4.0 CHAPTER 4 - BEARINGS

4.1 PURPOSE OF BEARINGS

Bearings and bearing plates are one of the most important components in a bridge structure because their main purpose is to transfer all loads safely from the superstructure to the substructure. The structural assembly of the bearing must be able to withstand large loads without failure. It is therefore generally made from high strength steel or synthetic rubber (elastometric). In order for the bearing to perform properly, it must meet two basic criteria: 1) It must be able to transfer the loads from the superstructure and spread the stress over an adequate area on to the substructure, and 2) It must be able to accommodate movement. Bridge structures are not static structures, as movements are caused by temperature changes (expansion and contraction), deflection, earth pressures, stream and ice flow, and centrifugal and longitudinal forces of vehicles, all of which can generate harmful stresses in the superstructure. Bearings must accommodate these small movements, without adding additional stresses to both the superstructure and the substructure.

4.2 TYPES OF BEARINGS

Bearings are generally classified as fixed or expansion type. Fixed bearings do not permit vertical and horizontal movements, but they do allow rotational movement about the horizontal axis perpendicular to the line of traffic. Expansion bearings permit both longitudinal and rotational movements of the superstructure.

In a bearing, there are generally three distinct components: sole plate, masonry plate, and a bearing device such as a rocker, roller, pad or plate. All three parts are not present all the time, but at least one part, the bearing device, should be exposed to allow inspection.

Attached to the underside of the main structural member at the end supports, (i.e. the bottom flange of girders, or the bottom chord of trusses), is the sole plate which is generally a rectangular piece of steel. It is attached by welds, bolts, or rivets.

The bearing device is the assembly between the sole plate and masonry plate which permits longitudinal and rotational movements of the bridge at the bearing point.

The masonry plate is similar to the sole plate except that it is cast on top of the bridge seat and anchored by bolts which are embedded in the concrete. Beneath the masonry plate, grout pads may or may not be present depending on whether there is complete surface contact between the plate and the support.

Bearing type when available is extracted from BIS and printed on the inspection form. A specific list of bearing types can be found in BIS documentation. A brief description of some common types of bearings used on bridge structures is presented below:

Neoprene Strip Bearings
These bearings consist of a strip of an elastometric compound consisting of neoprene. This type of bearing is used on standard bridges. It has a 60 Duro hardness and a 10mm thickness.

Reinforced Neoprene or Natural Rubber Pads
These are elastometric bearings made from neoprene (polychloroprene) or natural rubber which are strengthened with horizontal laminates of steel or fabric bonded to the rubber. This reinforcing improves the mechanical properties of the pad by increasing its resistance to bulging under a compressive load. It also increases compressive and rotational stiffness and controls vertical deflection and rotation of the bearing.

Reinforced Neoprene or Natural Rubber Pads, Teflon, and Stainless Steel
A stainless steel plate with a Teflon (TFE) layer between the sole plate and the top of the elastometric pad provide for horizontal movement in this type of bearing. This teflon layer can tolerate extreme temperatures and pressures while maintaining its low frictional resistance to movement.

Pot Bearings
Pot bearings are bearings that are made from large round elastometric pads which are confined by heavy steel rings in combination with stainless steel plates and Teflon (TFE) layers, permitting the bearing to move horizontally. The confinement permits the elastometric material to carry a larger load than unconfined pads.

Rocker Bearings
Rocker bearings are cylindrical sector shaped bearings attached by pins that have their rocker plate bearing surface on the masonry plate. This rocker plate is in contact with the masonry plate on a thin rectangular strip and hence requires a large radius to prevent overstressing through excessive contact stresses. In most rockers, a rounded tooth or pintle is provided to prevent displacement of the rocker in relation to the masonry plate.

Roller Bearings
Rollers are cylindrical steel bearings that are attached by pintle pins to either the sole or masonry plate to avoid the possibility of working themselves out from between the plates. A single roller is used at each bearing point. This system works better than the roller nest in the long run since there is less space for the accumulation of dirt. Also, dirt and debris are more easily removed by wind action. Unfortunately they still corrode and freeze, and under heavy loading conditions the masonry plate may tend to show signs of deformation.

Roller Nest Bearings
A roller nest is a bearing that consists of a group of cylindrical rollers housed in a frame or box. These rollers are kept parallel and separated with one or two space bars on each end. In principle this system should work well. However, this is not the case since the space between the rollers tends to trap moisture and dirt which promotes corrosion and freezing.

Steel Sliding Plate Bearings

The simplest of all bearings is the steel sliding plate bearing which is generally used for short span bridges. It consists of the sole plate and the masonry plate or it can be a single steel plate which serves both as a sole and masonry plate. The mating surfaces are planed smooth to reduce frictional resistances. Unfortunately these plates eventually freeze together because of dirt and corrosion.

Steel Sliding Plates with Bronze Plate in Between

To reduce the friction between the two steel plates, a bronze plate is inserted between the sole and masonry plate. The bronze plate is secured to either the top or bottom plate, however, the lubrication face on the bronze plate must be in contact with one of the two faces (sole or masonry).

Disc and Dome Bearings

In these bearings the top surface of the bottom masonry plate is convex and the bottom surface of the sole plate is concave. A self lubricating bronze plate is sometimes used between the sole plate and masonry plate. These bearings only provide for rotational movement. These bearings are expensive, as they require precision machining to obtain a true and matching surface.

Photos of some of these bearings can be seen in Figure 7.26 to Figure 7.30 in the Level 1 BIM Manual.

4.3 COMMON DEFECTS AND PROBLEMS OF BEARINGS

- The accumulation of dirt and debris at the bearing will cause deterioration by rusting. This debris has the tendency to hold in moisture containing de-icing salts which are very corrosive to steel. As a result of excessive corrosion, the bearing may freeze (lock-up) and resist movement. When movement is restricted, as in the case of expansion type bearings, it throws the stress back into the structure, which may overload some members and cause failure.

- Bearing elements that do not have full contact with the bearing surface could damage the span, support, bearing, or all three. Where there is partial contact between the sole plate and masonry plate, the loads transmitted to the abutment could exceed the allowable bearing stress of the concrete used in the abutment, causing the support to crush. Vice versa, the stress level could surpass the allowable value for steel and cause the web of the girder to fail by buckling.

- At the bearing points, bearings are designed to perform a specific function and are characterized by type, size, shape, and configuration. Proper alignment of the bearing is important to permit rotational and/or longitudinal movement. Should it be misaligned, stresses can occur at the supports, resulting in a transfer of stresses to other parts of the bridge to cause damage, creep, and constant vibration. Misalignment and repeated live loads may cause bearings to move out of place.

- For bronze sliding plates used between steel plates, galvanic corrosion (i.e. corrosion caused by two dissimilar metals) is possible.

- Loose bearings may be detected by noise at the bearing when the bridge is subjected to vehicular traffic. The causes of loose bearings may be due to one of, or a combination of the following factors:

    - Settlement or movement in the bearing support (pier or abutment), resulting in a loss of support for the bearing assembly.

    - Loss of bearing material due to excessive corrosion.

    - Structural members that are damaged or broken would cause excessive deflection or vibration in the bridge structure.

    - Rivets, bolts, or welds that fasten the bearing assembly to the bridge span or bridge support maybe come loose (sheared bolts or rivets, or cracked welds).

    - Pins that become worn due to lack of lubrication and metal to metal contact.

- Elastometric bearings have an advantage over steel bearings in that they have no moving parts that can corrode or seize; they are inexpensive to manufacture, and require little or no maintenance. However, these bearings made from natural rubber (polyisoprene) or neoprene (polychloroprene) can fail. The potential modes of failure are summarized below.

    - Splitting, tearing or cracking in elastometric pad due to poor quality of material used in the manufacturing of the pad.

    - Rubber is subject to fatigue as its properties change with time.

    - Excess flexibility or creep may cause excessive deflection and bulging of the sides.

    - Low temperatures and dynamic loadings can cause crystallization and stiffening.

    - Unreinforced pads are sometimes subject to slippage.

    - Tilting of the bridge structure may cause uneven loading and overloading of the pad.

- The following defects or problems with other components of the bridge may indicate that there are problems or malfunction in the bearing:

- Abutment or piers show signs of cracks on the face or side in the vicinity of a bearing. In addition to cracks, we could have spalled concrete.
- A bump at a bridge joint.
- A deflection in the bridge railing at a joint.
- A pier or abutment that is tipped.
- A wide open expansion joint even though other joints are closed or at normal opening. A jammed joint.
- Rust stains running down the vertical face of the pier.

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