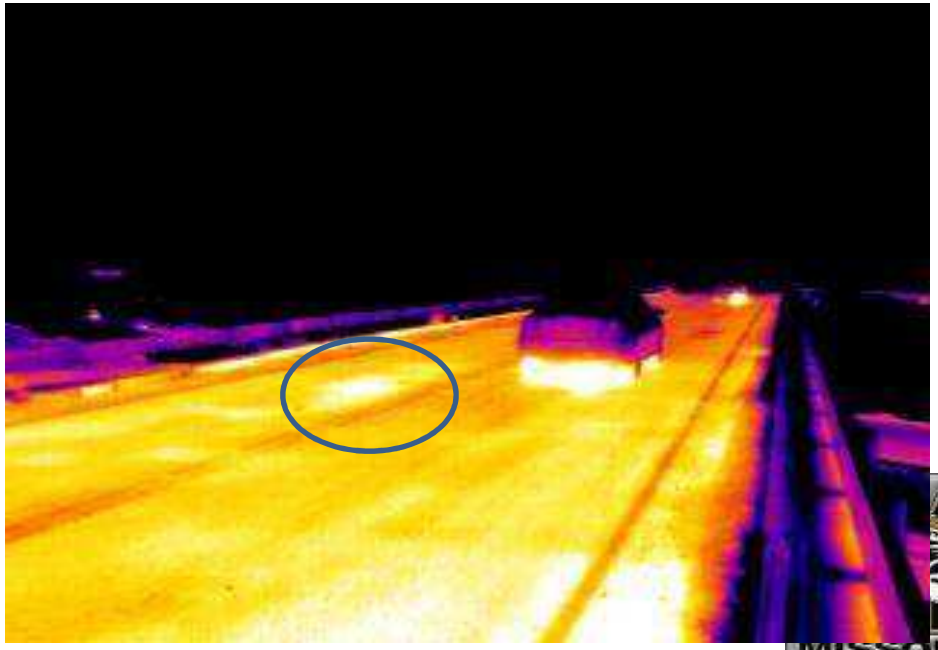
Defect A and B in asphalt covered bridge deck from shoulder, opposite side of road





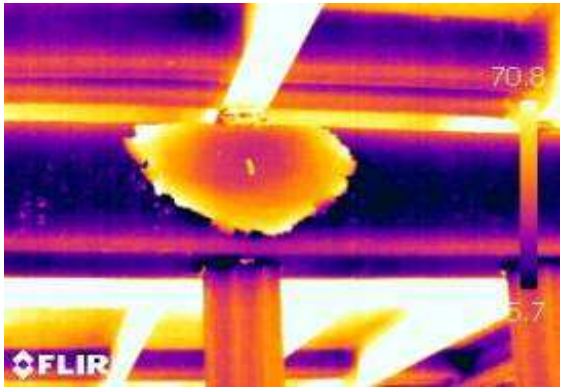
Defect under live traffic Field data (top), scale adjusted in office (bottom)



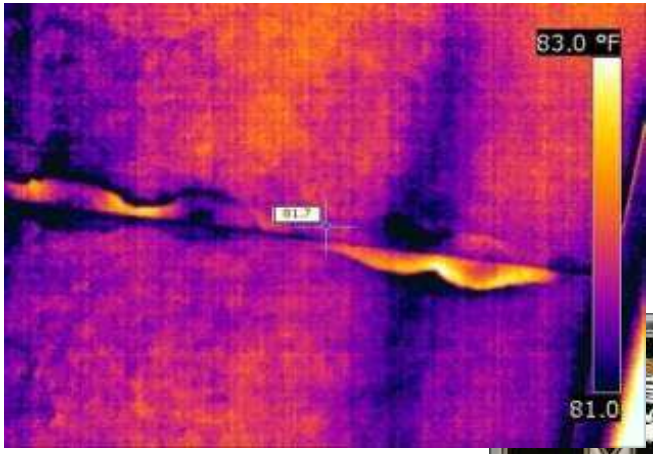


Other Examples

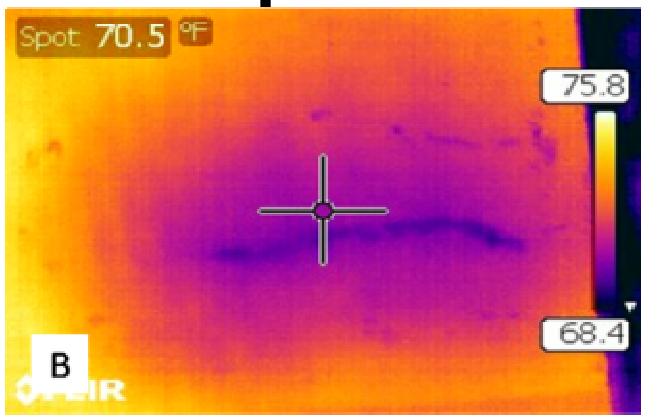
Anchor Bolt pullout due to bearing damage

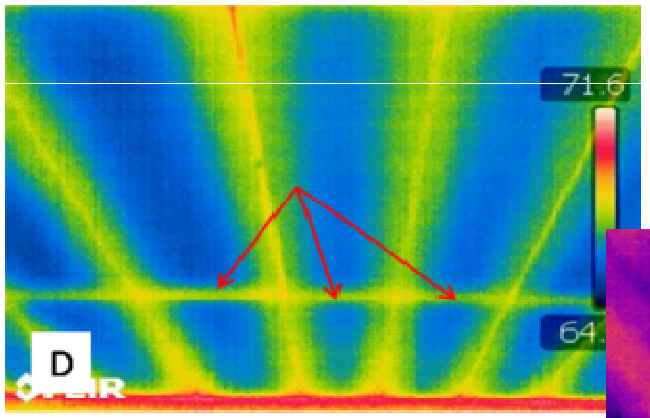


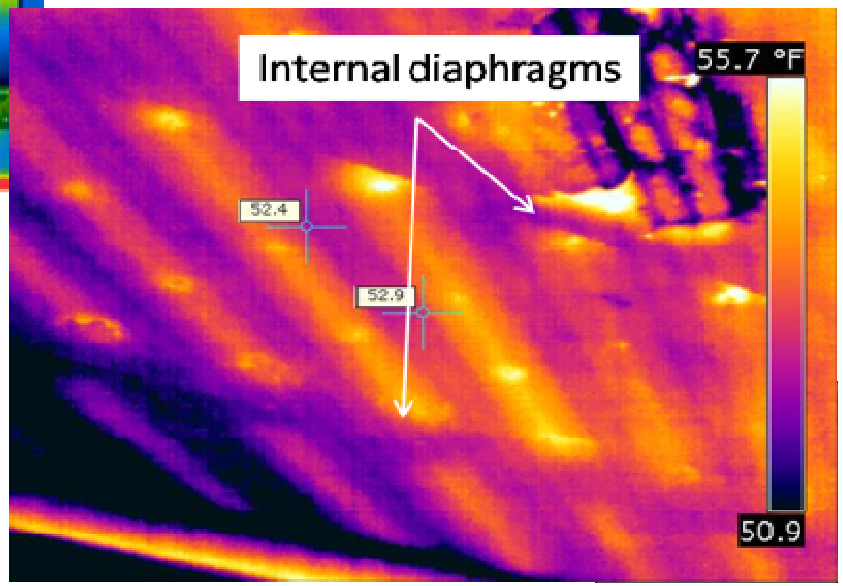
Prestressed deck panels



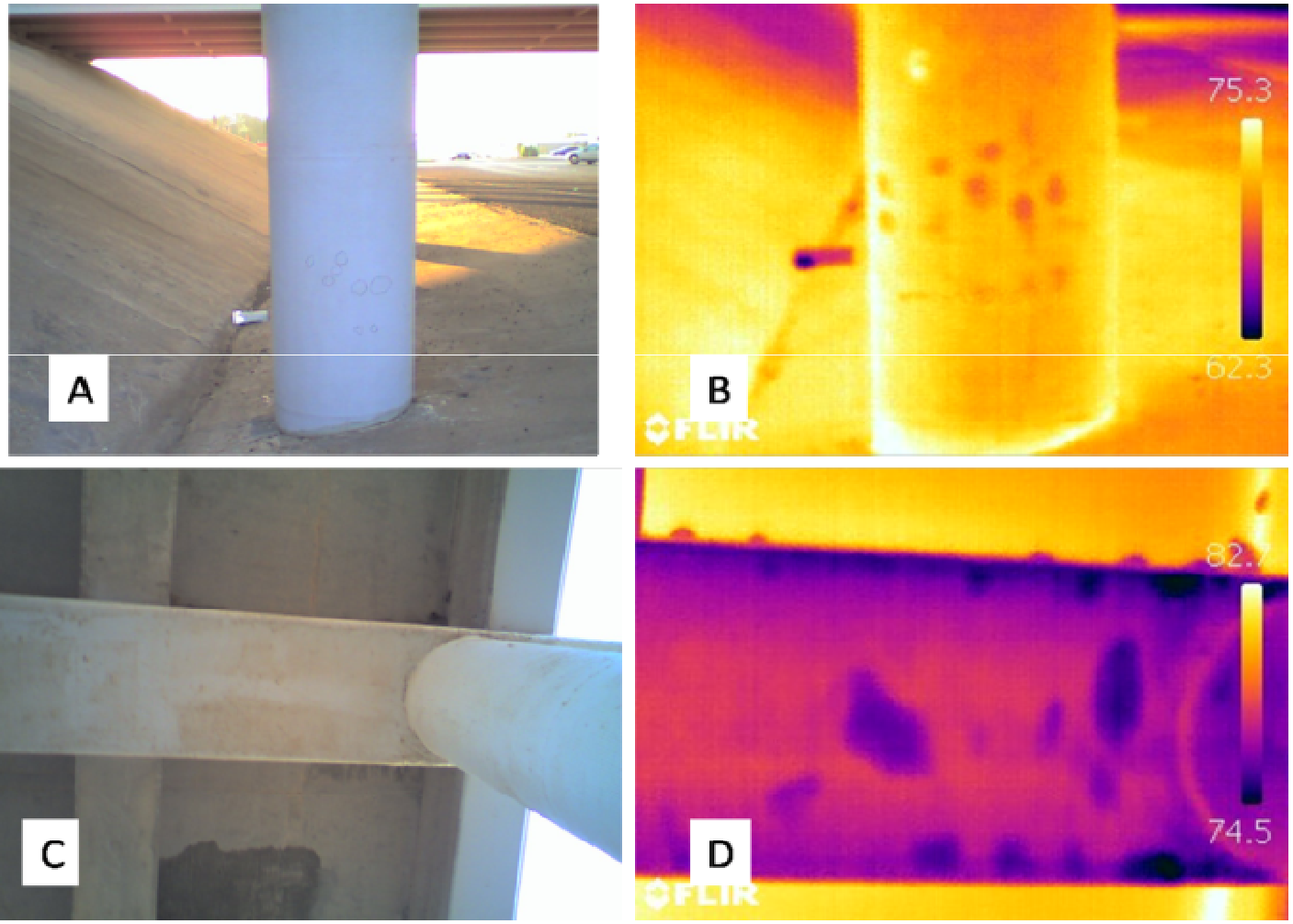
Soffit Inspections - NY







Composite Overlay - TX



Conclusions

- Field testing showed technology was practical and useable
  - Guidelines were developed based on the research
  - 1-day training
  - Implementation needs more development
- Parameters for environmental conditions for inspections were determined by experiment
- Provides a new, practical and implementable tool for ensuring the safety of highway bridges
  - Detect loose concrete in overpass bridges
  - Does not require lane closures to implement on decks
  - Can be applied to decks, parapets, abutments, concrete pavements

Conclusions

- Main Advantage
  - Extend the reach of the inspector
    - Observe damage without accessing surface
  - Relatively easy to use, real-time results
- Main Disadvantages
  - Uneven performance due to
    - Environmental conditions
    - Variations in damage
    - Best for <=~2 in., more limited for ~3-4 in., limit ~5 in.
- Best Use
  - A tool for the inspectors toolbox that greatly improves capability, with known limitations
  - Detect loose concrete that could fall into roadway

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Future Research
Phase II Pooled Fund

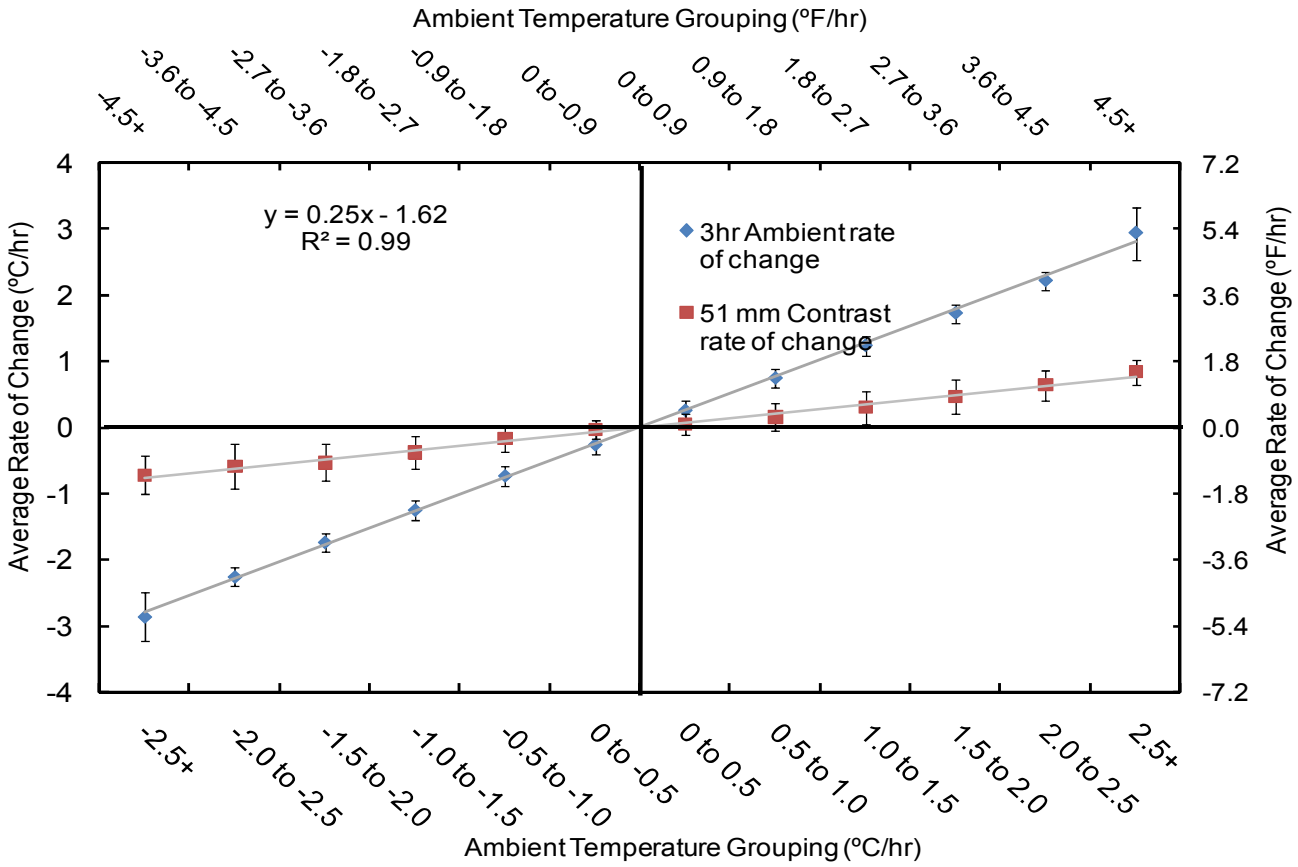
- Implement technology within normal inspection and maintenance operations
  - Identify obstacles to implementation and solve
  - Develop foundation of experience in states
  - Put tool in the hands of owners
    - Technology is intended for day to day operations
- Validation testing of technology
  - Better define reliability of method
    - Consistency under varying environmental conditions
    - Field verification during bridge rehab operations

Questions?

Backup slides

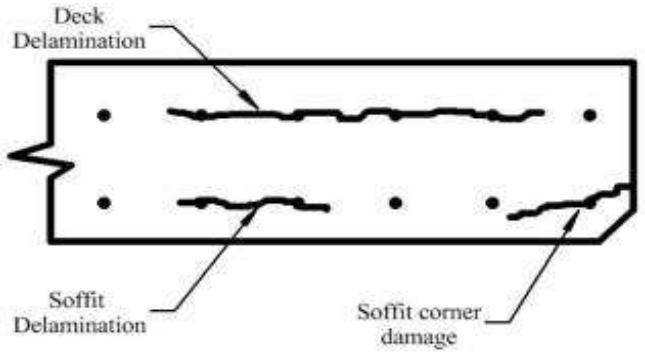
Ambient ROC, 2 in. Deep Target

- It was found that contrast is diminishing when ROC < 0.5 deg C/hr
  - During times of constant temperature, contrast is diminishing, avoid inspections during this time for 2 in. deep defects
  - Inspection should be done during changing ambient temperature



Background

- Deterioration of concrete bridge elements is a significant challenge in managing the safety and serviceability of aging bridges
- Corrosion of embedded reinforcing steel leads to delaminations and spalling of concrete
  - Damage is not visible to inspectors
- As damage develops, concrete separates from the structure (spalling)
  - In the soffit area of a bridge, spalling concrete can fall into traffic below
  - Risk to travelers



Current Technologies

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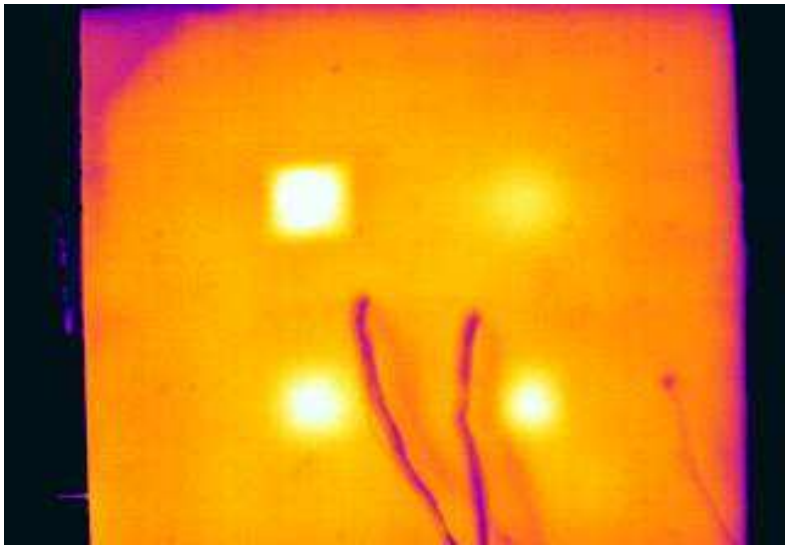
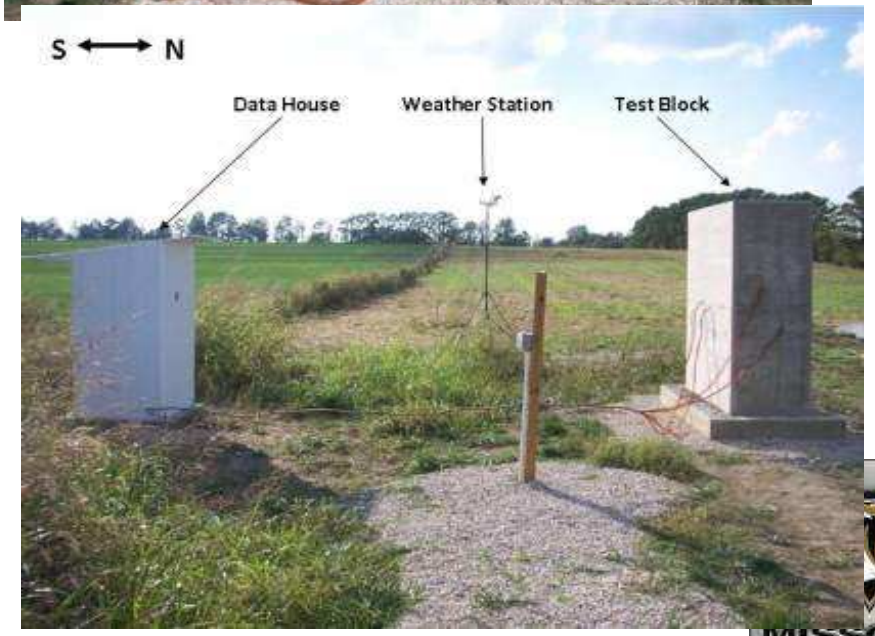
Experimental Plan

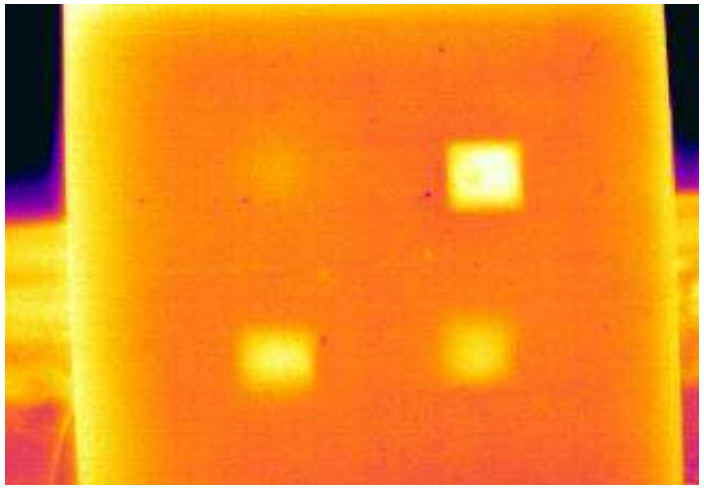
- Construct a large concrete block with simulated defects (targets) at different depths
  - Simulated defects will provide a uniform response to environmental effects
  - Different depths of targets will measure the time delay and contrast variations that could be anticipated in the field
- Demonstrate applications in field with state forces

Test Block

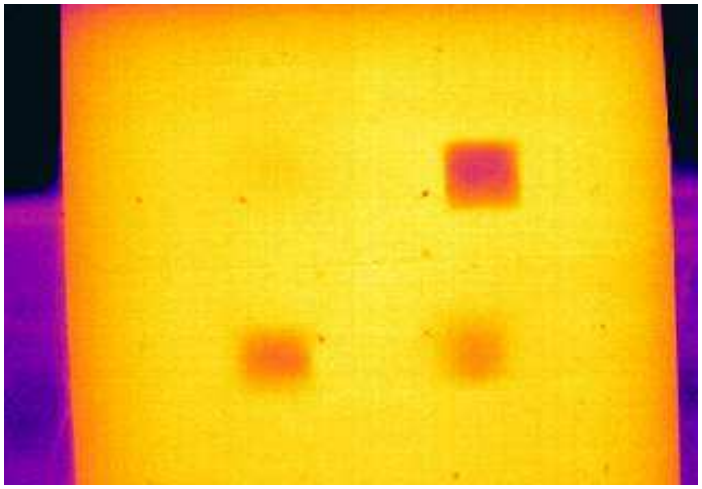




Example of simulated delaminations as observed during warming period and cooling period



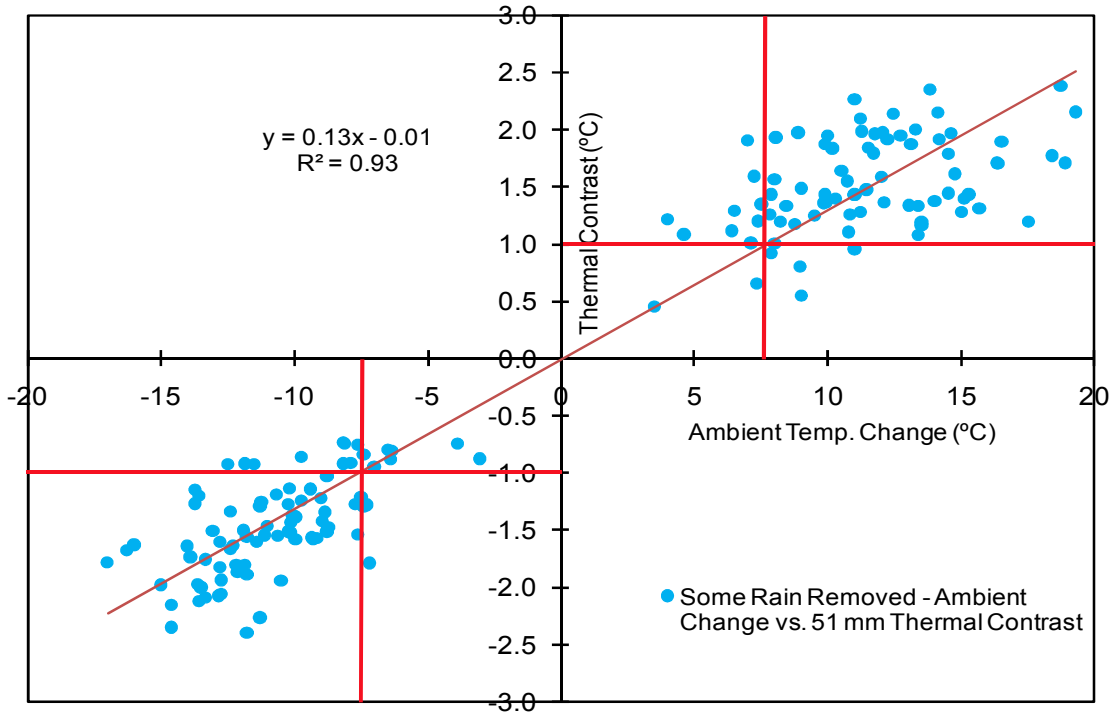
(5/4/08 3:00pm)
Positive contrasts due to warming period



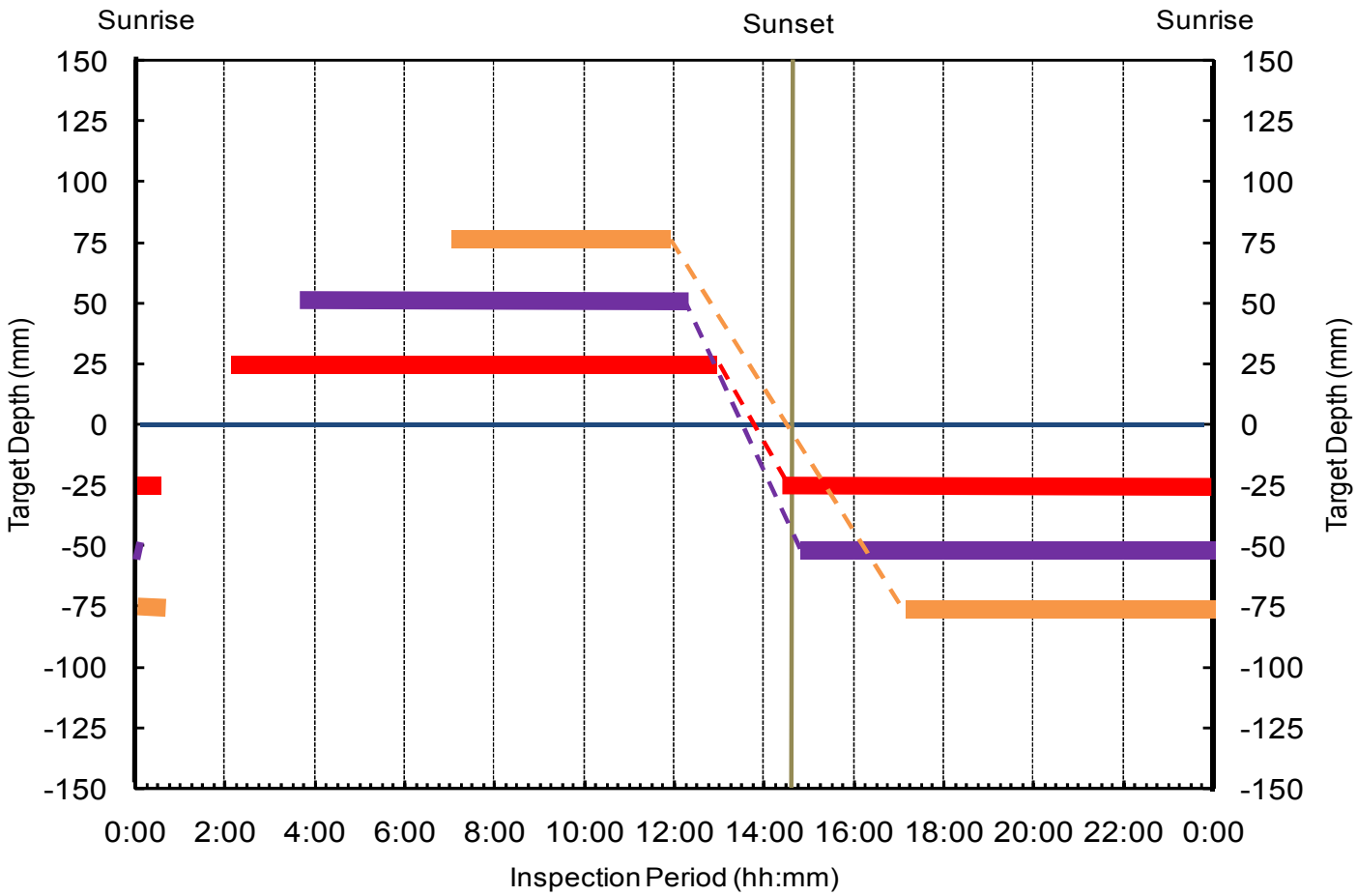
(5/5/08 3:00am)
Negative contrasts due to cooling period

Ambient Temperature Change vs. Thermal Contrast – shady side of block

- On average, 1.4 ºC of contrast either positive (day) or negative (night)



Inspection Period – North Side



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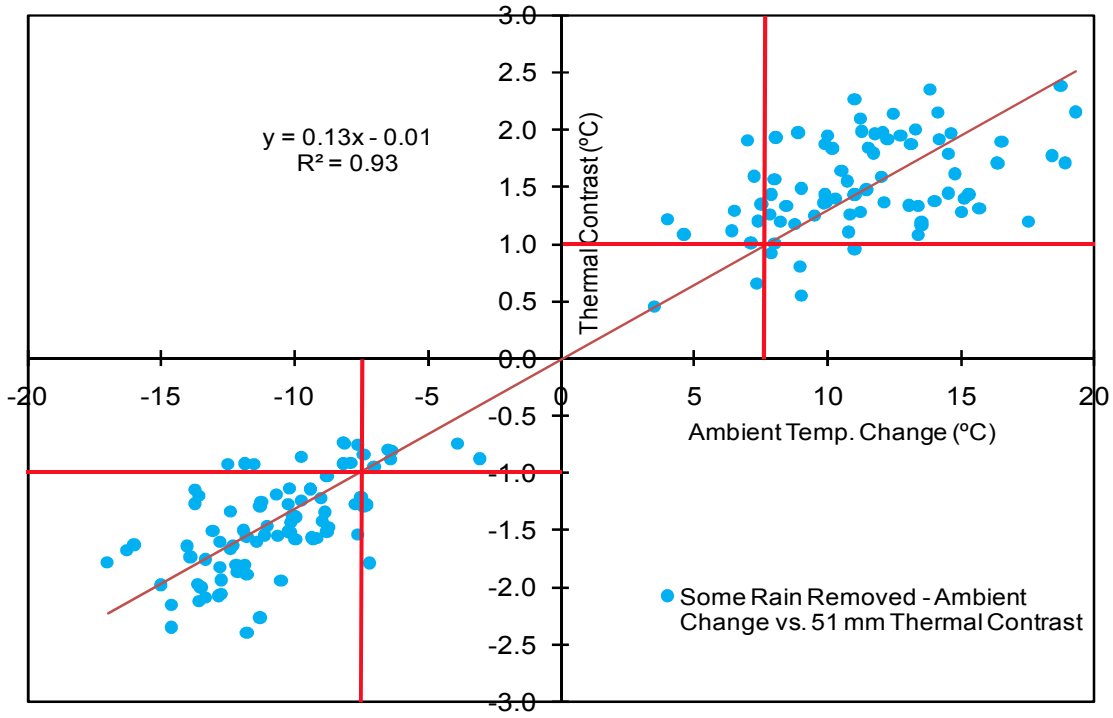

Inspection Period – North Side