Long-Term Bridge Performance Program

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FHWA/NSF Workshop on Future Directions for Long-Term Bridge Performance Monitoring, Assessment, and Management

January 9 and 10, 2007
Las Vegas, Nevada
FY-07 Activities

- Conduct **a number of Workshops** (i.e. collect feedback from owners, researchers, industry)
- Form an advisory committee
- **Approve a draft work plan**
- Select a Lead-Support Technical Contractor
- Issue RFPs
Draft Conceptual Framework for a

“Long-Term Bridge Performance Program”


submitted to

US Department of Transportation
Federal Highway Administration

By

Center for Innovative Bridge Engineering
University of Delaware

August 24, 2006
the recent surface transportation highway legislation enacted by the U.S. Congress on August 10, 2005

the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
Designated in the SAFETEA-LU as a 20-year research effort

- Funding authorized for FY 2006 thru 2009
  - Funding requested ~$20M/yr
  - Funding authorized ~$7.75M/yr (~$5.4M/yr available for FY-06 and FY-07)
Vision

To get out in front of the bridge deterioration curve and stay there
Overall Objective

Collect, Document and Maintained High-Quality Quantitative Performance Data

Representative Sample of Bridges Nationwide
Quantitative data will enable bridge owners to address a variety of bridge condition assessment and management issues

- Determining how and why bridges deteriorate
- Improving operational performance
- Help foster the next generation of bridge management systems
Overall Objective

Collect, Document and Maintained High-Quality Quantitative Performance Data

Representative Sample of Bridges Nationwide
Number of Highway Bridges by Material Type

- **472,769 bridges > 20ft (6.1m)**
  - Average Age: 40

### Reference: NBI database
Number of Highway Infrastructure by Material Type

596,931 bridges, culverts and tunnels > 20ft (6.1m)

Average Age: 40

<table>
<thead>
<tr>
<th>Material Type</th>
<th>All Bridges</th>
<th>Structurally Deficient</th>
<th>Functionally Obsolete</th>
</tr>
</thead>
<tbody>
<tr>
<td>R/C</td>
<td>250,000</td>
<td>75,945</td>
<td>80,424</td>
</tr>
<tr>
<td>Steel</td>
<td>190,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P/C</td>
<td>130,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timber</td>
<td>50,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>20,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
improved Stewardship & Management procedures will be a major factor in bridge performance for many years to come
Stewardship & Management of Existing Bridges

- Optimizing performance &
- Maximizing service life (while)
- Minimizing life-cycle costs
Bridge Inventory Needs

- High-quality measured data

- Analysis of data to support improved deterioration models and life-cycle cost analysis

- Means to quantify effectiveness of various maintenance, repair and rehabilitation strategies
  - (i.e., reflect the type, cost, timing, and effectiveness)
Bridge Inventory Needs

- Data to support performance measures and predictive models for all limit states
- Data on operational performance to reduce congestion, delay and accidents
- Decision-making tools and algorithms that support optimizing allocation of resources
- Improved data to develop the next generation of bridge management systems
The LTBPP will have the potential to address many of the inventory needs.
Components of the LTBPP

- Technical
- Administrative
Technical Component: Original Vision

Field Laboratories

- Detailed inspection, periodic evaluation and testing (*Thousands of bridges*)
- Instrument and continuously monitor (*subset of bridges*)
- Forensic autopsies of decommissioned bridges
Technical Component: Original Vision

**Field Laboratories**

- Detailed inspection, periodic evaluation and testing *(Thousands of bridges)*

Quantitative data to support the development of *improved* design standards, predictive models, maintenance practices, etc.
Technical Component: Original Vision

Field Laboratories

- Instrument and continuously monitor (subset of bridges)

To capture a broad range of data under traffic giving a measure of serviceability as well as recording extreme events
Technical Component: Original Vision

Field Laboratories

- Forensic autopsies of decommissioned bridges

To gain knowledge of the capacity, reliability, and failure modes of bridges that have been damaged by corrosion, overloads, alkali-silicate reaction, fatigue, fracture, etc.
Technical Component: Current Vision

Field Laboratories

- Detailed inspection, periodic evaluation and testing *(Representative sample of bridges, excluding long-span bridges)* (Phase 1)

- Instrument and continuously monitor (Phase 2)

- Forensic autopsies of decommissioned bridges (Phase 2)
Technical Component: Critical Elements

- Specific data to be collected
- Bridge sampling
- Technology for data collection
- Data quality and collection strategies
- Data mining and analysis
- Dissemination of Information
- Short-term deliverables and long-term goals
Technical Component: Critical Elements

- Specific data to be collected
- Bridge Sampling
- Short-term deliverables and long-term goals
  - NBI
  - Pontis
  - Other Databases
  - BMIS
Critical Elements: Specific data to be collected

**Damage**
- Impact
- Overload
- Scour
- Seismic
- Microcracking
- Settlement
- Movement
- Lack of Movement

**Deterioration**
- Corrosion
- Fatigue
- Water absorption
- Loss of prestress force
- Unintended structural behavior
- Chemical changes (e.g. ASR)
- Environment and climatic
Critical Elements: Specific data to be collected

- **Operation**
  - Traffic counts
  - Weight of trucks
  - Maximum stress
  - Stress cycles
  - Deflection
  - Displacement
  - Detours
  - Reduction in speed

- **Service**
  - Congestion
  - Accidents
  - Reduced traffic capacity
  - Delay
  - Unreliable travel time
  - Reduced load capacity
Critical Elements: Bridge Sampling
LTBPP Bridge Selection

Methodology

1. Bridge grouping according to performance measures

Conventional

2. Grouping / sampling (Tier I)

Innovative

3. Grouping / sampling (Tier II)

4. Environmental exposure and extreme hazards

5. Selecting candidate bridges
Action 1

- NBI Deck rating (Item 58):
  - 1-2
  - 3-4
  - 5
  - 6
  - 7-9
  OR
- Health Index

- NBI Superstructure rating (Item 59):
  - 1-2
  - 3-4
  - 5-6
  - 7-9
  OR
- Health Index

- NBI Substructure rating (Item 60):
  - 1-2
  - 3-4
  - 5-6
  - 7-9
  OR
- Health Index

* Standardize definitions required across all the States for selecting the elements representing each component
Critical Elements: Short-term deliverables and long-term goals

- Short-term deliverables

  Produce reports,
  Identifying the major mechanisms for bridge deterioration;
  the most common and costly bridge maintenance, repair and rehabilitation actions

  Protocols for detailed inspection, periodic evaluation and testing and other approaches
Critical Elements: Short-term deliverables and long-term goals

- Long-Term Goals
LTBPP: Expected Outcomes

- Improved knowledge of bridge performance
- Advances in deterioration and predictive models
- Support the development of improved design methods & maintenance practices
- Improved inspection/condition information thru NDE
LTBPP: Expected Outcomes

- Quantify effectiveness of various maintenance, repair and rehabilitation strategies
- Improved operational performance
  - (congestion, delay and accidents)
- Development of new technologies
- Help foster the next generation of bridge management systems
Administrative Component

- Federal, State and local agency partnerships
- State Coordinator
- Lead-support technical contractor
- Regional contractors to conduct detailed periodic inspection
Administrative Component

- Annual meetings with stakeholders to review and assess program activities
- Outreach and collaborative opportunities to mine data and develop new models, tools, algorithms
- Opportunity for collaboration
The State Highway Agencies are not overburdened with the LTBP Program
Administrative Component: Potential Organizational Plan

- LTBPP Management “Oversight” Committee
- Program Manager
  - Stakeholders
  - Professional Societies
- Lead-Support Technical Contractor
  - Subcontractor for Inspected Bridges
  - Subcontractor for Instrumented Bridges
  - Subcontractor for Decommissioned Bridges
  - Subcontractor for Cyber Infrastructure
- Advisory Committee
- Technology Transfer
- State Coordinator
State Roles & Responsibilities

- Provide access to bridges and bridge files and documents
- Assist in safety and traffic control measures
- Assist in annual program oversight and guidance via a State LTBPP Coordinators Committee
Opportunity for Collaboration

- National Science Foundation
- University Transportation Centers
- International Community
FY-07 Activities

- Conduct **a number of Workshops** (i.e. collect feedback from owners, researchers, industry)
- Form an advisory committee
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FY-07 Workshops

- Las Vegas
- Europe
- Japan
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August 24, 2006
Thank You!

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http://www.tfhrc.gov/structur/Ltbp.htm
Congestion is Getting Worse

**Congestion In 1982**
- **Duration:** 4.5 hours per day
- **Extent:** 32% of travel
- **Intensity:** 13 minute average delay

**Congestion In 2002**
- **Duration:** 7.1 hours per day
- **Extent:** 67% of travel
- **Intensity:** 39 minute average delay

**In 2002**
- Duration: 7.1 hours per day
- Extent: 67% of travel
- Intensity: 39 minute average delay

**In 1982**
- Duration: 4.5 hours per day
- Extent: 32% of travel
- Intensity: 13 minute average delay
Freight

- Congestion impedes freight movements and threatens economic growth.
- Freight movement affects each of us.
  - Economic growth → Jobs → Improved Standard of Living
Replacement or Rehabilitation of Deficient Bridges
- 10,000+ bridges
- $3.5 billion

Funds spent on maintenance and preservation are UNKNOWN

User Costs Unknown
How?
Outcome of the LTBPP

- **High-quality performance measured data**
- Data to support improved deterioration models and life-cycle cost analysis
- Quantify effectiveness of various maintenance, repair and rehabilitation strategies
- Data to support performance measures and predictive models for all limit states
- Decision-making tools and algorithms that support optimizing allocation of resources
- Help foster the next generation of bridge management systems
Outcome of the LTBPP

REACTIVE

↓

PROACTIVE
Limitations of Current Information

- NBI
- PONTIS *(Element Level Data)*
Limitations of NBI Program

- Condition Ratings based on subjective visual inspection
- Inadequate for bridge performance measurement
- Inadequate for owner level bridge management
- Inadequate for an optimal asset-management and maintenance strategy
Limitations of PONTIS

- Condition states still based solely upon visual inspection
- Bridge system performance is not generally addressed (element level data, single failure mode)
- Invisible deterioration, damage or distress not detected or measured
- Operational performance not measured
- Life-cycle cost and performance criteria not incorporated
- Vulnerability and reliability not adequately considered
- Unacceptable deterioration model
Framework of the LTBPP
Technical Component

- Specific data to be collected
- Bridge sampling
- Performance measures
- Technology to support data collection
- Data quality and collection strategies
- Data mining and analysis
- Dissemination of Information
Technical Component: Original Vision

Field Laboratories

- *Detailed period inspection* (and data collection) of a large number of bridges (~ thousands)

- *Instrument and monitor* bridges to capture unusual and extreme event loading and performance

- *Forensic autopsies* of decommissioned bridges
Bridge Inventory Needs

- Some critical bridge components cannot be inspected or easily inspected.
- Unknown foundations and uncertain vulnerability to scour.
- LTBP poorly documented, understood.
Detailed periodic inspection

To collect quantitative data to support improved design standards, predictive models, maintenance practices, etc.
Technical Component: Original Vision

Instrument and continuously monitor

To capture a broad range of data under traffic giving a measure of serviceability as well as recording extreme events.
Forensic autopsies of decommissioned bridges

To gain knowledge of the capacity, reliability, and failure modes of bridges that have been damaged by corrosion, overloads, alkali-silicate reaction, fatigue, fracture, etc.
Number of Highway Bridges by Material Type

- **All Bridges**: 472,769 bridges > 20ft (6.1m)
- **Average Age**: 40

- **R/C**: 472,769
- **Steel**: 73,042
- **P/C**: 74,801
- **Timber**:
- **Other**