Highway Bridge Technologies for Design, Construction, Inspection, and Management

FHWA’s Research and Development Programs and Processes

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Technical Director, Bridge & Structures R&D
U.S. Federal Highway Administration
1. Conduct **research** to develop knowledge, guidelines, analytical and physical tools, test methods and procedures

2. Provide specialized **technical assistance**
FHWA’s Bridge and Structures R&D Focus

• The “Bridge of the Future”
• Effective Stewardship and Management of existing highway infrastructure
FHWA Bridges and Structures R&D Teams

• Bridge Design and Construction Team
• Bridge Safety, Reliability and Security Team
• Infrastructure Inspection and Management Team
Bridge Design and Construction Team

Areas of Expertise

- Structural Steel
- Fatigue – Fracture
- Structural Concrete
- Geotechnology
- Structural Experimentation
- Instrumentation

Major Programs

- Corrosion Resistive Steel
- Lightweight Concrete
- UHPC
- Fatigue/fracture of Galvanized Light Poles
- Integrated Bridge Abutments
- Fracture Control Plan and Inspection Requirements
Areas of Expertise

- Hydraulics
- Aerodynamics
- Seismic
- Blast
- Security
- FRP
- Timber

Major Programs

- Wave Forces
- Scour
- Wind – Rain Vibration
- Seismic Retrofit
- Covered Bridge
- Security
Infrastructure Inspection and Management Team

**Areas of Expertise**

- Corrosion
- Deterioration
- NDE – NDT
- Bridge Inspection
- Structural Monitoring
- Coatings
- BMS

**Major Programs**

- Long-Term Bridge Performance Program
- Steel Bridge Testing
- Higher Performing Steel Bridges (coatings)
- ASR
Structures Laboratory
Hydraulics Laboratory
Paint & Coatings Laboratory
Research Mechanisms

- In-house
- Competitive contracts & cooperative agreements
  - Academia
  - University Transportation Centers (UTCs)
  - Professional (practice & research) organizations
  - Other.....
Research Program Funding

- Congressionally authorized (discretionary R&D funding)
- Congressionally directed (earmarks, designations)
- Transportation Pooled Fund studies
- Cooperative/collaborative (e.g., with NCHRP, NSF, NIST, …)
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Authorized Research Programs

- ASR Research & Deployment
- High-Performance Steel R&D
- Innovative Bridge Research & Deployment (IBRD)
  - High Performance Concrete R&D
- Long-Term Bridge Performance Program
- Steel Bridge Testing
- Ultra-High Performance Concrete
- Seismic Research Program (*earmark*)
Authorized Research Programs

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- High-Performance Steel R&D
- Innovative Bridge Research & Deployment (IBRD)
  - *High Performance Concrete R&D*
- Long-Term Bridge Performance Program
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- Ultra-High Performance Concrete
- Seismic Research Program (*earmark*)
FY 2008 Appropriations Bill

- Congress rescinded all FY08 funding for the IBRD program

- Impacts
  - HPC R&D Program
  - Geotech R&D
  - Hydraulics R&D
  - Aerodynamics R&D
  - Infrastructure Durability Lab (proposed)
  - State IBRD construction grants
Selected R&D Programs/Projects
Long Term Bridge Performance Program

Objectives:

To collect, document, maintain, and make available high-quality, **quantitative bridge performance data**, from a **representative sample** of bridges nationwide
Rutgers University (CAIT) / PB LTBPP Team

- Rutgers University – Center for Advanced Infrastructure and Transportation
- PB Americas inc. (formerly, Parsons Brinckerhoff)
- Utah Transportation Center, Utah State University
- Virginia Transportation Research Center, VDOT
- Bridge Diagnostic Inc.
- Siemens America
- Institute for Transportation Studies, UC Berkeley
- Advitam
Lightweight High-Performance Concrete

Objective: To address shortcomings in current AASHTO LRFD

Research will address:
- Shear provisions
- Strand development and transfer length
- Mild steel development and splice length
- Creep, shrinkage, and modulus of elasticity
Lightweight High Performance Concrete Research
ASR Research and Development Program

Program Objectives:

• Eliminate highway infrastructure deterioration for new construction
• Seek cost effective techniques for rehabilitation of existing structures
• Develop reliable accelerated laboratory and non-destructive methods for field application
Structural Steel One-Coat Study

- Among eight one-coat systems, four have performed poorly compared to 3-coat and 2-coat control systems.
- One system (Calcium Sulfonate Alkyd) has been an excellent performer despite its soft coating property and very weak adhesion strength.
- Accelerated lab testing to be completed May 2008; outdoor exposure testing to be completed end of 2008.
Objective – to identify and evaluate coating materials that can provide 100 years of virtually maintenance-free service life for the steel structures

Study will start in June 2008 – planned as a 36-month in-house research project
Seismic & Multi-hazards Research - 2005-2009

- MCEER (Univ at Buffalo) – Advancing Seismic Design and Construction Technology for Highway Systems
- Univ of Nevada, Reno – Developing Integrated Systems for Seismic Risk Assessment
- MCEER (Univ at Buffalo) – Developing Multiple Hazard Design Principles for Highway Bridges
Hydraulics Research

• Completed New Pressure Flow Scour Prediction Method
  (Memo, HEC-18)

• Completed Drag, Lift and Moments on Inundated Bridge Decks
  (Memo, LRFD, HDS-5)

• Scour in Cohesive Soils / Ex-situ Scour Testing Device
  (Expected Completion FY09)

• TPF Study on Fish Passage in Large Culverts with Low Flows
  (Partners: AK, MD, MI, GA, VT, MN Expected Completion FY10)
FHWA NDE Web Manual

Bridges

Pavements

Other Structures
# Capability Matrix

## Bridges: Girders/Trusses: Steel Beam/Girder Crack Detection in Steel Girders

<table>
<thead>
<tr>
<th>Type</th>
<th>Application Topic</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Eddy Current</td>
<td>Rating</td>
</tr>
<tr>
<td>Standard</td>
<td>Ultrasonic</td>
<td>Rating</td>
</tr>
<tr>
<td>Standard</td>
<td>Dye Penetrant</td>
<td>Rating</td>
</tr>
<tr>
<td>Standard</td>
<td>Magnetic Particle</td>
<td>Rating</td>
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<tr>
<td>Standard</td>
<td>Visual</td>
<td>Rating</td>
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<tr>
<td>Standard</td>
<td>Acoustic Emissions</td>
<td>Rating</td>
</tr>
<tr>
<td>Standard</td>
<td>Crack Detection Gages</td>
<td>Rating</td>
</tr>
<tr>
<td>Special</td>
<td>Eddy Current Array</td>
<td>Rating</td>
</tr>
<tr>
<td>Special</td>
<td>Phased Array Ultrasonic</td>
<td>Rating</td>
</tr>
<tr>
<td>Special</td>
<td>Other Ultrasonic</td>
<td>Rating</td>
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<tr>
<td>Special</td>
<td>Radiography</td>
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<tr>
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<td>Thermography</td>
<td>Rating</td>
</tr>
<tr>
<td>Special</td>
<td>Electrochemical Potentiostat Cell</td>
<td>Rating</td>
</tr>
</tbody>
</table>

### Crack Detection with Eddy Current

<table>
<thead>
<tr>
<th>Capability</th>
<th>Rating</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing/Non-Growing Crack Detection</td>
<td></td>
<td>Primarily used for crack detection</td>
</tr>
<tr>
<td>Growing/Non-Growing Crack Growth Detection</td>
<td></td>
<td>With periodic inspection</td>
</tr>
<tr>
<td>Surface Defects: Detect length of surface cracks</td>
<td></td>
<td>Well-suited to surface defect detection</td>
</tr>
<tr>
<td>Surface Defects: Detect depth of surface cracks</td>
<td></td>
<td>No depth information provided</td>
</tr>
<tr>
<td>Surface Defects: Detect orientation of surface cracks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Defects: Detect growth rate of surface cracks</td>
<td></td>
<td>With periodic inspection</td>
</tr>
<tr>
<td>Sub-Surface Defects: Detect length of sub-surface cracks</td>
<td></td>
<td>Near-surface defects can be detected</td>
</tr>
<tr>
<td>Sub-Surface Defects: Detect depth of sub-surface cracks</td>
<td></td>
<td>No depth information provided</td>
</tr>
<tr>
<td>Sub-Surface Defects: Detect orientation of sub-surface cracks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-Surface Defects: Detect growth rate of sub-surface cracks</td>
<td></td>
<td>With periodic inspection</td>
</tr>
<tr>
<td>Defect Location: Detect cracks in uneven surfaces</td>
<td></td>
<td>Well-suited to irregular surfaces</td>
</tr>
<tr>
<td>Defect Location: Detect cracks in crown of weld</td>
<td></td>
<td>Probe can be scanned over crown</td>
</tr>
<tr>
<td>Defect Location: Detect cracks in toe of weld</td>
<td></td>
<td>Probe can be scanned over toe</td>
</tr>
<tr>
<td>Defect Location: Detect cracks in root of weld</td>
<td></td>
<td>Probe can be scanned over root</td>
</tr>
</tbody>
</table>
**Application Topic Document**

**NDE Manual**

*Engineering Applications: Bridges: Superstructure: Steel*

**Weld Inspection for Defects: In-Service: Magnetic Particle**

**Application Areas**
Magnetic particle techniques are used to find surface breaking cracks on steel bridges.

**Basic Concept / Problem Description**
Magnetic particle testing can detect surface breaking cracks that are too small to be observed visually. This method can only be applied to ferromagnetic materials. Therefore it will not work on materials such as aluminum.

When a specimen is subjected to a magnetic field, the presence of a defect will cause local distortions in the magnetic field around the defect area. This effect is referred to as magnetic flux leakage. If fine particles of magnetic material are placed on the specimen in the presence of the magnet field, they will be attracted to a defect area due to the presence of the magnetic flux leakage around the defect.

![Magnetic Flux Leakage](http://www.nist.gov/educationresources/communitycollege/magparticleintroduction/basicprinciples.htm)

The technique is used as follows:
1. A magnetic field is applied to a specimen
2. Fine magnetic particles are applied to the specimen
3. The specimen is observed for defects

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**Data Acquisition**

There are different types of devices that are used to perform a magnetic particle inspection. (Photo: http://www.putnamcorp.com)

1. **Permanent Magnets**
   a. This device uses permanent magnets to generate a magnetic field on a specimen.

2. **AC Value**
   a. This device uses an electromagnet to generate the magnetic field between two poles.

3. **Pods**
NDE Web Manual – Planned Additional Content

- Pavements
- Tunnels and Culverts
- Geotechnical Constructions
- Ancillary Structures
Selected Technical Assistance Examples
I-35W

• Investigation
• Testing
• Analysis
Fatigue of Galvanized Poles

Issue

- Premature failures of cantilever signal arms, sign structures, and high mast light poles constructed of galvanized steel
- Past studies addressed the effect of galvanizing on fatigue resistance
- VA DOT pole failed on I-81 after only 1.5 years of service
- Literature indicates that galvanizing can cause liquid metal embrittlement under certain conditions
Varina-Enon Bridge (I-295 over James River, VA)
Varina-Enon Bridge (I-295 over James River, VA)
Varina-Enon Bridge (I-295 over James River, VA)
Bridge Inspectors NDE Showcase (BINS)

- Eddy Current (EC)
- Ultrasonic Testing (UT)
- Impact Echo (IE) / Ultrasonic Pulse Velocity (UPV)
- Ground Penetrating Radar (GPR)
- Infrared Thermographic (IR)
What Does the Future Hold?

We are proposing, for the next authorization/re-authorization (2010 and beyond), a major redirection of our RD&T programs –

*Highways* of the Future
Highways of the Future Strategies

- Long Term Infrastructure Performance
- Durable Infrastructure Systems
- Accelerated Highway Construction
- Environmentally Sensitive Infrastructure
- Performance-Based Specifications
- Comprehensive & Integrated Asset Management
Thank you.....