CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6785: Extending the Use of Elastomeric Bearings to Higher-Demand Applications

Background

Elastomeric bearing pads have been utilized for support of bridge superstructures for several decades; however, the majority of these applications have typically consisted of bridges with short to moderate span precast, prestressed concrete girder systems. More complex girder bridges with horizontal curvature, significant support skew, and longer spans typically utilize sliding bearings such as pot or disc bearings.

Past research on the thermal behavior of steel bridge systems showed that pot bearings often do not readily allow the bridge to expand and contract due to significant forces that are necessary to overcome the friction between the bearing and the superstructure. Further, elastomeric bearings can be significantly less costly than pot or disk bearings. Therefore, elastomeric bearings are of interest for use in higher-demand applications that include larger reactions and more significant thermal movements. However, there is uncertainty in the behavior of the elastomeric bearings in these applications. Some of the questions of the behavior of larger elastomeric bearings include potential increased variation in the properties of the elastomer throughout the bearing as well as uncertainty in the performance of the larger bearings at resisting the necessary compression, shear, and rotational requirements.

The Texas Department of Transportation (TxDOT) has utilized elastomeric bearings in a limited number of higher-demand applications in recent years, and the bearings have generally performed well, with the exception of a few isolated cases in which the bearings are showing significant distress in a relatively short period of time. The cause of the distress in these isolated cases is not clear from a cursory review of the demand on these specific bearings. The purpose of this study was to investigate the use of elastomeric bearings in such applications.

What the Researchers Did

The following major tasks were completed in this project:

1. A four-span, horizontally curved bridge was instrumented and monitored for more than a year. The bridge consisted of twin steel trapezoidal box girders with relatively large elastomeric bearings compared to traditional applications. While many of the bearings were in good condition, a few showed signs of significant distress. The girders were instrumented at the support regions to monitor longitudinal and transverse movements of the superstructure as well as girder rotations. In addition, the as-constructed conditions of the bridge at the support locations were measured for comparisons with typical construction tolerances.
2. A number of bearings were purchased and tested to measure the variation in material properties as a function of the bearing size. To gain a measure of the variation in the elastomer properties across the width and thickness of the bearing, a new testing procedure involving a dual shear testing (DST) specimen was developed. The DST specimen made use of the existing bond between the steel shims and the elastomer and allowed for higher-resolution

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readings of the variation of elastomer properties throughout the bearing.

3. Full-scale tests were carried out on the bearings to measure the properties under:
   - Pure compression.
   - Compression and shear.
   - Compression, shear, and rotation.
4. The results from the material and large-scale laboratory tests were used to validate a finite element model of the elastomeric bearings. The validated model was then used to carry out parametric studies to evaluate the performance of a variety of bearing geometries. The results were also used to evaluate current TxDOT and American Association of State Highway and Transportation Officials (AASHTO) design methodologies for elastomeric bearings. Modifications to existing design procedures were developed to allow the use of elastomeric bearings in higher-demand applications.

What They Found

The data gathered from the field monitoring demonstrated the deformational demands on the bearings through both daily and annual thermal cycles. The measured demands were consistent with typical values used in bridge design. Measurements showed that the as-constructed conditions of the substructure elements were the likely cause of bearing distress on the specific bridge that was studied. The bearings that were performing well after more than 10 years of service were located on supports in which the as-constructed conditions were within specified construction tolerances, while the distressed bearings were located on supports that had significant slope—creating excessive overloading of portions of the bearing and leading to relatively poor behavior and durability.

The newly developed DST specimen provided good resolution measurements of the variation of the shear stiffness of the elastomer throughout the bearings. Although the tests showed that the larger bearings did exhibit slightly higher variations in the shear stiffness throughout the bearings, the variations were not significant and are not expected to impact the behavior of the bearing. In general, the average properties of the four different bearings were fairly similar.

The large-scale tests on the full-size bearings provided useful data for validating the finite element model. The AASHTO expressions for the compression stiffness of the bearing were found to significantly over-estimate the axial stiffness of the bearings; however, this difference should not significantly impact the behavior of the bearings. Comparisons between the computer models and the test results for the shear stiffness and rotational stiffness showed good agreement with the computer models. The bearings in the laboratory tests were pushed well beyond design values so that various failure modes could be observed. The bearing failure modes included slipping, stability/buckling, shear rollover, and the onset of rupture of the bond between the elastomer and the steel shims.

The parametric finite element studies were compared with the AASHTO Method B design procedure, which was found to provide a good methodology for bearings ranging from traditional geometries to those intended for higher-demand applications. Some modifications were recommended to this method.

What This Means

Elastomeric bearings provide a good alternative for use in higher-demand applications and should accommodate the necessary bridge movements better than bearing systems that rely on slipping mechanisms. A properly designed bearing following the modified AASHTO Method B should provide good behavior. However, the successful implementation of any bearing system for bridge applications is contingent on construction quality within specified tolerances.

For More Information

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