

# Use of NDT for Bridge Deck Evaluation

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## Bridge Deck Investigation

- **Is visual evaluation and chaining enough?**
  - **Maybe Yes, if we are looking for .....**
    - Deck replacement and overlay projects ???
    - Majority agencies use visual and sounding as their primary tool for rehab projects.
  - **Probably not for asset management, maintenance and preservation .....**
    - Better repair and rehab options
    - Better decision making process



## Bridge Deck Evaluation

- **Delamination survey**
  - Infrared image, sounding, Impulse response
  - Spalled, patched, and delaminated area
- **Corrosion activity survey**
  - Half-cell, GPR, Salt (chloride) content, Carbonation depth
- **Bridge deck concrete**
  - Compressive strength, Permeability,
- **Traffic volume info.**
  - Average Daily Traffic (ADT) or Average Daily Truck Traffic (ADTT)



## Bridge Deck Evaluation – Cont.

- **Cracking**
  - Longitudinal, Transverse, Location, and Extent and width
- **NBI rating**
  - Bridge deck, Wearing surface, and Deck underside
- **Load rating**
  - Load capacity



## Delamination Investigation

### ■ Sounding – Chain Dragging or Hammer sounding

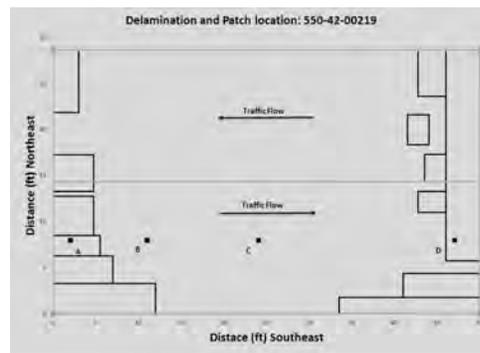
- Most common inspection method
- Detects area has hollow sound
- Chain dragging for general area and hammer sounding for the boundaries of delamination
- The speed of sounding depends on the level of deterioration.



## Delamination Investigation

### ■ Sounding – Chain Dragging or Hammer sounding

- Limitations:
  - Subjective results – operator's skill and hearing
  - Sometimes, hollow sound is out of audible range detected by the human ear



## Delamination Investigation

### ■ Infrared Thermography Analysis

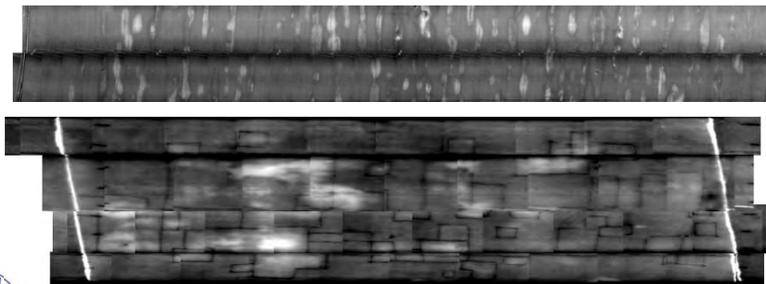
- Measures temperature variation on the bridge deck
- Delaminated area heats up faster and cools down more quickly compare to sound concrete.
- Data collection is very fast and easy



## Delamination Investigation

### ■ Infrared Thermography Analysis – Limitation

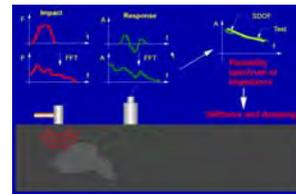
- heavily weather dependent
- Works well up to 2 in deep flaw.
- Sunlight is essential – no clouds, wind, and rain
- Only few hours of operation per day



## Delamination Investigation

### ■ Impulse Respond Analysis

- Measures dynamic responds to a given impulse.
- Evaluate the dynamic characteristics of structural elements (bridge deck, deep foundation, walls etc...)
- Very similar to impact echo technique
- Software calculates: void index, flexibility, mobility etc...



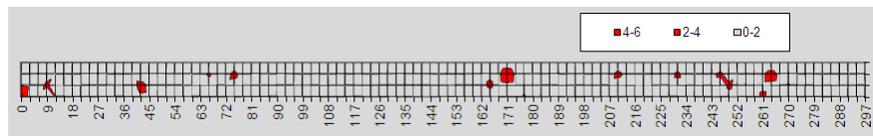
SHRP 2 R06- A 2 NDT Report



## Delamination Investigation

### ■ Impulse Respond Analysis: Limitations

- Smaller defects might not detected.
- Test results depends on selecting good test points
- Equipment are very sensitive to use
- Not suitable for long bridges



## Corrosion Investigation

### ■ Half-Cell Potential Measurement

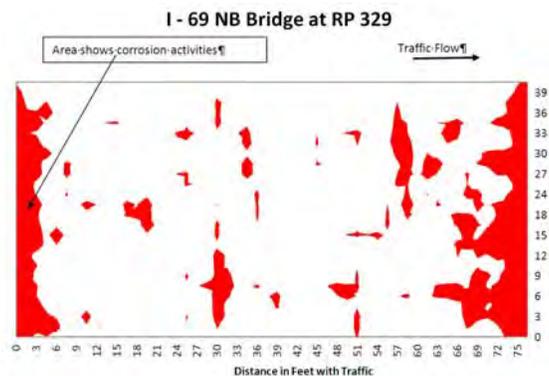
- This is a well known and widely used test method to evaluate the corrosion activities on the black rebar in the concrete deck
- Measures the potential differences between two metals as a voltage with a impedance voltmeter.



## Corrosion Investigation

### ■ H-C: Limitation

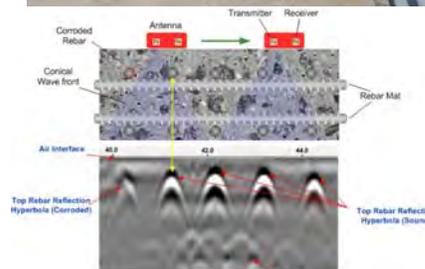
- Works on black rebar – not epoxy covered bars
- Cover depth, moisture, or salt content might be an issue



# Corrosion Investigation

## ■ GPR

- Ground Penetrating Radar – electromagnetic wave
- Send out high frequency wave and measures returned wave reflected by rebar
- Can be used to determine cover depth, corrosion activities, delamination ....



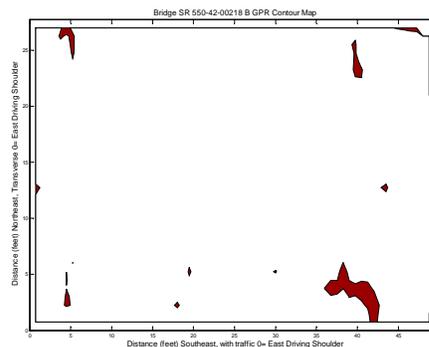
SHRP 2 R06- A 2 NDT Report



# Corrosion Investigation

## ■ GPR Limitation

- There is no standard analysis procedure
- Moisture and salt contents influence
- Analysis Time
- GPR measurement is not definitive information regarding presence of corrosion, corrosion rate, or section loss.



## Salt Content Investigation

### ■ Chloride Ion Profile Analysis

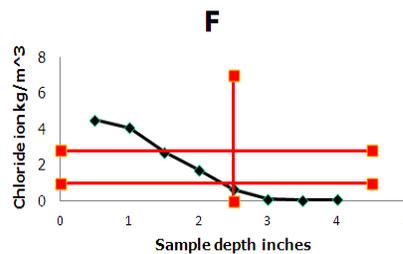
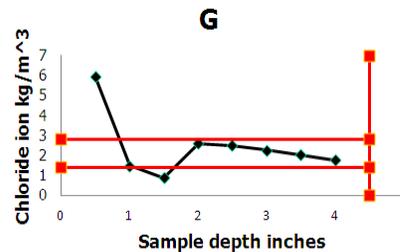
- Measures Chloride ion amount in the concrete deck
- Concrete provides alkaline environment
- Chloride ion is lowering the ph level of concrete due to HCl acid and break oxide film on the rebar surface.
- Higher chloride ion concentration, higher chance of corrosion.



## Salt Content Investigation

### ■ Chloride Ion Profile Analysis

- Chloride concentration to initiate the corrosion process – 1.4 kg/m<sup>3</sup>
- Chloride concentration to accelerate the corrosion process – 2.8 kg/m<sup>3</sup>



## Deck Condition Rating at INDOT

### ■ NBI Deck Rating

- 9 – Excellent Condition: no spalls, delaminations, cracks
- 8 – 7 Good Condition: Some minor to no problems
  - No spalls, delaminations, few transverse (insignificant) cracks, no leaking and corrosion from the bottom
- 6 – Satisfactory condition: structural elements show some minor deterioration
  - Spalls and delamination up to 5%, map cracking up to 10%, Transverse cracking spacing at more than 5 ft
- 5 – Fair condition: all primary structural elements are sound, but some may have minor section loss, cracking, spalling
  - Spalls and delamination up to 10%, map cracking up to 25%, Transverse cracking spacing at less than 5 ft. The underside of the deck has spalls with exposed rebars with up to 10% section loss.



## Deck Condition Rating at INDOT

### ■ NBI Deck Rating

- 4 – Poor Condition: Advanced section loss, deterioration, spalling
  - (1) Longitudinal Cracks over majority of the deck. (2) Spalls and delamination up to 25%, (3) map cracking up to 50%, (4) underside has wet-looking areas. (5) full-depth failures are imminent. (6) significant efflorescence is present. (7) The underside of the deck has spalls with exposed rebars with up to 30% section loss.
- 3 – Serious Condition: Loss of section, deterioration, spalling. Local failure are possible. Flexure and shear cracks may be present
  - (1) Full-depth failures are present. (2) Spalls and delamination more than 25%, (3) significant efflorescence is present. (4) underside has large wet-looking areas. (5) Significant exposed rebars with greater than 30 % section loss.



## Deck Condition Rating at INDOT

### ■ NBI Deck Rating

- 2 – Critical Condition – Advanced deterioration of primary components is present. Unless closely monitored, it may be necessary to close the bridge until corrective action is taken.
- 1 – Imminent Failure Condition: the bridge is closed to traffic
- NBI rating is based on the crack spacing and distress (patches, delamination, and potholes)



## Decision Matrix (needs more work...)

### ■ How can we use the test data in decision making process?

- NBI rating is 7 or greater – no testing
- NBI rating is 6 or less
  - Start with Infrared image
    - Less than 10% distress – maintenance
    - More than 10% distress – more testing
  - Testing for corrosion activities and salt content
    - Based on test results – maintenance work or overlay or rehab



### Decision Matrix (needs more work..)

#### Partial or full depth patch and deck sealers

- Distress + Half-cell (or GPR) < 15%
- Chloride ion concentration is less than 1.4 kg/m<sup>3</sup>

#### Deck Overlay

- 15% < Distress + half-cell (or GPR) < 50%
- Chloride ion concentration is less than 2.8 kg/m<sup>3</sup>

#### Do nothing and use it for remained life. Then do Structural rehabilitation

- Distress + half-cell (or GPR) > 50%
- Chloride ion concentration is more than 2.8 kg/m<sup>3</sup>



Questions?

