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Means and Methods of Evaluating Reinforced Concrete Structures

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Deck Condition Assessment Using Non-Destructive Testing Methods

Results from a Comparative Case Study of the I-129 Missouri River Bridge in Sioux City, IA

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Presenter: James Donnelly, WJE

Outline

- Background and Motivation
- Evaluation Approach
- Findings
- Conclusions

Background/Motivation

- Bridge decks must be evaluated to determine repair and maintenance priorities
- **Rapid**, **inexpensive**, and **accurate** evaluation techniques are needed

I-129 Missouri River Bridge

- Built in 1976
- 8-inch deck with 2-inch low-slump overlay
- Uncoated reinforcement
- Approx. 2600 feet long (15 spans)
- Local concrete repairs, epoxy injection of delaminations

EVALUATION APPROACH

Approach

- Visual/sounding survey of entire bridge
- Selected 6 study areas
- Coring - basis for evaluating method accuracy
- Delamination assessment

Delamination Assessment Methods

Study area marked with 2-ft grid

- Chain drag/sounding
- Infrared thermography (IR)
- Ground penetrating radar (GPR)
- Impact echo (IE)
- Half-cell potential testing

Chain Drag/Sounding

- Dragged chain or hammer creates sound
- Concept: The pitch of delaminated areas is different from sound concrete

Infrared Thermography (IR)

- Optical camera: surface defects/discolorations
- IR camera: measures temperature variations
- Concept: Natural cooling/heating of deck produces temperature differentials at delaminations

Ground Penetrating Radar (GPR)

- Radar signal reflects off reinforcing steel
- Concept: Features associated with corrosion (locally elevated moisture, chloride, or corrosion byproducts) affect reflection from top bar
- *Indirect indication of corrosion/delamination*

Impact Echo (IE)

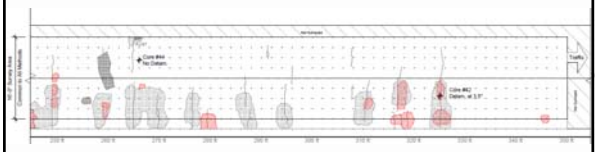
- Surface of concrete excited by impactor and resultant echo measured
- Concept: Near surface delaminations produce flexural resonance; deeper delaminations produce higher frequency resonant echo than full deck

Half-Cell Potential Testing (HCP)

- Measures potential difference between reference half-cell and reinforcing
- Concept: Potential more negative in areas of corrosion
- *Indirect indication of delamination*

FINDINGS

Chain Drag/Sounding



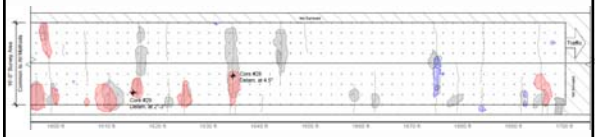
- Identified cracks, delaminations, and other surface defects in combination with visual survey
- When compared to findings from 29 core locations, delamination identification was 93% accurate. (Two false negatives.)

Chain Drag/Sounding

- Requires lane closures
- Relatively labor intensive
- Accuracy dependent on user, traffic volume, and other environmental factors (traffic noise problematic)

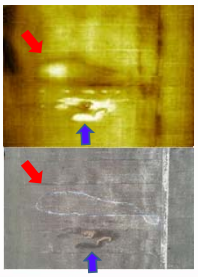
➢ Used as basis for evaluation of other methods

Infrared Thermography (IR)



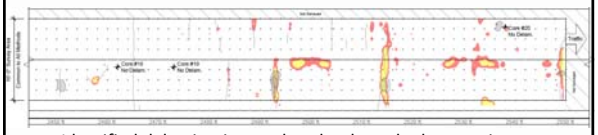
- Identified delaminations, surface discolorations and patches
- IR correctly identified 37% of delaminated area (from sounding), but "false positives" covered an area 42% the size of delaminated area

Infrared Thermography (IR)



- Can be performed with rolling lane closures
- Accuracy is field-user independent
- Results affected by:
  - Sun exposure and time of day
  - Surface discolorations (epoxy residue)
  - Depth of delamination
- Interpretation of results requires experience

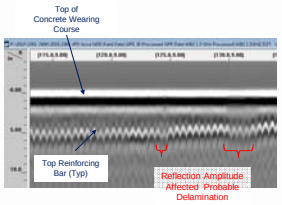
Ground Penetrating Radar (GPR)



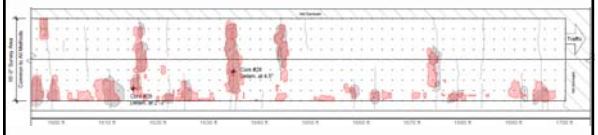
- Identified delaminations, rebar depth, and rebar spacing
- GPR with a 2.6 GHz antenna correctly identified 29% of delaminated area (from sounding) and "false positives" covered an area 92% the size of delaminated area.
- The 1.6 GHz antenna was less accurate.

Ground Penetrating Radar (GPR)

- Requires lane closures, but not user intensive
- Accuracy is field-user independent
- Provides "probable" delamination and rebar location
- Interpretation of results requires experience



Impact Echo (IE)

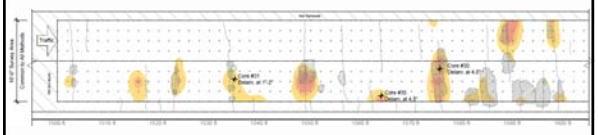


- Identified top and bottom surface delaminations
- IE correctly identified 69% of delaminated area (from sounding), but "false positives" covered an area 94% the size of delaminated area.

Impact Echo (IE)

- Requires lane closures, but not user intensive
- Accuracy is field-user independent
- Provides data regarding top and bottom surface delaminations
- Interpretation of results requires experience

Half-Cell Potential Testing (HCP)



- Identified areas with a higher likelihood of top reinforcement corrosion
- Areas at risk for corrosion coincided with 44% of delaminated area (from sounding), but included another area 165% the size of delaminated area.

Half-Cell Potential Testing (HCP)

- Requires lane closures
- Somewhat user intensive
- Requires drilling in deck to expose reinforcement
- Provides data regarding corrosion state of embedded reinforcement
- Interpretation of results requires experience

Conclusions

- The most accurate NDT methods evaluated were impact echo and infrared thermography
- Ground penetrating radar provided useful information regarding reinforcement depth and location
- Half-cell potential testing identified areas where corrosion is likely and future delaminations may develop
- Infrared thermography is the only method that can be performed without a lane closure, but is sensitive to weather
- Accuracy of impact echo, infrared thermography and ground penetrating radar are relatively independent of the user in the field

Questions?