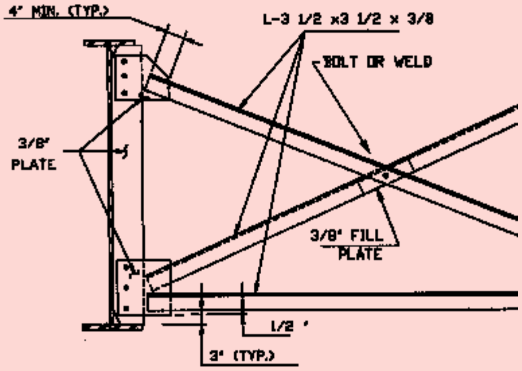

BRIDGE CROSSINGS

No. 7, June 1997

Practical Information For The Bridge Industry

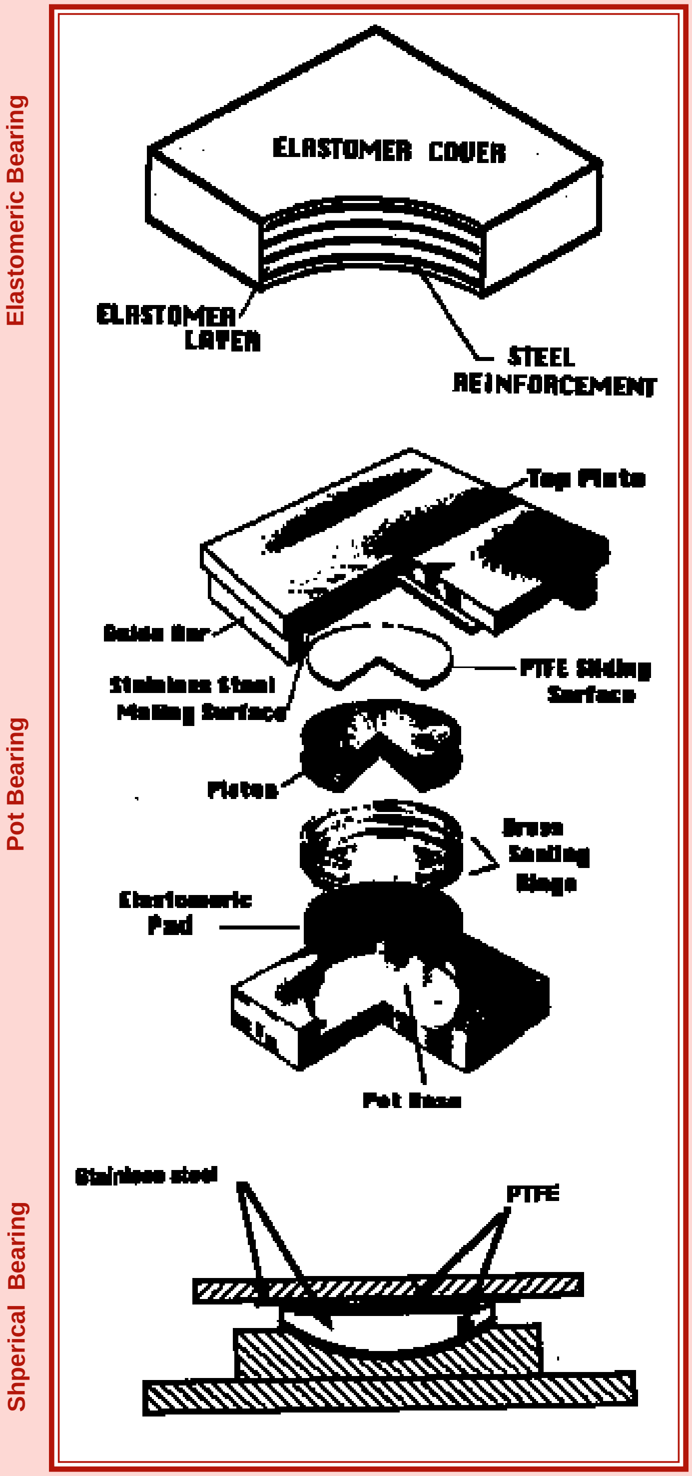

Figure 1: Bearing Types

Bearings For Steel Bridges

By Charles H. Roeder, P.E.

Bearings assure that a bridge remains functional by allowing movements while supporting vertical loads. As a result, bearings must be designed with full consideration of both movements and loads. Movements include both translations and rotations, and the sources of movement include bridge skew and curvature effects, initial camber or curvature, construction loads, misalignment or construction tolerances, settlement of supports, thermal effects and traffic loading. Thermal translation, Δ, is the most important for steel bridges and is estimated by:

$$\Delta = \alpha L \Delta T$$

where L is the expansion length, α is the coefficient of thermal expansion, and ΔT is the change in the average bridge temperature from the average temperature at installation. A change in the average bridge temperature causes a thermal translation, but a change in the temperature gradient causes bending and deflection. Skew and curved bridges may have more complex movements than suggested by the above equation, and these special geometric effects must be considered.

Rotations also must be considered in the selection and design of the bearing. Bearing rotation may be caused by girder end rotations as well as initial camber of girders and out of level support surfaces. The magnitude and direction of all translations and rotations must be considered at all stages of the life of the bridge and bearing.

Bearings resist forces and accommodate movements, but the resistance of a force and accommodation of movement in the same direction are normally mutually exclusive events. Restraint forces occur when any part of a movement is prevented. Forces due to direct loads include the dead load of the bridge and loads due to traffic, earthquakes, water and wind. Temporary loads due to construction equipment and staging also occur. It should be noted that the majority of the direct design loads are reactions of the bridge superstructure on the bearing. The engineer must consider the worst possible combination of loads and movements without designing for unrealistic or impossible combinations or conditions.

Bearings are typically located in an area that collects dirt and moisture, and as a result, bearings should be designed to have the maximum possible protection against the environment and to allow access for inspec-

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Table 1: Summary of Bearing Capabilities

Bearing Types	Load Min. (kN)	Load Max. (kN)	Translation Min. (mm)	Translation Max. (mm)	Rotation Limit (rad.)	Costs Initial	Costs Maintenance
Plain Elastomeric Pad	0	450	0	15	0.01	Low	Low
Cotton Duck Pad	0	1400	0	5	0.003	Low	Low
Fiberglass Pad	0	600	0	25	0.15	Low	Low
Steel Reinforced Elastomeric Bearing	225	3500	0	100	0.04	Low	Low
Flat PTFE Sliding	0	>10000	25	>100	0	Low	Moderate
Spherical Lub. Bronze	0	7000	0	0	>0.04	Moderate	Moderate
Pot Bearing w/o Sliding	1200	10000	0	0	0.02	Moderate	High
Pot Bearing w/ Sliding	1200	10000	25	>100	0.02	Moderate	High
Rocker Bearing	0	1800	0	100	>0.04	Moderate	High
Single Roller	0	450	25	>100	>0.04	Moderate	High
Spherical PTFE w/o Sliding Surface	1200	7000	0	0	>0.04	High	Moderate
Spherical PTFE w/Flat PTFE Sliding Surface	1200	7000	25	>100	>0.04	High	Moderate

Note: 1 kip = 4.45 kN and 1 inch = 25.4 mm

tion. Further, allowances for bearing replacement should be part of the design process, since the expected life of most bearings is shorter than for other bridge components.

Bearing Selection

After the design requirements are established, the bearing type must be selected. The selection should be made with the goal of achieving the most economical solution that supports all required loads while accommodating all required movements. The economic evaluation should consider both the initial cost as well as the long term maintenance. A wide range of bearing types are possible (see Figure 1), including: elastomeric bearings; bearing pads; PTFE (polytetrafluorethylene) or lubricated bronze sliding surfaces; pot bearings; disk bearings; rocker or roller bearings; and cylindrical or spherical bearings.

Many engineers misjudge the capabilities of individual bearing types, or they improperly evaluate the loads and movements. Either error leads to a poor selection of bearing type, poor bearing performance and increased maintenance and construction costs. More information on these topics is contained in the "Steel Bridge Bearing Selection and Design Guide," which was recently published by the NSBA (call 800/644-2400). It is important that the engineer initially select the most viable options for further design consideration (see Table 1). This table is not a design document, however. It does provide approximate practical limits to help the engineer select the most viable options. Examination of this table and comparison of the bearing capabilities with the design load and movement requirements for steel bridges shows that elastomeric bearings or elastomeric bearing pads will often be the lowest maintenance and most economical solution for steel bridges. Unfortunately, this finding is opposed to the preconceived notions of some engineers and these preconceptions often lead to a bearing system that is well below the optimum. The engineer should keep his or her options open during the selection process and Table 1 clearly identifies the options that should be carried forward into later stages of the design process.

Bearing Design

A discussion of bearing design exceeds the space limitations of this article. However, for more information, please consult the AASHTO "Load and Resistance Factor Design Specifications" or the NSBA "Steel Bridge Bearing Selection and Design Guide."

Attachment and Installation of Bridge Bearings

Lateral forces may arise from wind, traffic or hydraulic loads and they are induced by the bearing resistance due to imposed displacements or seismic loading. For stream crossings, hold downs—such as anchor bolts—are recommended if the elevation of the bottom of the superstructure is within 2' of the design flood elevation. The potential for uplift under gravity load exists only in bridges that are continuous with a high live load-to-dead load ratio, very uneven span lengths, curved, or heavily skewed. The engineer must consider uplift and lateral forces when designing anchorage and attachment details. The detail depends upon the lateral load and

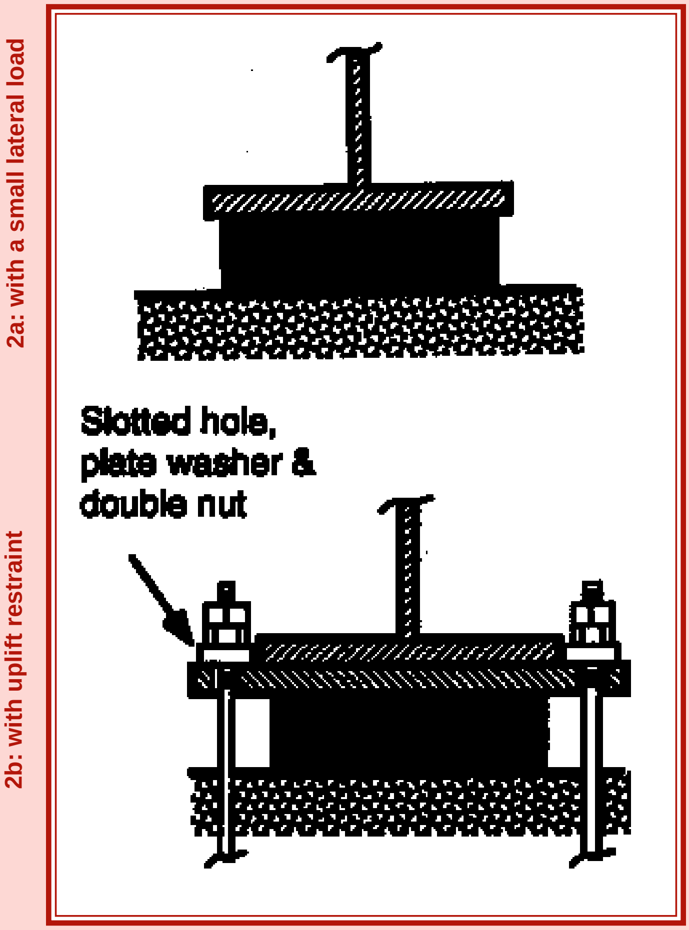

Figure 2a & 2b: Attachment and anchorage of flexible bearings

uplift resistance required at the bearing as well as the stiffness of the bearing system. In past years, bridge design specifications required that steel bridges be anchored against uplift in all cases; today attachment and anchorage requirements depend upon the load and restraint requirements rather than arbitrary rules or restrictions.

A variety of attachment details are possible. Lateral forces are small in elastomeric bearings or bearings equipped with a PTFE sliding surface. Therefore, these flexible bearings often require little or no lateral resistance and friction may provide adequate lateral restraint (see figure 2a). Uplift restraint is needed only in special conditions, since gravity will provide adequate uplift resistance in most cases. However, flexible bearings permit simple details such as that of Figure 2b when uplift resistance is required.

Stiff bearing systems such as pot bearings develop large lateral forces with very small deformations. Therefore, attachment and anchorage are likely to be required, and the larger forces must be anticipated. Stronger and stiffer attachment details (see Figure 3) are used for pot bearings and other stiff bearing systems. Prior discussion has noted that elastomeric bearings are often the most economical alternative wit the least maintenance for steel bridges and the greater simplicity inherent in the installation, attachment and anchorage of these bearings is another reason for their greater economy. Because of the greater stiffness and the resulting forces expected with stiff bearing systems, it is often advantageous to use a structural key way rather than the bearings to restrain unwanted movements in these systems.

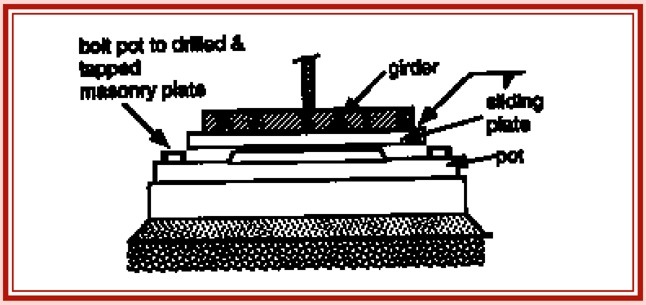

Figure 3: Minimum attachment detail for a stiff bearing

Conclusions

Bridge bearings are not well understood by many engineers. The materials used in them are different from those encountered in other structural systems and the behavior and modes of failure also are quite different. As a result, bridge bearings are a contributing factor to a large portion of the long-term maintenance cost of steel bridges. This article presents a breif overview of the bridge bearing issue. For a more in-depth discussion, please refer to “Steel Bridge Bearing Selection And Design Guide,” published by the NSBA. The publication can be ordered by calling 800/644-2400.

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The mission of The National Steel Bridge Alliance (NSBA), which was formed in 1995, is to enhance the art and science of the design and construction of steel bridges. Its activities include organizing meetings, conferences and national symposia, conducting the Prize Bridge Awards competition, supporting research, developing design aids, and providing assistance to bridge owners and designers. The NSBA membership includes representatives from all aspects of the steel bridge industry.