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Tech Brief
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CIRCULAR ELASTOMERIC BEARINGS

FHWA/NJ-2002-005 August 2005

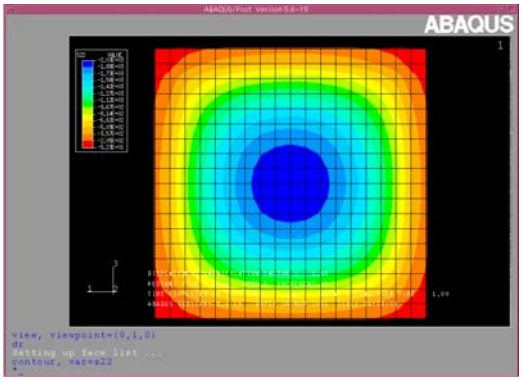
PROBLEM…

Reinforced and unreinforced elastomeric bearing pads have been used for bridges in NJ for about five years. The shape of these bearings is square or rectangular and their orientation is generally in the direction of thermal movements. Circular elastomeric bearings are not used in NJ but have been used in several states. These bearings are more suitable on skewed and curved bridges with limited space on pier cap or abutment seat, however, their behavior needs to be studied and evaluated.

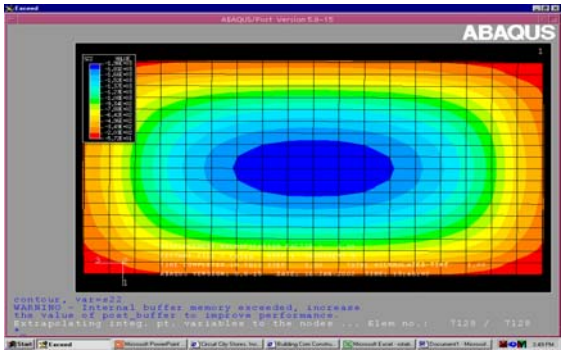
WHAT WE DID…

We evaluated the performance and cost of laminated circular elastomeric bearings and compared them to square and rectangular bearings. The comparisons were made with regard to critical parameters such as compression, compression and rotation, and compression and shear, and to determine whether using circular bearings can result in a cost savings over square and rectangular elastomeric bearings. In order to achieve these objectives, the following was done. First, surveys of current DOT experiences in circular elastomeric bearings, as well as the experiences of area consultants and manufacturers, were conducted. The surveys included questionnaires that were sent to the all DOT's and to area consultants with follow up phone calls to clarify certain responses. Elastomeric bearing manufacturers were surveyed by phone and e-mail. Second, a comprehensive finite element investigation of circular versus square and rectangular elastomeric bearings was completed. The FEA investigation used the ABAQUS computer program to perform the analysis. Third, an experimental evaluation of circular, square, and rectangular bearings was completed. The thickness of each tested bearing was 3 inches with five steel laminates. The surface area of each bearing was similar. The bearings were tested in compression, compression and rotation, and compression and shear, and loads and displacements were recorded. Special test set-ups were used to carry out the experimental program.

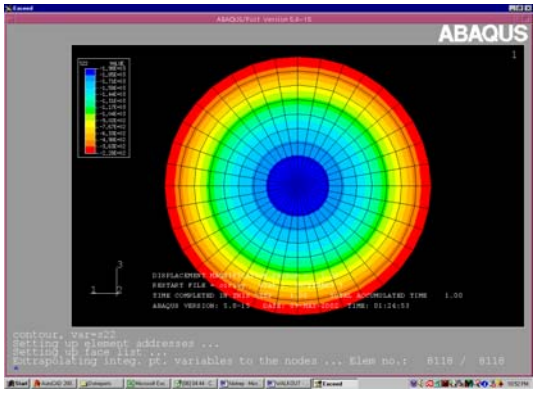
FINITE ELEMENT MODELING….



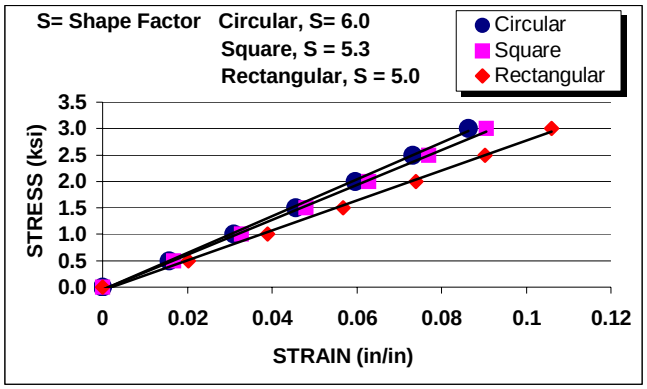
Compressive stress distribution in laminated square bearing



Compressive stress distribution in laminated rectangular bearing

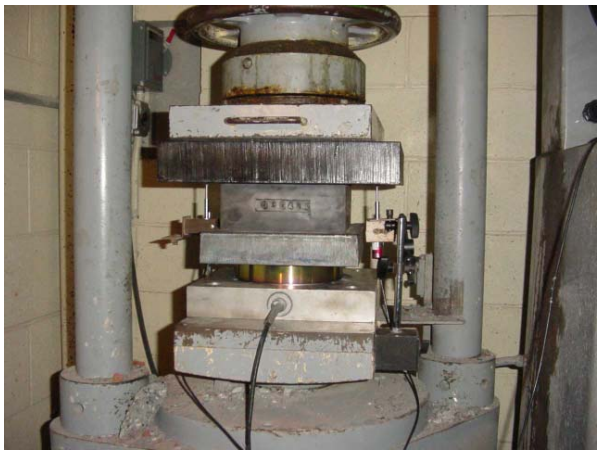


Compressive stress distribution in laminated circular bearing

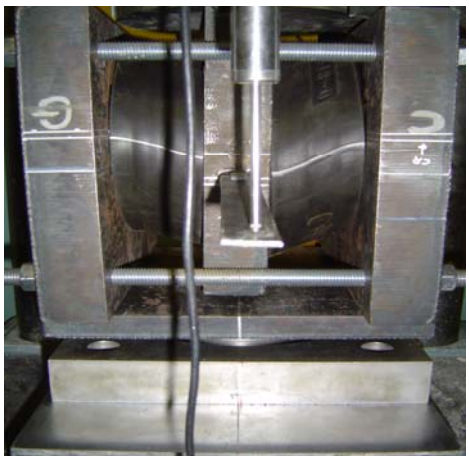


Stress-strain behavior in compression of laminated elastomeric circular, square, and rectangular bearings

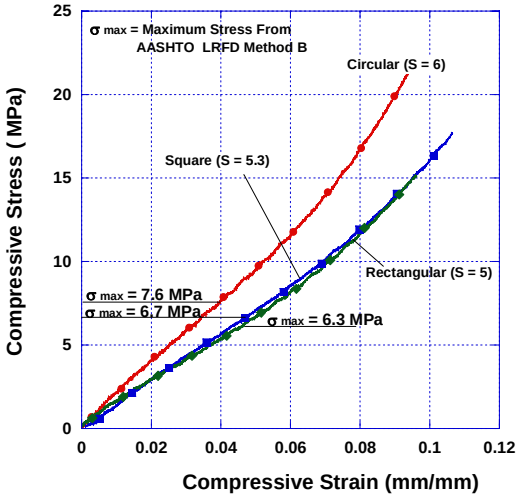
TESTING….



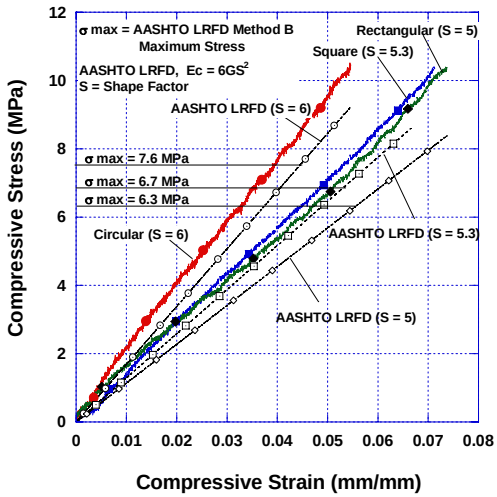
Square bearing being tested in pure compression.



Circular elastomeric bearings in shear and compression test



Compressive stress versus strain for various bearing geometries from test results.



Initial portion of the compressive stress versus strain curve from test results and from AASHTO LRFD equations

FINDINGS…

- Some states are already using laminated elastomeric circular bearings in their bridges and other states would consider using them. Most states have used them in curved bridges, bridges with large skews, and on pier caps with limited space. Most states had questions on the rotational limits of circular bearings and on elastomeric bearings in general. Many believe more studies are needed to establish rotational capacities of bearings and to reconcile the differences between AAHSTO Methods A and B to help designers and state bridge engineers.

- Most of the states using laminated elastomeric circular bearings did not have enough data to compare maintenance of circular bearings to square and rectangular bearings. Very few states have instrumented and monitored elastomeric bearing movements and short and long term performance. Most of the states using circular bearings did not have enough data to compare the cost of circular bearings to square bearings. Few states reported a slight increase (about 10 percent) in the cost of circular bearings. Results from the bearing suppliers and manufacturers showed only minor differences in the cost between circular and square bearings.

- Results from the FEA showed that the stress-strain behavior in compression is basically the same for all three bearing geometries. The smaller vertical deflections observed in laminated elastomeric circular bearings compared to square and rectangular bearings with the same thickness and surface area were mainly due to the higher shape factor, S, in circular bearings.

- Results from the FEA showed that under combined normal stress and shear, tensile stresses were observed at the interface between upper elastomer layer and steel plate for both circular and square bearings. The level of tension was approximately 75 psi for circular bearings compared to 100 psi for square bearings.

- The stress-strain relations in pure compression of laminated elastomeric circular, square, and rectangular bearings tested in this study follow a trend similar to that of the AASHTO LRFD design guide curves in Section 14.7.5.3.4. The effective compression moduli Ec of circular and square bearings from tests were about 10 percent higher than AASHTO LRFD approximate values. For rectangular bearings, Ec was about 20 percent higher than AASHTO LRFD values.

- The measured moment capacity versus rotation of laminated circular bearings and rectangular bearings rotated about their major (strong) axis are similar to the predicted AASHTO LRFD moment capacity at low rotations. The square bearings had a higher moment capacity than the moment capacity predicted by AASHTO LRFD at low rotations. For square bearings, the measured moment capacity versus rotation is not as linear as expected. For rectangular bearings rotated about their minor (weak) axis, the measured moment capacities were lower than those from the AASHTO LRFD equation for rotations greater than 0.005 rad. This reduced moment capacity needs further investigation.

- Laminated circular bearings should be considered as an acceptable bearing geometry along with laminated square and rectangular bearings for bridges. The surveys, the finite element analysis, and the experimental results confirmed that there was no significant difference in cost and performance between laminated circular, square, and rectangular bearings with the exception of the conflicting results for rotation, which needs further investigation.

- In situations where the direction of rotation is not well defined (highly skewed and curved bridges), laminated circular bearings have an advantage over laminated rectangular and square bearings because their rotational capacity is the same in all directions while those of rectangular and square bearings are dependent on the axis of rotation.

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A final report is available online at
http://www.state.nj.us/transportation/refdata/research

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research, and Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Bureau@dot.state.nj.us and ask for:

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