NCHRP 20-68A “US Domestic Scan Program”

Domestic Scan 17-03
Experiences in the Performance of Bridge Bearings and Expansion Joints used for Highway Bridges
Findings, Conclusions and Recommendations

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Washington State DOT
Bridge & Structures Office
Domestic Scan 17-03

“Experiences in the Performance of Bridge Bearings And Expansion Joints Used For Highway Bridges”

• This scan is being conducted as a part of NCHRP Project 20-68A, the U.S. Domestic Scan program

• The program was requested by the AASHTO Subcommittee on Construction (SOC), with funding provided through the National Cooperative Highway Research Program (NCHRP)
1. This scan will facilitate the exchange of ideas and best practices for Bridge Bearing and Expansion Joint design, performance evaluation, maintenance, and repairs.

2. Discussions will include design, construction, maintenance and operation of transportation agencies that have experienced good performance of their bridge joints and/or bearings.

3. Details for various bridge types (i.e. materials, span arrangements, geometry) and sizes will be examined
General Guidance to the Scan Team

Based on an initial review of bearing and joint performance it is suggested that the following state DOT’s be studied:

1. States with severe climate challenges (cold and freezing conditions) - Illinois, New York and Massachusetts
2. States with considerable precipitation and cold climates - Washington State and Oregon.
3. States very high ADT’s on many bridges - California, Texas, & New York
4. Coastal states with large size bridges such as Florida, Virginia, and Louisiana
5. States with success details (Minnesota) and lessons learned to offer (Pennsylvania).
Scan team members and host States

Team Member Home State

Host Agency State

Manufacturers
- DS Brown
- Mageba
- Scougal
- RJ Watson
- Watson Bowman
# Scan Team Members

U.S. Domestic Scan Program: Mr. **Harry capers**

<table>
<thead>
<tr>
<th>Name</th>
<th>Role/Position</th>
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<tbody>
<tr>
<td>Bijan Khaleghi</td>
<td>AASHTO Chair, State Bridge Design Engineer, Washington State DOT</td>
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<tr>
<td>Zhengzheng “Jenny” Fu</td>
<td>Assistant Bridge Design Administrator, LADOTD Room 603A</td>
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<tr>
<td>Ed Kestory</td>
<td>District Structures Maintenance Engineer, District 5 Bridge Inspection, Florida DOT</td>
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<tr>
<td>Ahmed N. Mongi, P.E.</td>
<td>QA/QC Unit Leader, Design Section Division of Highways Engineering, West Virginia DOT</td>
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<tr>
<td>Rebecca Nix</td>
<td>Bridge Management Engineer, Utah Department of Transportation</td>
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<tr>
<td>Linh Warren, P.E.</td>
<td>Structural Engineer, FHWA Office of Bridges and Structures</td>
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<tr>
<td>John F. Stanton, PhD, PE -- SME</td>
<td>Professor, Civil and Environmental Engineering, University of Washington</td>
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<tr>
<td>Jill Walsh, PhD, PE –Tech. Consultant</td>
<td>Assistant Professor, Saint Martin’s University</td>
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## Host States - Presentations

<table>
<thead>
<tr>
<th>State</th>
<th>Characteristic</th>
<th>High ADT</th>
<th>Extreme cold</th>
<th>Coastal</th>
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<tr>
<td>California</td>
<td>Dave Neumann,</td>
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<td>Don Lee, Tim Delis</td>
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<td>Paul Fossier,</td>
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<td>Kelly Kemp, Jenny Fu</td>
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<td>Michigan</td>
<td>Jason DeRuyver,</td>
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<td>Matt Filcek</td>
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<td>Minnesota</td>
<td>Ed Lutgen</td>
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<td>New York</td>
<td>Peter McCowan</td>
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<td>Oregon</td>
<td>Bruce Johnson</td>
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<td>Pennsylvania</td>
<td>Ralph Destefano</td>
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<td>Texas</td>
<td>Curtis Rokicki,</td>
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<td>Leon Flournoy</td>
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<td>Utah</td>
<td>Rebecca Nix</td>
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<td>Virginia</td>
<td>Adam Matteo</td>
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<td>Washington</td>
<td>Rich Zeldenrust</td>
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## Manufacturers - Presentations

<table>
<thead>
<tr>
<th>Company</th>
<th>Speaker</th>
<th>Bearings</th>
<th>Joints</th>
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<tr>
<td>DS Brown</td>
<td>Mark Kaczinski</td>
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<tr>
<td>Mageba</td>
<td>Amit Kutumbale</td>
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<tr>
<td>Scougal</td>
<td>Rob Anderson</td>
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<td>RJ Watson</td>
<td>Zachary Searer</td>
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<tr>
<td>Watson Bowman</td>
<td>Gary Moore</td>
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### Domestic Scan 17-03 - SCHEDULE

<table>
<thead>
<tr>
<th>Event</th>
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<tr>
<td>Pre-scan Meeting</td>
<td>10/01/17</td>
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<tr>
<td>Scan conducted</td>
<td>3/19-3/23/2018</td>
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<td>Summary report</td>
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<td>Formal report - draft</td>
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<tr>
<td>Formal report - final</td>
<td>08/21/18</td>
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Domestic Scan 17-03 Anticipated Outcomes

• This scan provides valuable information to the AASHTO Committees for future consideration when developing their **work plans and research needs**.

• A synthesis of this scan would also be of interest to:
  – State DOTs,
  – FHWA and other Federal offices,
  – Local transportation agencies,
  – Bearing and joint manufacturers,
  – University researchers,
  – Bridge consultants and contractors
Suggestions for Amplifying Questions

1) Questions focusing on the Performance
   a. Successful Strategies
   b. Advances in Practice & Emerging Technologies
   c. Possible Successful Examples/Case studies, Lessons Learned

2) QA/QC
   a. Training and retraining
   b. Quality Control/Assurance Plan
   c. Certifications

3) Performance Measures
   a. Metrics, Evaluations of performance
   b. Corrective Action Procedures

4) Sustainability
   a. Insuring future resourcing
   b. Succession planning and training
   c. Modernization and upgrading of equipment
## Workshop Agenda

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<tr>
<th></th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wed</th>
<th>Thurs</th>
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<td><strong>Morning</strong></td>
<td>Travel day</td>
<td>Introduction (1 hr)</td>
<td>New York DOT (webinar) confirmed</td>
<td>Minnesota DOT</td>
<td>Scougal DS Brown RJ Watson Mageba</td>
<td>Scan team final meeting (scan team only)</td>
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<td>California DOT (confirmed)</td>
<td>Virginia DOT (webinar) confirmed</td>
<td>Utah DOT (1.5 hr) confirmed</td>
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<td><strong>Afternoon</strong></td>
<td>Travel day</td>
<td>Louisiana DOT (confirmed)</td>
<td>Oregon DOT Pennsylvania DOT (confirmed)</td>
<td>Texas DOT (1 hr) confirmed</td>
<td>Watson Bowman Group discussion</td>
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<td>Michigan DOT</td>
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<td><strong>Evening</strong></td>
<td>Scan Team kick off meeting</td>
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Major Findings & Recommendations

• Over-arching Issues
• Bearing Design
• Bearing Construction
• Bearing Inspection and Maintenance
• Expansion Joint Design
• Expansion Joint Construction
• Expansion Joint Inspection/Maintenance
• Overall Conclusions
• Recommendations
Over-arching Issues

• **Funding.**
  – Gas taxes have not risen with bridge costs.
  – New bridges attract funding more than maintenance.

• **Attraction and retention of staff.**
  – Consultants pay more.
  – Design-build reduces interesting work for DOTs.
  – Staff retiring/transferring to private sector.

• **Training and knowledge transfer.**
  – Need: experienced engineering staff and training

• **Design responsibility and incentives for innovation.**
  – AASHTO requirements are prescriptive.
  – Consider performance based design
  – Difficult for manufacturers to understand different states requirements for getting on approved supplier list.
Bearings – Design - 1

• **Uplift and horizontal forces.**
  – Design system to avoid uplift forces.
  – If possible, use some element to resist horizontal forces.

• **Provision for replacement.**
  – Make provision at design time, e.g. jacking points.

• **Type selection.**
  – Steel-reinforced elastomeric for short-medium span.
  – HLMR (pot, disk, spherical) for high loads.
  – No new rocker steel bearings.

• **HLMR type selection – no consensus.**
  – Some states ban pots (elastomer leakage).
  – CA uses mostly spherical bearings
  – States moving from pots to disks bearings
Bearings – Design - 2

• **Steel-reinforced elastomeric bearings.**
  – Most states use Method B. (More logical).
  – Walking out of place: TX bans Natural Rubber. CA uses minimum compressive stress. Some states use a recess. Others recommend bonded external plates.

• **Sliding surfaces.**
  – AASHTO specifies only PTFE. More durable materials are now available.

• **Disk bearing design specifications.**
  – AASHTO requirements lack detail. Need more complete provisions.

• **Performance-based specifications.**
  – Manufacturers would prefer them (incentive for innovation).
  – European specs use them.
  – How to implement transition?
Bearings – Construction

• **One-time movements (e.g. creep and shrinkage).**
  – How to accommodate? Design for full horizontal capacity/lift and re-set.

• **Storage and Handling.**
  – Do not open (HLMR) bearings on site (contamination).
  – Treat as a mechanical device. i.e. carefully.

• **Steel prices.**
  – Steel prices fluctuate. Thick plate (e.g. for pots) becoming more difficult and expensive to buy.

• **Elastomeric bearing testing.**
  – AASHTO M251 testing requirements not synchronized with LRFD design spec.
Joints – Design

• **Major problems.**
  
  – **Indirect damage:** Leaking onto bearings and girder ends.
  
  – **Direct damage:** Snowplow hits, raised fingers in finger joints.

• **Jointless bridge philosophy.** The best joint is no joint’.
  
  o Link slabs over intermediate piers make it jointless, but need to be designed for rotations. (Not continuous for LL)
  
  o Full depth continuity diaphragm makes system continuous for live load. Also beneficial for seismic

• **Abutments:** *Use integral or semi-integral* (Jointless)

• **Length between joints:**
  
  o Limited by longitudinal movement required for temperature range, creep, shrinkage.


Joints – Design - 2

• **Joint type selection – guidelines:**
  - $0" < \Delta < 2"$ : plug or filler type.
  - $2" < \Delta < 4"$ : gland type (e.g. strip seal). $<5"$ (WA)
  - $4" < \Delta$ : finger joint, modular joint, etc.

• **Skew bridges.**
  - Extra stress in gland types.
  - Finger joints bind up.
  - More taxing for modular joints.

• **Design responsibility.**
  - EOR specifies the required movement, but manufacturer generally designs the joint.
Joints – Design – 3

• **Compression seals.**
  – Less widely used today.

• **Strip seals vs pre-formed silicone.**
  – Strip seal gland secured by a groove formed in steel end dam. Sometimes use adhesive in groove.
  – Pre-formed silicone, secured by adhesive.
  – Need test program to determine best approach. (Durability and ease of replacement).

• **Modular joints.**
  – Early versions showed fatigue problems.
  – Now mostly resolved – Requiring fatigue test
  – Large opening needed in deck to accommodate support beams and boxes.
Joints – Construction

• Construction/installation is where most problems occur.
  – Pre-submit installation procedures.
  – Pre-construction meeting.
  – Manufacturer’s rep on site (especially for large joints).

• Installation temperature.
  – Opening must be consistent with plans for that temperature.

• Lane closures.
  – Some lane closures are unavoidable.
  – If joint installed in lane-wide sections, need to connect sections. Welds are best. Bolts eventually corrode.

• Modular joints.
  – Large ones will be heavy. May need a large crane.
  – Concrete must be consolidated around support beams.
  – Allow for (thermal) change of opening during installation.
Joints – Inspection and Maintenance

• **Active maintenance program.**
  – Prolongs joint life.
  – Protects bearings by preventing leaks.
  – Some states use State personnel, others contract out.
  – Documentation important – need to know types for replacement parts.
  – Keep as-built drawings up to date for all repairs.
Joints – Inspection and Maintenance

• **Levels of Maintenance Work**
  
  – **Level I**: clean joints. Frequency varies by state. Most in spring, some also in fall, some as-needed. Typically more frequent in snowy regions. Gravel can puncture glands, lock up finger joints. Clean trough at same time.
  
  – **Level II**: Minor repairs when cleaning. e.g. gland patching.
  
  – **Level III**: Partial replacement (e.g. gland in strip seal or preformed silicone). Adhesive in strip seal groove may make removal difficult.
  
  – **Level IV**: Total replacement, including steel end dam.
OVERALL CONCLUSIONS

Wide variation in practices among states.

- Variations depend partly on climate, traffic.
- Sharing of best practices likely to prove real benefits.

Life-cycle costs.

- Cost of failed joints and bearings high in proportion to initial cost (e.g. closing and lifting bridge to replace bearings).
- Maintenance is essential to prevent major problems to other bridge components.

Funding.

- Almost all states reported limited funding, need to allocate funds strategically (e.g. policy for maintenance vs. replacement.)
OVERALL CONCLUSIONS

Joints - Most common types for new construction:

- Large movements (> 4”): modular joints. (>5” WA)
- Medium movements (2” to 4”): strip seals and pre-formed silicone joints.
- Small movements (< 2”): many options.

Bearings – Common types for new construction

- Small to moderate loads: Steel reinforced elastomeric bearings are very widely used.

Older bearing types (steel rocker, roller)

- Replace as the opportunity arises.
OVERALL CONCLUSIONS

Continuity of operations.

• Staff attraction and retention.
• Transfer of knowledge to less experienced staff.

Jointless bridges.

• Reduction or elimination of joints provides benefits and protects bearings.
• Link slabs at interior piers.
• Integral or semi-integral abutments at bridge ends.
RECOMMENDATIONS

• **Training tools.** Develop training tools to help transfer knowledge from experienced to newer employees.

• **Selection guides.** Develop guides for selecting joints and bearings, based on the information assembled in this scan and elsewhere.

• **Gathering field information.** Develop web-based methods for gathering and organizing field information on joints and bearings.

• **Elastomeric Bearings** – Resolve the inconsistencies between the LRFD design spec and M251 Materials specifications.

• **Disk Bearings** – Develop NCHRP topic for writing a design specification for disk bearings.
**NCHRP 20-68A “US Domestic Scan Program”**

**Domestic Scan 17-03**

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QUESTIONS?