CAIT: CENTER FOR ADVANCED INFRASTRUCTURE AND TRANSPORTATION

One of only five USDOT-designated University Transportation Centers, providing transportation infrastructure systems education and research in safety, mobility, economic growth, human and natural environments, and national security.

BEAST: Bridge Evaluation and Structural Testing laboratory
World’s first facility rapidly simulates bridge deck deterioration testing

RABIT: Robotics Assisted Bridge Inspection Tool
Collects and analyzes bridge surface conditions
For the first time, will allow the scientific study of deterioration processes on full-scale bridge decks in a rapidly compressed time. The lines of innovation:

- Calibrate field data with BEAST data to estimate/forecast remaining service life for much larger population of bridges
- Develop reliable deck deterioration models
- Evaluation of numerous technologies, materials and components
- Validating new technologies being developed to augment bridge deck inspection
BEAST: Site Features

- Fabrication, instrumentation, and casting yard
- BEAST Lab Location
- New Lab Space
- Access to major routes:
  - Route I-95 – 6.5 miles
  - Route I-287 – 5.5 miles
  - NJ Route 18 - 2 miles
  - NJ Route 1 - 5 miles
## BEAST: Technical Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Bridge Deck Tester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Specimen Size</td>
<td>50-ft span by up to 28-ft wide</td>
</tr>
<tr>
<td>Specimen Superstructure Depth</td>
<td>Up to 60 inches above floor</td>
</tr>
<tr>
<td>Overall Length (ft)</td>
<td>Approximately 125 feet</td>
</tr>
<tr>
<td>Overall Weight (lb)</td>
<td>120,000 lb</td>
</tr>
<tr>
<td>Max Normal Load (lb) Normal</td>
<td>60,000</td>
</tr>
<tr>
<td>Min Normal Load (lb) Normal</td>
<td>10,000</td>
</tr>
<tr>
<td>Trafficking Speed (mph)</td>
<td>0 to 20</td>
</tr>
<tr>
<td>Primary Drive System</td>
<td>Electric winch</td>
</tr>
<tr>
<td>Drive System Power (hp)</td>
<td>400 HP</td>
</tr>
<tr>
<td>Axle Size</td>
<td>Two Full 30,000 lb capacity each</td>
</tr>
<tr>
<td>Portability</td>
<td>Lateral movement provided between loading cycles</td>
</tr>
<tr>
<td>Bi-directional Loading</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical Power</td>
<td>3 Phase 480 Volt</td>
</tr>
</tbody>
</table>
Testing Capabilities: Bridge Systems, Components & Materials

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Any concrete bridge deck mix design, corrosion inhibitors, supplemental cementing materials, and additives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decking Systems</td>
<td>Open, filled, partially-filled or unfilled grid decks such as exodermic bridge deck systems; orthotropical or other metal deck systems; prefabricated deck systems; precast slabs; and others</td>
</tr>
<tr>
<td>Rebar</td>
<td>Steel, epoxy coated, galvanized, stainless steel, steel clad, glass and carbon fiber polymer, etc.</td>
</tr>
<tr>
<td>Prestressing &amp; Post-tensioning Strands</td>
<td>Bar, wire, strands, couplers, anchorages, ducts, and other components</td>
</tr>
<tr>
<td>Coatings &amp; Sealants</td>
<td>Latex-modified concrete, joint sealants, epoxy waterproofing seal coating, etc.</td>
</tr>
<tr>
<td>Superstructure Frames</td>
<td>Structural steel, reinforced concrete, precast concrete, prestressed concrete, and timber</td>
</tr>
<tr>
<td>Joints</td>
<td>Preformed joint filler, elastomeric joint assemblies, strip seal expansion dams, modular bridge joint systems, longitudinal joints, shear locks, and others</td>
</tr>
<tr>
<td>Bearings</td>
<td>Bearing pads, reinforced elastomeric bearing assemblies, high-load multi-rotational bearing assemblies, and others</td>
</tr>
<tr>
<td>Deck Drainage</td>
<td>Scuppers, inlets, downspouts, grates, and other drainage elements</td>
</tr>
<tr>
<td>Safety Devices</td>
<td>Striping paint, pavement reflectors, auditory safety devices (e.g., Bott's dots, rumble strips, etc.), ITS devices and sensors, traffic cams, signage materials, and more</td>
</tr>
</tbody>
</table>
Summary of Protocol

- Mean Stage - Two days at 65F
- Min Stage - Five days at 0F
- Mean Stage - Two Days at 65F
- Max Stage - Five Days at 104F
- 1% Brine solution applied during Min Stages

Features

- Estimated to produce 15 to 20 years of environmentally induced deterioration in 6 months
- Accommodates periodic assessments during median temperature cycles
Live Loading Protocol

Loading Magnitude
• Full 60 kip – results in roughly twice the force effects and local stresses of a typical, legal truck
• Half 30 kip – most realistic

Loading Frequency
• Maximum is approximately 20,000 cycles per day
• Over 6 months this results in 3.65 million cycles
• Corresponds to 15 years of truck traffic on a bridge with ADTT of 650

Loading Configuration
• Stationary – worst case, unrealistic
• Roving – Options 1 and 2 changed during Mean Temperature Cycles
Questions?

Thank you!

cait.rutgers.edu

Thank you!
Live Loading Protocol (Option 1) >>

Maximum, Realistic Deck Force Effects

- 6 ft.
- 7 ft. (typ)
Live Loading Protocol (Option 2) >>

Minimum Deck Force Effects

- 6 ft.
- 7 ft. (typ)
Live Loading Protocol (Option 3) >>

Maximum, Unrealistic Deck Force Effects

6 ft.

7 ft. (typ)
Potential Fixed Instrumentation

(low spatial resolution, high temporal resolution)

**Global**
- A series of RGB cameras, including live load mounted
- A series of IR cameras

**Deck**
- Groups of embedded VW strain gages and thermistors
- Curing, dead load, temperature, live load stresses
- Redistribution of stresses due to shake-down, deterioration
- Uniform grid of chloride and corrosion sensors

**Girders, Diaphragms**
- Groups of 3 to 4 longitudinal VW strain gages, thermistors, and displacement sensors: ¼- Mid-, ¾ - Span
- Dead load, curing, temperature and live load stresses
- Location and migration of N.A. (dead load, temperature, live load)
- Initial and changes in transverse load distribution (dead load, temperature, live load)
- Fiber Optic WIM to capture shear forces
Carried out on a base interval during Mean Temperature Cycles and based on sensor responses or thresholds

- Comprehensive, multi-modal NDE scanning (RABIT)
- Modal impact testing to estimate frequencies and mode shapes (THMPR)
- NBIS Bridge Inspection
- Inspection as per LTBP Protocols
Potential Payload Projects

Long-term Performance of...
• Sensing and data acquisition
• Utilities and conduit
• Roadway condition sensors

More Fundamental Projects
• Development and validation of approaches to integrate NDE, SHM, and visual inspection
• Reliability of NDE, sensing, etc.
• Development and validation of mechanistic-based simulation modeling of deterioration
• Quantification of the reliability of model-experimental correlation approaches