FHWA Bridge Research Update

Meeting of the AASHTO Subcommittee on Bridges & Structures

Portland, Oregon
June 16-20, 2013

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Outline

- Infrastructure Research & Technology Strategic Plan
- Infrastructure Inspection & Management Research Team
- Hazard Mitigation Research Team
- Bridge & Foundation Engineering Research Team
Infrastructure R&T Strategic Plan

One, unified plan to provide strategic direction for all Infrastructure related research and technology efforts at FHWA.

- For the next 5 years and beyond
- Work plans for 14 of 76 initiatives
- Projects and activities of national importance
Strategic Plan Objectives

1. Highway Safety - Reduce the number of fatalities attributable to infrastructure design characteristics and work zones.

2. Infrastructure Safety and Security - Improve the safety and security of highway infrastructure.

3. Infrastructure Management - Improve the management of infrastructure assets and advance the implementation of a performance-based program for the NHS.

4. Project Delivery - Improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality and cost.

5. Mobility - Reduce user delay attributable to infrastructure system performance, maintenance, rehabilitation and construction.

6. Infrastructure Performance - Improve highway condition and performance through increased use of design, materials, construction and maintenance innovations.

7. Environmental Sustainability - Reduce the life-cycle environmental impacts of highway infrastructure (design, construction, operation, preservation, and maintenance).
DETECTION OF CORROSION DAMAGE IN MULTI-LAYER GUSSET PLATES USING HIGH PULSE X-RAY

Detection and sizing of section loss in gusset mock-ups is fairly accurate using Pulsed Radiography Technique.

DEVELOPMENT OF NDT PROTOCOLS FOR CONCRETE BARRIERS

1 – MIRA Ultrasonic Tomographar
2 – Ground Penetrating Radar
3 – Thermal Imaging
4 – Digital Radiographic Testing

RESPONSE BASED LOAD RATING OF CONCRETE & STEEL BRIDGES

Real time strain measurements are used to calculate stochastic live load moments and subsequently determine a load rating.
Corrosion – Dr. Paul Virmani

- Chloride-contaminated grout study
- Corrosion-resistant steel
- Nanotechnology for corrosion protection of steel
Improved Weathering Steels

Fall of 2007 studies of bridge steels that do not require supplemental coatings:

1) readily produced

2) structural properties at least equal to ASTM A 709

3) ease of weldability and fabrication

4) similar costs as A709 steels
Research Studies

- Northwestern University-A710 Grade B
- Mittal Steel – modified A1010 w/lower Cr
- Lehigh University – 1 optimal steel out of 24 compositions
Long-Term Bridge Performance (LTBP) Program
Sue Lane, Dr. Rob Zobel, Dr. Hamid Ghassemi

- Began Long-Term Data Collection in March 2013
  - 2 Bridge Type Clusters in Mid-Atlantic Region
    - Steel Multi-Girder Bridges with CIP Deck
    - Prestressed Concrete Multi-Girder Bridges with CIP Deck
- Feb 2013—Held LTBP Meetings with Gulf States
- March 2013—Held LTBP Mtgs in NW and SW
- April 2013—Will hold LTBP Meetings with “Music” states (TN, KY, IN, OH, GA, SC, NC)
Protocols for Condition Assessment of Prestressed Concrete Girders Using NDE and Physical Testing – Dr. Rob Zobel

Technologies Deployed for Protocol Development – Corrosion Activity/Potential:

- Instantaneous Rate of Corrosion (Linear Polarization Resistance)
- Degree of Electrical Continuity
- Concrete Electrical Resistance (Wenner 4-Pin)
- Statistical Distribution of Concrete Cover (Using Pachometer and GPR)
- Carbonation Depth
- Crack Mapping
- Acid Soluble Chloride
- Half-Cell Potential
Prestressed Girders at TFHRC
VMS CFD Sign Simulation-Hal Bosch

- Integrated software approach utilizing both LS-DYNA and STAR-CCM+
- Simulated testing of pressure and vibration effects on highway signs from passing trucks.
- Analysis performed at Argonne National Laboratory.
Field Testing

- Field testing performed at various bridges including Bill Emerson, Penobscot Narrows, and the L.P. Zakim Bridge in Boston.
- Dynamic measurements to evaluate methods for mitigation of large wind-induced cable vibrations.
Other Studies

- Pressure Sensitive Paints
- Mitigation of Wind-induced Vibration of Stay Cables
- Wind Tunnel – Parametric Study
- Wind Tunnel Investigations of Inclined Stay Cables with Helical Fillet
Hydraulics R&D studies for FY13 – Dr. Kornel Kerenyi

- Hydraulic Performance of Shallow Foundations for Support of Bridge Abutments
- In-situ Scour Testing Device
- Computational Fluid Dynamics (CFD) and Computational Structural/Soil Mechanics (CSM) Services at DOE’s ANL/TRACC
GRS Abutment Study

Hydraulic Performance of Shallow Foundations for Support of Bridge Abutments
In-situ Scour Testing Device
Computational Modeling Services at the Argonne National Lab/TRACC
Culvert Inspection System – Dr. Frank Jalinoos

• There are an estimated 2,000,000 culvert units supporting the nation’s highway infrastructure.

• Only larger culverts with span length greater than 20 ft (6 m) are documented in the National Bridge Inventory (NBI). According to the December 2010 count, out of 604,000 structures in NBI, there are approximately 131,000 (large) culverts equaling 22% of the total count. Therefore, only an estimated 6% of culverts are inventoried in a central national database.

TFHRC Hydraulics lab, in cooperation with Southwest Research Institute, has developed an ultrasonic culvert mapping system that images culvert interior in 3-D and in both air and water.
Housing Design

The housing design is about 4.5” in diameter and 15-18” long

- 360-degree mirror
- Camera
- Wi-Fi Antenna
- System Electronics
- Ultrasonic Transmitters & Receivers
- Battery

Smart Sensors for Hydraulics
Field Testing

Smart Sensors for Hydraulics
Foundation Characterization Research Scope

1. Pile Tip Elevation
2. Foundation Type (shallow/deep)
3. Foundation Geometry (L, W, D)
4. Foundation Material (concrete, steel, timber, masonry, stone)
5. Foundation Integrity
6. Pile Distribution
7. Load Carrying Capacity
8. Others…

(NCHRP E 21-5)
National Historic Covered Bridge Program – Research, Education and Technology Transfer (2000-2012) - Sheila Duwadi

- 50 projects have been funded
- A number of studies have been completed
- Significant number of studies are underway
- New initiatives have been identified and will be started this fiscal year
Countermeasure Development for Suspension Bridge Components – Eric Munley

- Effects of blast loadings on Early 20th Century steel alloys
- Countermeasures for towers
- Countermeasures for main cables
- Countermeasures for suspenders
Upcoming:

- Material Selection for Countermeasures
- Countermeasure Design on Cable-Stay Members
- Countermeasures to Hand-Emplaced Attack Methods
- Development of Alternate Load Paths around Damaged/Destroyed Steel Truss Members
Structures Lab Manager – Dr. Fassil Beshah

- Issue Task Orders & Directives
- Contract Modifications
- Review Invoices
- Maintain & Calibrate Equipment
FHWA Research on PBES Connections – Dr. Ben Graybeal

- Staged construction connections
- UHPC composite connections
- UHPC compressive mechanical response
- Grout material characterization
- Deck-level connection performance
- Connections for adjacent box beams
- Composite connection stud spacing on steel girders
- Shrinkage of grouts…especially non-shrink grouts.

Reports Available

Research Underway
DECK-LEVEL UHPC CONNECTIONS
Other Studies

- Early Age Dimensional Stability of Grout
- Deck Level Connections
- UHPC Composite Connection
- Seismic Testing of Deck Bulb-T Connections
Optimized Shear Stud Spacing - Dr. Justin Ocel
• Future looking project investigating “new” types of joining for bridge fabrication
• Friction-stir (FSW), Thermal-stir, high frequency (HF), and hybrid FSW/HF
Phased Array Acceptance Criteria
Other Studies

- Plasma Cut Holes
- Weathering Steel Assessment (Argonne)
- Gusset Plate
- GMAW Acceptance
- Curved Tube Flange Girders
- Monitoring Milton-Madison Demolition
Geotechnical Research

Michael Adams & Dr. Jennifer Nicks
GRS Performance Tests

- Database (19 new cases) of axial load-deformation relationships for geosynthetic reinforced soil
- Parametric Analysis
- Relationship to plane strain
- Application to design (strength and service limit)
- LRFD Calibration
Characterization of Open Graded Aggregates

- Measure strength properties
- Describe impact of saturation, angularity, source, and density
Long-Term GRS Dead Load Tests

- Monitoring of four GRS piers with a combination of different aggregates and geotextiles under a 4.4 ksf dead load
GRS-IBS Evaluation Program

- FHWA Every Day Counts initiative
- Working with State DOTs to instrument and monitor IBSs for 3-years
  - MnDOT (Rock County)
  - MASSDOT (Sheffield Rd)
  - Maine DOT (North Haven)
  - St. Lawrence County
  - Utah DOT (I-84 Echo Rd)
Condition Assessment of MSE walls

- Sampling and testing of steel bar mat, connections, and backfill material from 1976 MSE bridge ramp along I-495/I-66 in DC metro area
- Study corrosion and impact of salting and drainage with depth
Retaining Wall Asset Management

• Develop guidance based on the program established by Federal Lands Highway Division for the National Park Service

• Performed by Central Federal Lands
Advanced Geotechnical Instrumentation

- Automated data collection
- MEMS technology
- Tactile pressure sensors
Other Completed Studies

- Helical Anchor Tensile
- Connection Strength

Research Underway

- Geosynthetic Tensile Connection Strength
- GRS Finite Element
- GRS Abutment Scour
Upcoming Research Activities

- Deformation of shallow foundations
- Laboratory investigation of aggregates
- Performance testing
- Reinforced soil design
- Performance monitoring of walls, slopes, and non-bridge, non-pavement assets
- Characterizations of bridge foundations
- Design of large diameter driven pipe piles