Executive Summary

Introduction

Bridge bearings are intended to allow free movement of the superstructure in response to thermal changes and other loadings while supporting it against gravity loads. Joints in the deck accommodate those movements by opening and closing but must be sealed to prevent water and deicing salts from leaking onto the bearings below and causing them to deteriorate. Damaged bearings can bind up and induce unintended forces and damage in other bridge elements. Rectifying that chain of damage, from joint seal to bearing to structure, costs agencies tens of millions of dollars every year, which is many times the initial cost of the items themselves. The damage also has the potential for causing significant traffic interruptions, with corresponding opportunity costs. Properly maintaining bearings and joints is therefore a cost-effective way of ensuring bridge safety and serviceability. Little work has been done on joints and bearings at the national level during the last 15 years so this is an appropriate time to conduct a domestic scan on the subject.

Scan Purpose and Scope

Domestic Scan 17-03, Experiences in the Performance of Bridge Bearings and Expansion Joints Used for Highway Bridges, was conducted March 21 through 25, 2018. It was initiated to facilitate the exchange of recent ideas and best practices for bridge bearings and expansion joints and included design, performance evaluation, and maintenance and repair/reconstruction. Discussions involved staff from design, construction, maintenance, and operations of state and other transportation agencies. Details (i.e., materials, span arrangements, and geometry) for various bridge types and sizes were examined. Lessons were drawn from both the good and bad experiences by the various participating agencies.

The team selected scan hosts that would encompass a wide range service conditions for bearings and joints. Considerations included such items as: climate challenges of the regions in which they are located, traffic volume, and project size. The states were selected on the bases of:

- States with severe climate challenges (cold and freezing conditions) - Illinois, New York and Massachusetts.
- States with considerable precipitation and cold climates - Washington State and Oregon.
- States with very high ADT's on many bridges - California, Texas, & New York.
- Coastal states with large bridges such as Florida, Virginia, and Louisiana.
- States having success with the details and practices that they use (Minnesota) and those with lessons learned that they could share (Pennsylvania).

General topics of interest to the scan team include:

- Design and details, construction specifications and maintenance procedures for durable bearings and expansion joints that have a history of good in-service performance;
- Visual inspection and other testing of joint and bearing details;
- Specialized technology and standards used in monitoring, inspection, and repair of joint and bearing details, with the goal of ensuring safety and serviceability, minimizing downtime during bridge construction and rehabilitation; and
- Relative costs for design, construction, maintenance, and inspection of various joint and bearing details.
- Lessons learned and suggestions for improvement.

The findings of this scan are expected to be of specific interest to the AASHTO Committee on Bridges and Structures Technical Committee T-2 “Bearings and Expansion Devices”, the AASHTO Committee on Materials and Pavements, and the AASHTO Committee on Maintenance. The scan report will provide current information on successful expansion joints and bearings to bridge owners. It will also provide valuable information to the AASHTO Committees for future consideration when developing their work plans and research needs. A synthesis of this information would also be of interest to State DOTs and FHWA offices, other Federal and local agencies involved in bridges, bearing and joint manufacturers, university researchers, consultants, county, city and local DOTs.

Summary of Findings and Recommendations

The scan team identified a number of commonalities among DOT’s issues with bearings and joints as well as climate and volume specific issues.

Maintenance

In most states, the focus has been on maintenance and repair than on new construction. That reflects the fact that the bulk of freeway construction occurred in the 1960s and 1970s, and that the bridges built in that era are now approximately 50 years old and starting to show their age. However, limits on funding mean that bridge life may have to be extended, and hence diligent maintenance is important.

Policies for conducting maintenance were found to vary from state to state and were partly related to climate. Snowy states tend to conduct more frequent and aggressive cleaning and maintenance of both joints and bearings. Most states are also adopting electronic approaches to monitoring and record keeping and have made efforts to reduce the number of bridges in poor condition by conducting aggressive repair strategies. Those efforts depend on the maintenance resources available, such as manpower and funding, which vary widely from state to state.

Bearing Types

The types of bearing used have changed over the years. In the past, many bridges were made with steel girders and steel rocker and roller bearings, but metal bearings have been found to perform poorly, especially in earthquakes. These bearings are almost never specified today for new construction, but many still exist on older bridges. They are being, or have already been, replaced in seismic states, and in many others as well. For short to medium spans, steel reinforced elastomeric bearings are now the most widely used, because they have no moving parts, have a low first cost, and need essentially no maintenance. For higher loads and larger movements, High Load Multi-Rotational (HLMR) bearings (pots, discs and spherical bearings) are used. Of these, disc bearings are starting to capture the largest share of the market because they use less steel than pot or spherical bearings and are easier to inspect. They have also provided reliable performance over the years. However, exceptions exist. For example, California uses spherical bearings almost exclusively for high load applications and is well satisfied with their performance. The manufacturers with international sales reported that, in Europe, pot bearings are widely used, apparently without problems, and disc bearings are not used at all.

Joint Types

Joint types are described largely by their movement capacity, and are categorized as small (< 2”), medium (2” to 4”) and large (> 4”).

For large movements, finger joints were the traditional choice, but are gradually falling out of use, and modular joints are becoming more common. A third option, California’s Plate Joint Seal Assembly, has been developed recently and attracted interest. Modular joints suffered from fatigue problems early in their development, but those have largely been resolved. Nonetheless, modular joints are large, complicated mechanisms that require considerable care during fabrication and installation.

Many different types of joints are available for medium movements, and the descriptions are complicated by the fact that the same joint type is known by different names in different regions. The choice of joint depends somewhat on whether the joint is for new construction or retrofit. For new construction, gland-based systems are now the most common choice. In mechanically bonded strip seals, the gland is held in place by a slot in the steel end dam. In adhesive based strip seals (or “pre-formed silicone seals”) the gland is secured by adhesive to the header concrete, or to the armor if that exists. Other choices for medium joints include foam-based systems and elastomeric compression seals. Most states reported more problems with these types of joints than with gland-based systems.

For small movements, poured silicone seals with a foam backer rod are the most widely used. They have provided good performance and are relatively easy to replace. They have also been used as a retrofit joint over a strip seal when an overlay is applied and the joint needs to be raised. Plug seals are also quite widely used, again because they are simple to install. Asphalt plugs are most often used with asphalt overlays, while elastomeric concrete plug joints are more often used in other cases. However, several states reported poor durability for plug joints, in particular with respect to rutting.

Joint Locations

The patterns of joint use are more varied. First, most states are moving in some way towards "jointless bridges", in which the joints are either eliminated altogether or moved to a location behind the abutments, where there are no bearings to be adversely affected by joint failure. New bridges are built with no joints over the piers, and existing bridges are being retrofitted with link slabs, or even diaphragms, over the piers to eliminate a joint there. All longitudinal movement is then taken at the abutments. In fully integral abutments, the piles, stem and back wall are all made monolithic with the girders, and expansion is accommodated by bending of the piles and compressible material, such as foam, behind the back wall. In semi-integral abutments, the foundation and stem are monolithic. The diaphragm and back wall are made monolithic with the girders, but are supported on bearings and which allow movement relative to the stem. The back wall extends below the stem and prevents debris and moisture from contacting the bearings. The joint is either directly behind the back wall or is moved to the far end of the approach slab. In either location, a leak in the joint will not jeopardize the bearings.

Develop Design Specifications

For bearings, there is a need for greatly expanded design requirements for disc bearings, for which the requirements presently in the AASHTO LRFD Design Specifications are minimal. The specifications for elastomeric bearings presently contain an allowance of 0.005 radians (0.5% slope) to account for rotational errors during installation. This includes both levelling of the grout pad and estimating more accurately the girder camber. It is clear that many bearings are not installed to this accuracy, so the bearings have to sustain a permanent rotation that is larger than intended. Either verification of installation accuracy should be improved or the allowance in the design specifications should be increased. The specifications for testing elastomeric bearings, presently contained in the AASHTO materials specification M-251, also need to be updated and better correlated with the LRFD Design Specifications. The manufacturers also expressed the view that a performance-based, rather than prescriptive, specification would provide the incentive for innovation and new bearing types.

For joints, the requirements in the AASHTO LRFD Design Specifications are less prescriptive than those for bearings, and consequently more types of joints exist. The findings of NCHRP project 12-100 compare the performance of different joint types, and help guide type selection, at least for small movements. The shift towards fully- and semi-integral construction raises questions of design, at both the system and detailed levels, and research to address these would be helpful. For example, Virginia has recently developed its own abutment design, which is a variation on the semi-integral theme. An evaluation, and perhaps further development, of that design would be useful.

Knowledge Transfer

Many areas for improvement were identified. Some were associated with organizational and administrative functions, such as use of internet-based methods for tracking the condition of bridge elements (such as joints and bearings) using tablet computers for entering data in the field, ways of transferring knowledge from more to less experienced staff, the development of training tools for type selection (e.g., a selection guide), and procedures for inspection, maintenance and repair.

Future Work Identified

Some detailed questions remain with respect to particular joints. In mechanically bonded Strip Seals, the gland can be replaced, but there is as yet no agreement about whether the gland should be secured with adhesive in the slot, or about the economic benefits of using stainless steel for the end dam to avoid corrosion and facilitate gland replacement. Many of the problems associated with joints center around the headers, and studies to compare the performance of the different types of concrete (cementitious HPC, SCC, UHPC, polymeric, etc.) would be beneficial.

Planned Implementation Actions

The scan team initially presented its findings and recommendations to the AASHTO SCOBS T-2 during the June 2018 Meeting. An overview of the findings was also presented at the general session of that meeting. To disseminate information from the scan, the team is giving technical presentations at national meetings and conferences sponsored by the TRB, ASBI and other organizations and is planning to write papers for various publications.