11.0 BEARING DEVICES

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11.1 General

Bridges are not static structures, but are continually in motion. Linear movements of expansion and contraction (translations) are caused by temperature changes. Rotational movement is caused by imbalances in dead loads and live load movements (traffic). Other movements can also be caused by earth pressures and settlement.

To allow for these movements to occur, a bridge has bearings devices which transmit loads from the superstructure (deck and beams) to the supports or substructures (piers and abutments). These bearing devices are located under the beam, girder or slab at points of support (abutments, piers or hinges).

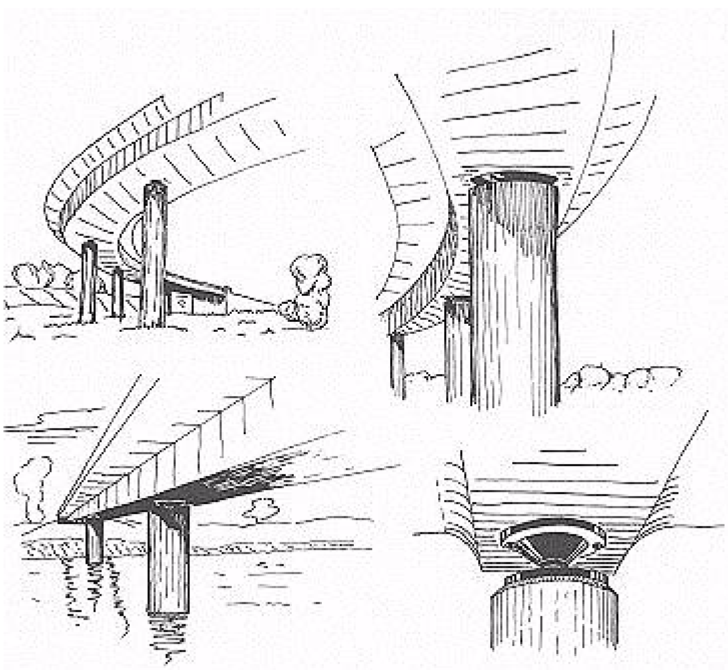

Figure 1

If this movement is restricted or prevented, a build up of forces will cause undesirable movements or distress and potential failure.

The bridge designer will prohibit movement in some bearings and allow movement in others. In general, there are two types of supports shown on plans, fixed (F) or expansion (E). The Construction Layout sheet in the plans will show the designers intent. A support with a (F) will have a bearing device that will resist longitudinal movements. And a support with an (E) will move longitudinally.

Because the bridge is moving almost continually due to the temperature, each bearing must be properly 'set-up' before the deck is placed. This 'set-up' is done by aligning the centerlines of the bearing stiffeners of beams or girders with the proper location on the pier or abutments based on temperature. The Contractor will do this after the structure framing is complete. Most bearing devices are connected to the piers or abutments by anchor bolts. These bolts will be grouted into the piers or abutments by using preformed anchor bolt hole block-outs (wells). These wells are critically-surveyed locations which align the bridge. The well block-outs are tied to the rebar in the support during the pouring of the support. This grouting is usually done at the fixed piers at the time of erection of that piece for overall erection stability. ***As the bridge is erected, and prior to grouting anchor bolts, the beams or girders must be positively connected to the supports. Wind or vibration can create problems when only friction is relied on. The Contractor must maintain this stability at all times during erection.***

During the winter months if the preformed anchor bolt holes are left ungrouted for any length of time they must be protected from freezing moisture. Seal the holes, or fill them with antifreeze or a similar substance to prevent freeze (expansion) damage.

11.2 Types:

Bridge Bearing devices are classified as fixed or expansion. Fixed devices are called bolsters and only allow rotation at that support location.

Mechanical Devices:

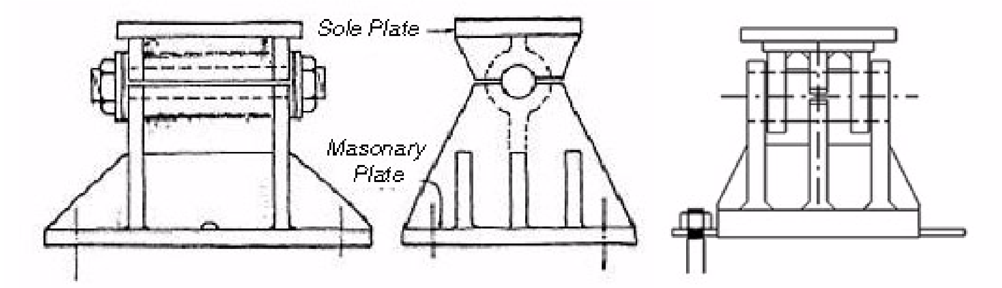

Figure 2 Fixed or Bolster type Mechanical Device

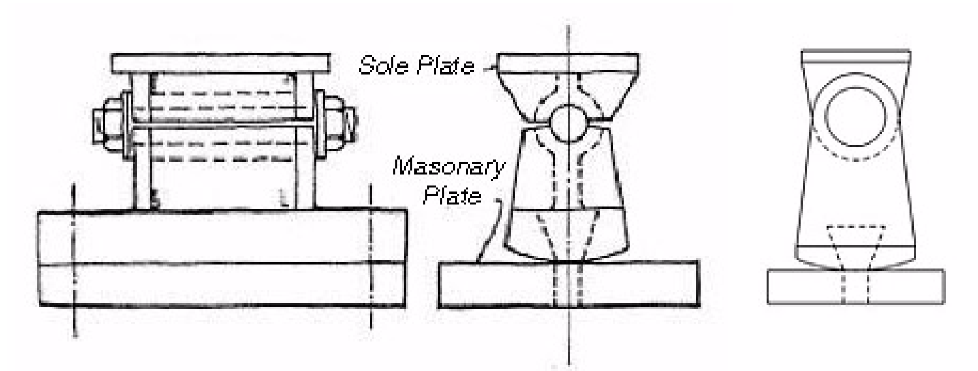

Figure 3 Expansion or Rocker type Mechanical Device

Expansion devices allow both rotation and translation (longitudinal) movements. These devices are further classified as mechanical or elastomeric. Figures 2 and 3 are examples of mechanical devices. These are made in the fabrication shop from heavy plate steel welded together. These devices are usually made up of a upper and lower element with a large stainless steel pin as the common element. These devices have finely machined surfaces at the location where the 'pin' rubs on the upper and lower 'cradle'. A lubricant such as powdered graphite must be used on machined surfaces to reduce friction and prevent corrosion.

To allow the expansion device to move the 'rocker' rocks or tips. This means that the top element is not in line (off-set) with the bottom element. As stated, this happens due to temperature changes and therefore, these devices have to be set after girder line erection to the correct tip angle. Basically, the Contractor has to 'tell' the bridge what temperature it was when it was constructed. The designer will show, on the plans, the temperature off-set relationship based on a 'datum' temperature of 60º F. The Contractor will tip the rockers toward the closest abutment if the temperature is higher than the datum, or away if the temperature is lower than the datum temperature (See Figure 5).

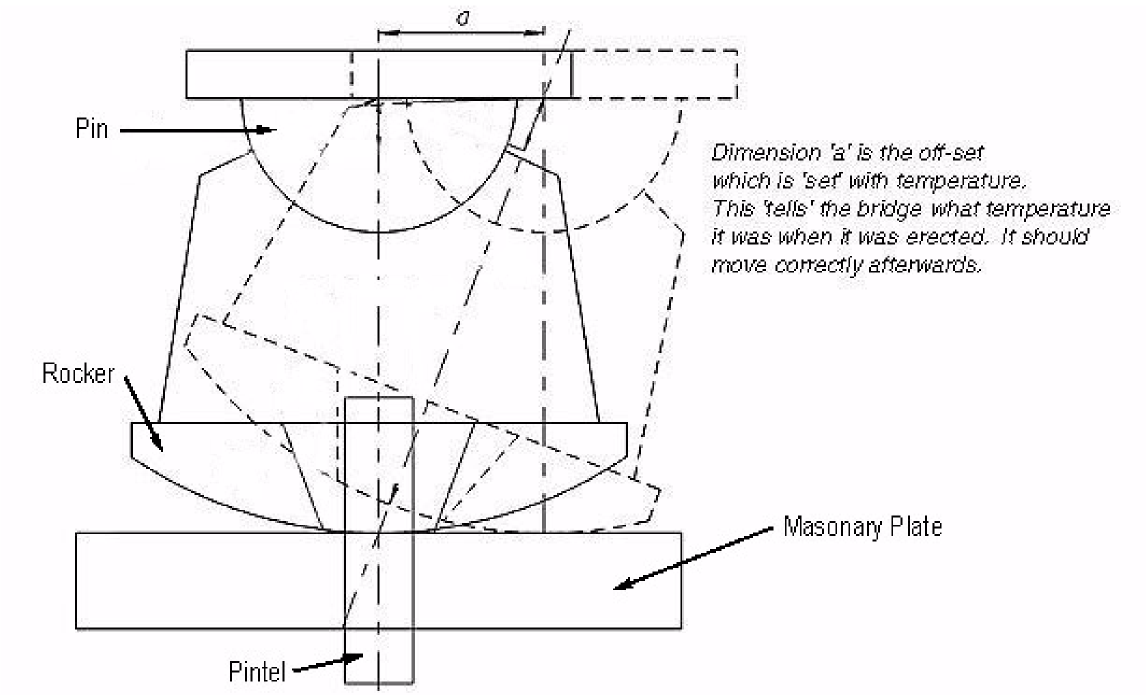

Figure 4
Rocker 'Rocking' Working

Most KDOT rockers translate at the top by rotating on a half-pin attached to a sole plate (the part that attaches to the bottom flange is called the sole plate). The rocker contacts the pin at the cradle at the top and the masonry plate at the bottom. The rocker rotates about the radius point of the half-pin. The superstructure movement causes the rotation and/or translation. The fixed pintel keeps the rocker in position on the masonary plate. The pintel is a vertical pin which is driven into the masonry plate at the shop that prevents the rocker from sliding instead of rocking. (See Figure 4).

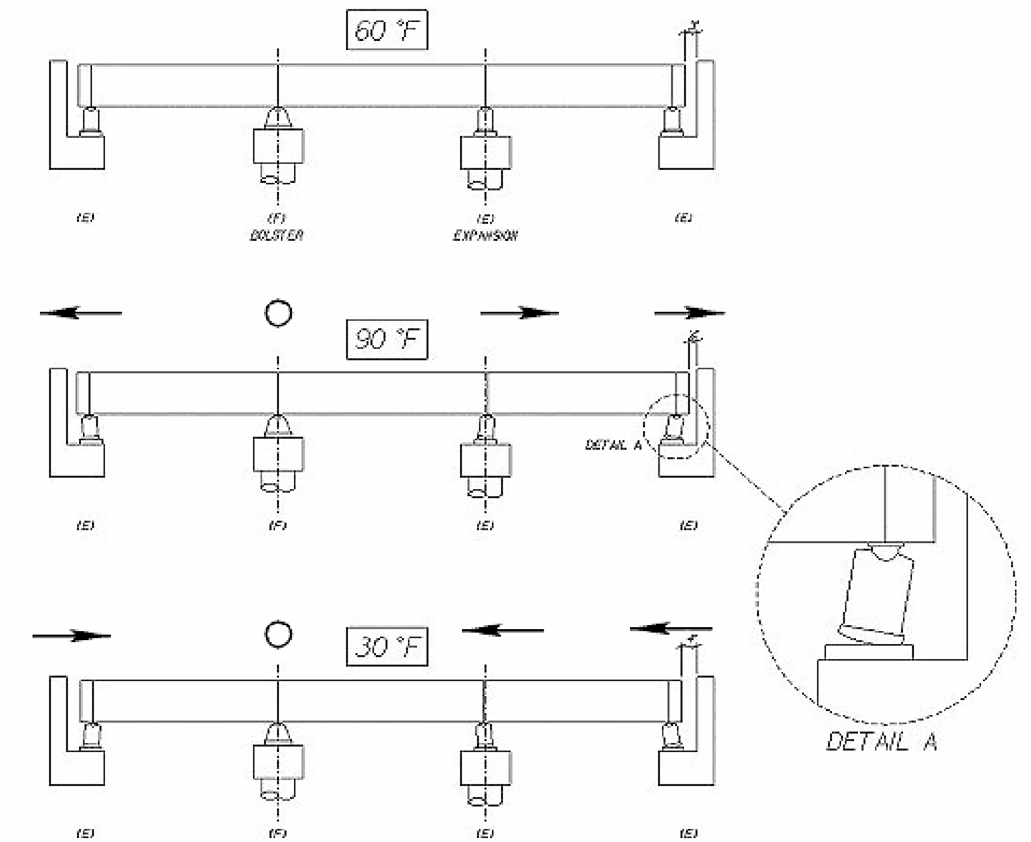

Figure 5 Temperature vs. Bridge Length

The pintel can be internal or external, and may or may not be a threaded connection.

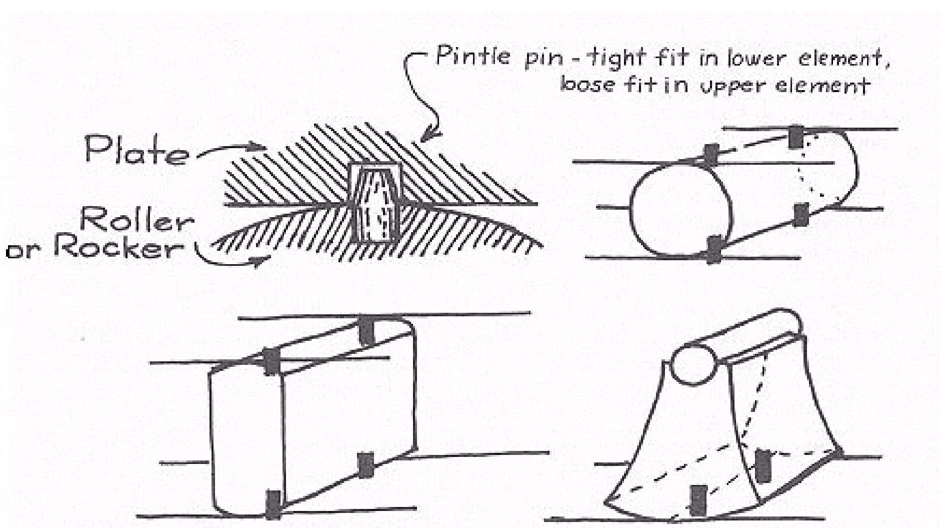

Figure 6 Pintle Pins

Pintle Pins are drive fit on one side and loose fit on the other (all these are internal pintles)

Elastomeric Devices:

Below Figure 7 shows how the second group of devices called elastomeric devices work.

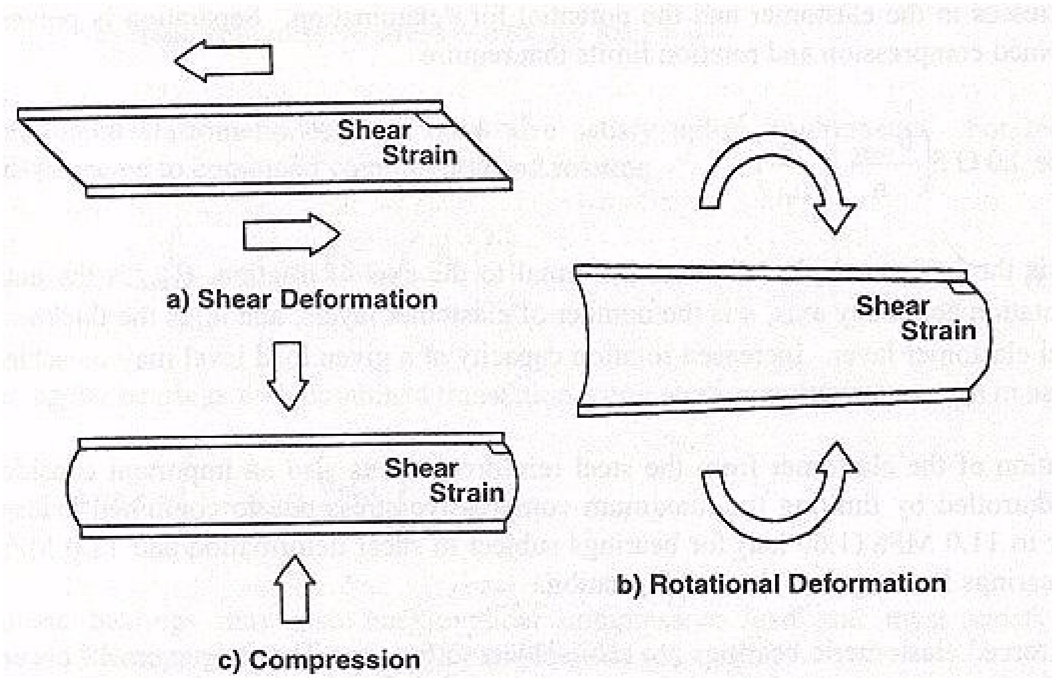

Figure 7 Cross-Section of Elastomeric Bearing. (No moving parts to 'freeze-up')

Elastomeric material is an engineered 'rubber' that has properties that allow the device to move longitudinally (translate) and rotate by deforming the pads. There are no moving parts to freeze up and nothing to 'set-up' for these devices, except for setting the anchor bolt in the slotted hole. There is no upper and lower element to off-set; it is a one piece unit.

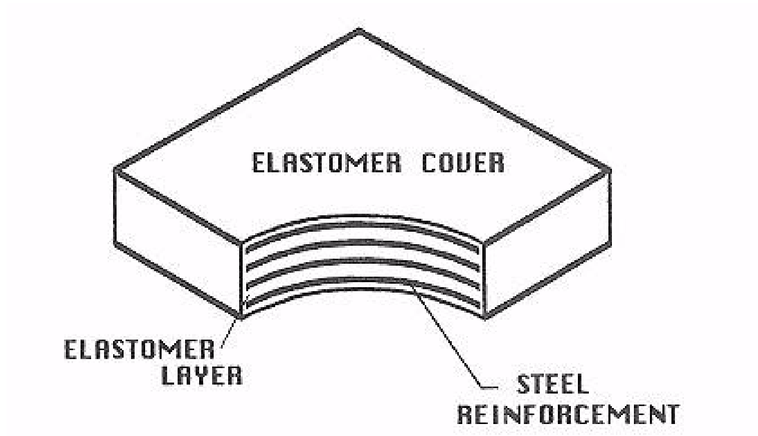

Figure 8 Showing the internal reinforcement inside the device.

Elastomeric devices are reinforced internally with steel and are vulcanized (heated and pressed) to a sole plate which is then field welded to the bottom flange.

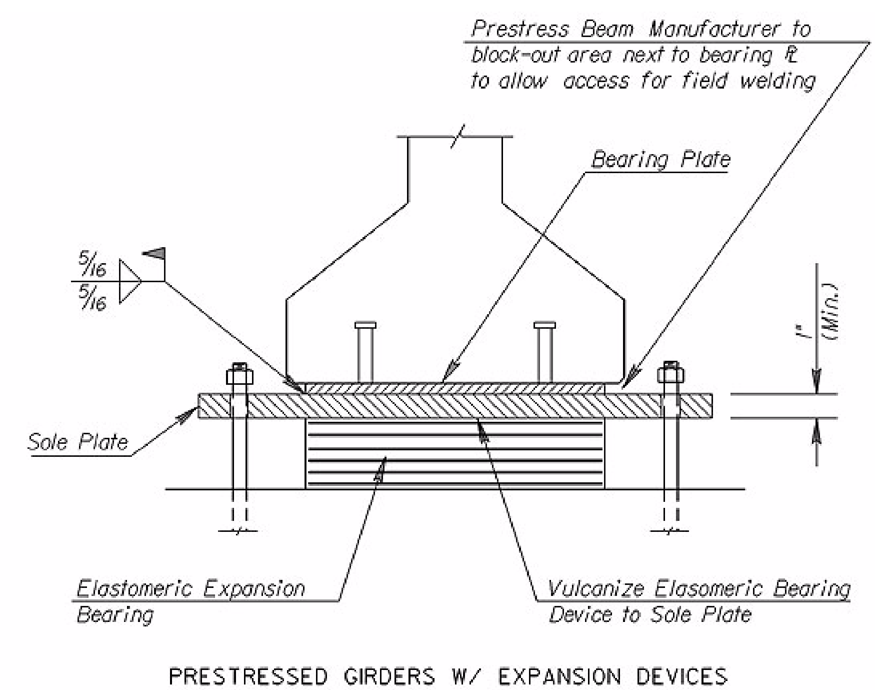

Figure 9 Detail of Elastomeric Device showing that it consists of only one element.

The anchor bolts are located within slotted holes (on the sole plate) which are set according to temperature so they do not bind (Note: Field welding is required)

Figure 9 shows a common detail for the elastomeric device. Notice that the device's sole plate is field welded (the little flag) to the bottom flange. This locates the center the beam or girder bearing stiffener with the center of the bearing device and in this case also the center of the pier (See Figure 10). Note that Figure 9 also shows a gap (No Threads) on the anchor bolt between the nut. This gap allows the Sole Plate to rotate.

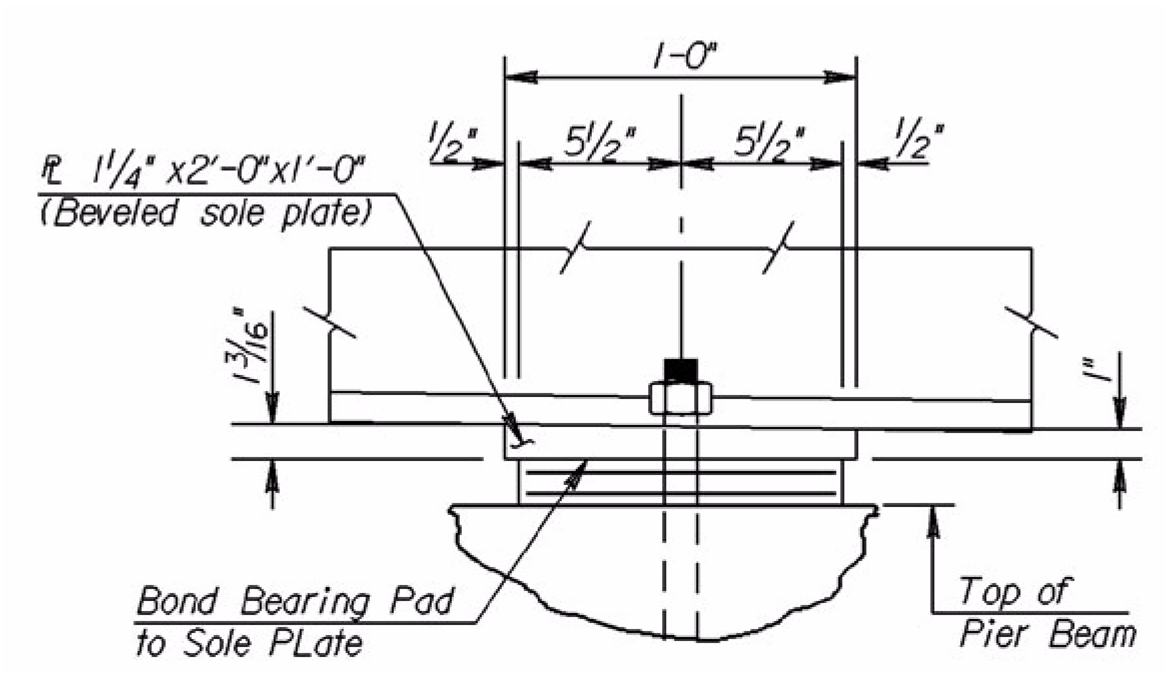

Figure 10 Alignment of Device (elastomeric)

Elastomeric Devices (TFE 'slider'):

If the bridge movements become too large then the designer will use a second kind of elastomeric device called elastomeric with TFE (or **TFE 'slider'**). This means there will be a upper and lower element. The contact surfaces between the elements are made of Teflon for the lower, and stainless steel for the upper. This type of device is becoming very popular.

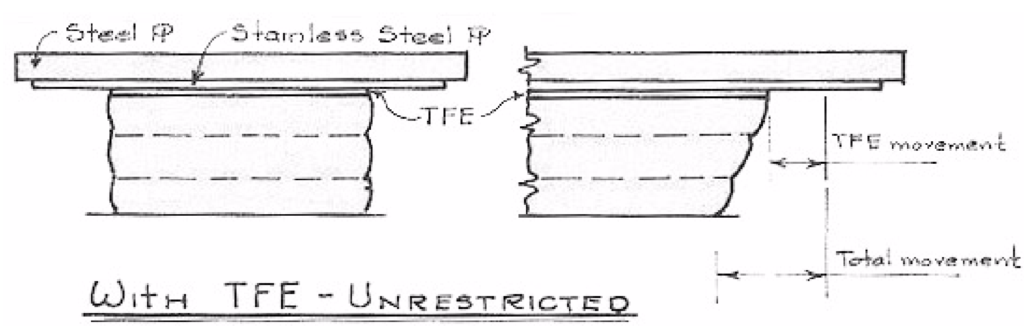

Figure 11 PTFE Elastomeric TFE 'slider' Bearing Device

The device (Figure 11) shows the concept of the TFE 'slider'. Starting at the top of this device is the steel sole plate. The sole plate which has a thin sheet of stainless steel welded to it on the bottom side (this is the upper element). Welding the stainless steel attaches it to the sole plate and seals out any moisture. This weld is an inspection point and should be looked at to insure a steel weld has been made. The lower element starts with a sheet of Teflon attached to a backing plate (not shown is this picture) the backing plate is attached (vulcanized) to the elastomeric device. Usually, the bottom of the device is elastomer and is resting on the concrete substructure element (pier or abutment). The concept is that when stainless steel is in contact with Teflon there is very little resistance between the two elements and they will slide freely. These two 'mating' surfaces must be kept clean and free of paint if they are to work properly.

11.3 Storage and Shipment:

Because of the many pieces that can be involved in some of these devices, the Contractor is encouraged not to unpackage the devices until they are going to be used on the bridge. If the packaging is damaged, the manufacturer or fabricator can be contacted to determine what inspection is required. The storage site should be clean and away from daily working operations with all of the pieces stored in one location. During the loading and unloading the bearing devices can be damaged if care is not taken to insure proper nylon lifting straps are used. Bearing devices have machined and polished surfaces which can be easily damaged by a cable or chain. Inspection of these finished surfaces is to be done just prior to the pieces being fit together (upper and lower element) at their final location.

Figure 12 Storage of Bearings

Don't unpackage the bearings until they are ready to be used; then handle them with care. Check installation dimensions (i.e. the width or axis of rotation and the length along the flange).

11.4 Installation:

(DS Brown Recommendation for Installation)

General: A bearing device is designed with a range of motion and an orientation. If the structure is not built correctly or if the bridge is not 'set-up' properly then the devices will not work as intended. As such, these locations and elevations are critical and must be verified before the bridge erection begins. Repairs due to improper construction of bearings are expensive and usually do not show up until the structure 'feels' the temperature changes of the next season. The bearing seat elevation is the finished concrete surface that the bearing rests on. The finish of this surface must be level and generally smooth and requires extra care and planning during placement of the concrete. Orientation of the device is critical. If a sole plate is tapered, the error may be doubled if it is installed in the reverse position. This creates on 'edge' load and can damage the Teflon surface.

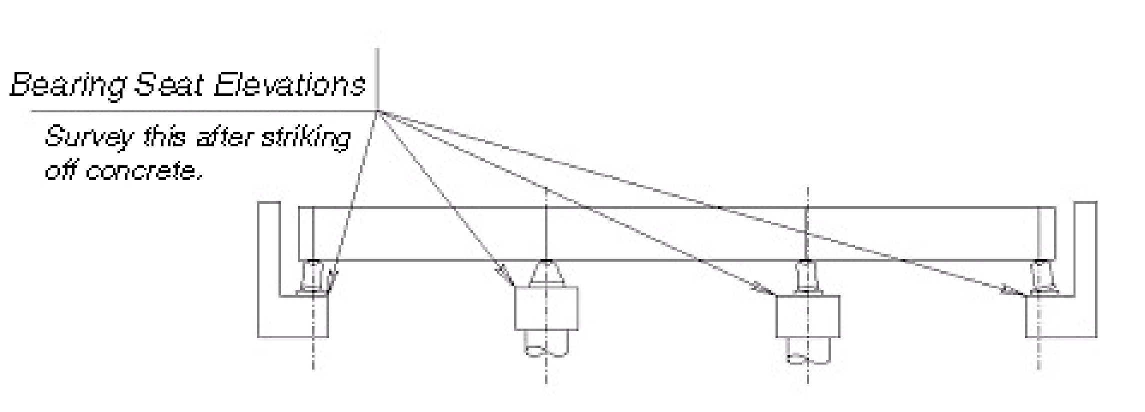

Figure 13 Bearing Seat Elevations (surveyed during concrete placement of the support).

If there is a masonry plate on the device, there will be a leveling pad between the plate and the concrete. This is used to spread out the load and reduce any stress risers, such as an unground piece of aggregate.

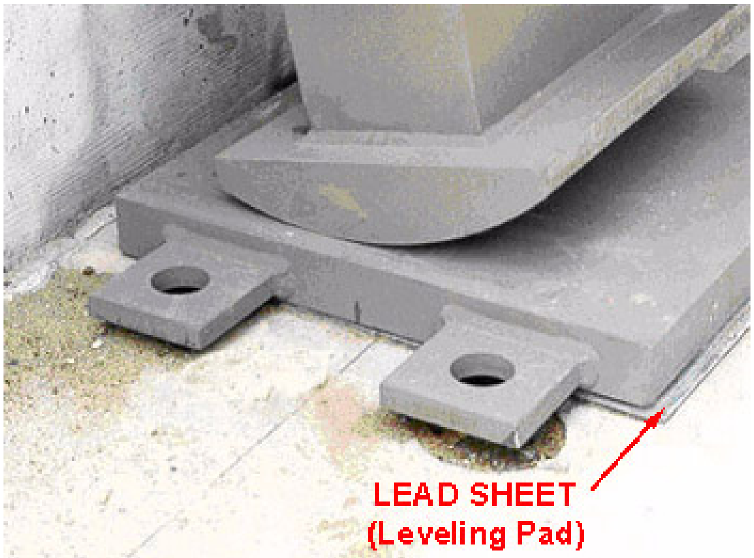

Figure 14 Mechanical Rocker
Showing pre-formed anchor bolt holes and fabric sheet under masonry plate (lower element)
Note: Centerline marks on the abutment and the masonry plate.

Before installation of any bearing devices the bearing seat elevation (the concrete that the device sits on) must be surveyed. The vertical tolerance for this is ± 1/4". Review the plans to determine if there is a taper on the sole plate (the plate that welds to the beam or girder) and the orientation of the beveled plate. A bearing can have a beveled sole plate due to the vertical curvature or the superelevation of the cross-section. The plates of the device should be match-marked from the fabricator. Do not rely on this fact, check the plans. Inspect the devices and measure them after unpacking to insure the correct device is going to be used on the correct location. Look at the plans to determine the devices short and long dimension. Match the way they are being installed on the bridge. This is critical for elastomeric devices because the length and width dimensions can be relatively close in size.

Survey the distance between each substructure element at each end of the bridge width. For example (Figure 15 not longitudinally curved) measure the distance from the center of pier #1 to the center of pier #2 along girder line A and girder line F. This measurement will determine if the supports where constructed parallel to each other and at the correct distance. Do this at each adjacent support, then measure the overall distance from center of bearing at abutment #1 to the center of bearing at abutment #2. Use the preformed anchor bolt hole locations as reference.

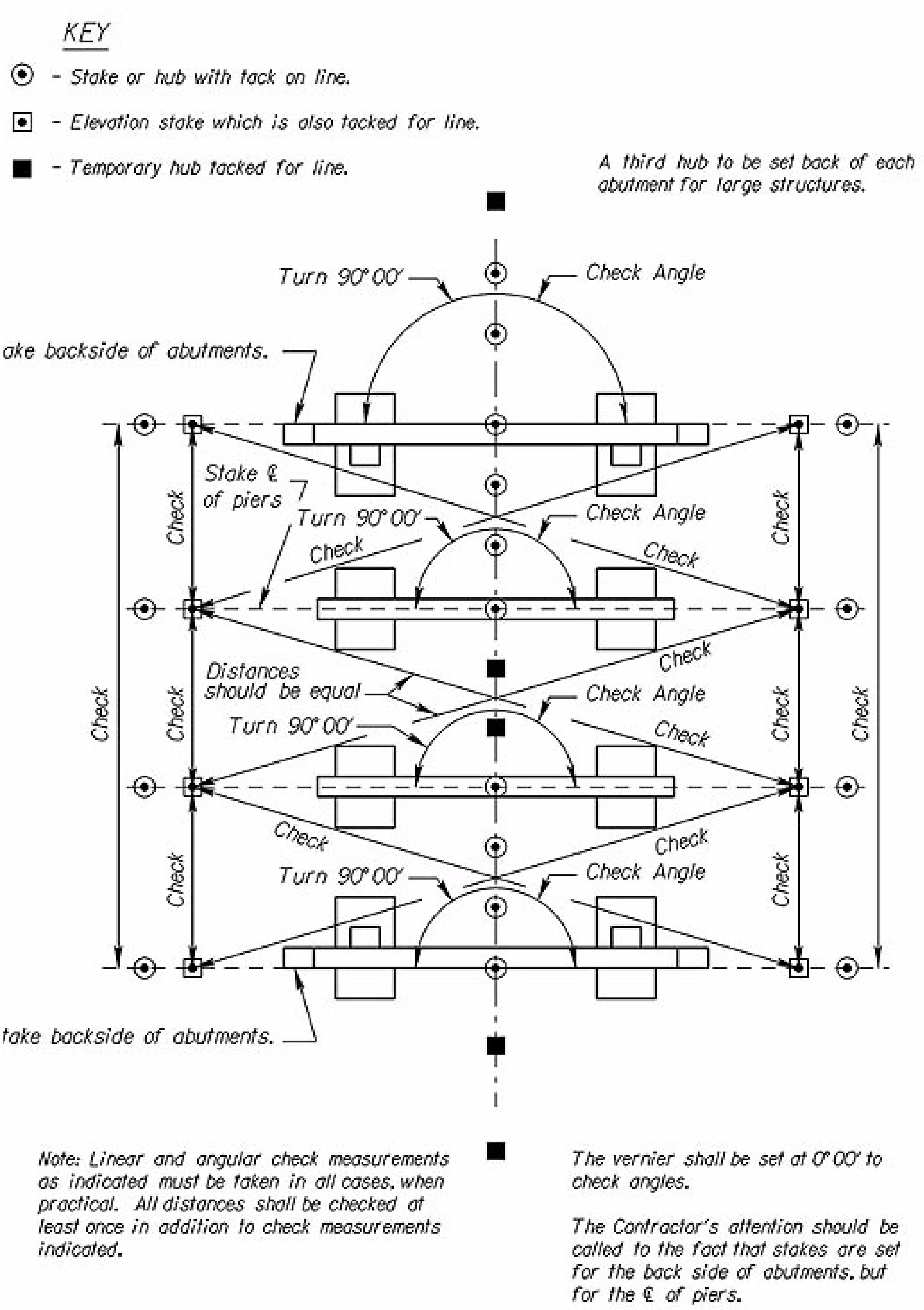

Figure 15:
TYPICAL EXAMPLE FOR STAKING PIERS AND OPEN-TYPE ABUTMENTS
Figure 15: Checks before beginning erection and placing devices. If there are differences, then adjustments are required.

If there are differences between the plan lengths and the measured lengths, determine where the error is so that adjustments can be made during construction. Ideally, the Contractor would start at a fixed or bolstered pier and line up the centerline of the pier, masonry plate and the bearing stiffener. The rest of the bearings would be correct if the anchor bolt holes were in the center of the rest of the supports and the supports were in the correct location. The bridge would then 'know' what temperature it was. The upper and lower elements of the device would be in the correct off-set for any temperature. Most bearings however, will require adjustments to 'tell' the bearing device what temperature it is; that is, set the off-set between lower and upper element. This adjustment is also required for elastomeric devices so that the anchor bolt does not bind within the slotted hole (Figure 17).

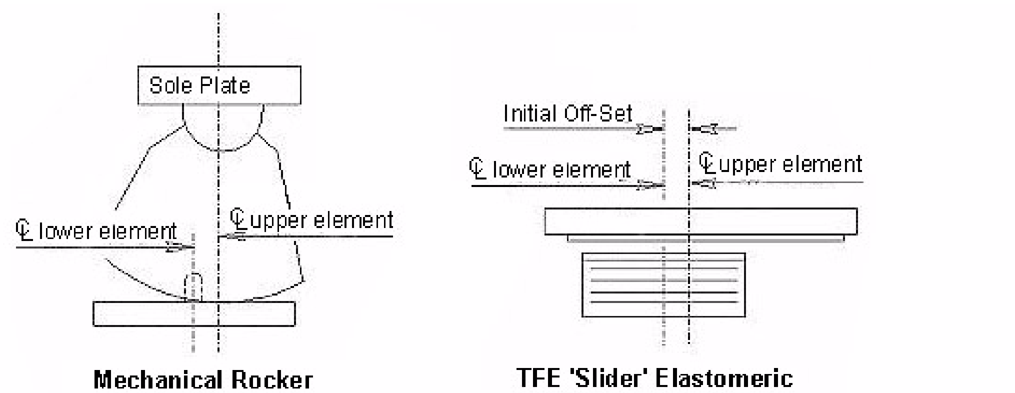

Figure 16

Figure 16 shows the adjustment to offset the upper and lower elements for a rocker or TFE 'slider'. Notice that the TFE 'slider' has two temperature-critical elements to set; the upper and lower elements working relative to each other and the anchor bolt within the slotted hole so that the device, as a whole, works relative to the support.

Figure 16 Mechanical and TFE devices have to be 'told' what the temperature is by off-setting the upper and lower elements according to the temperature so that they move correctly relative to each other.

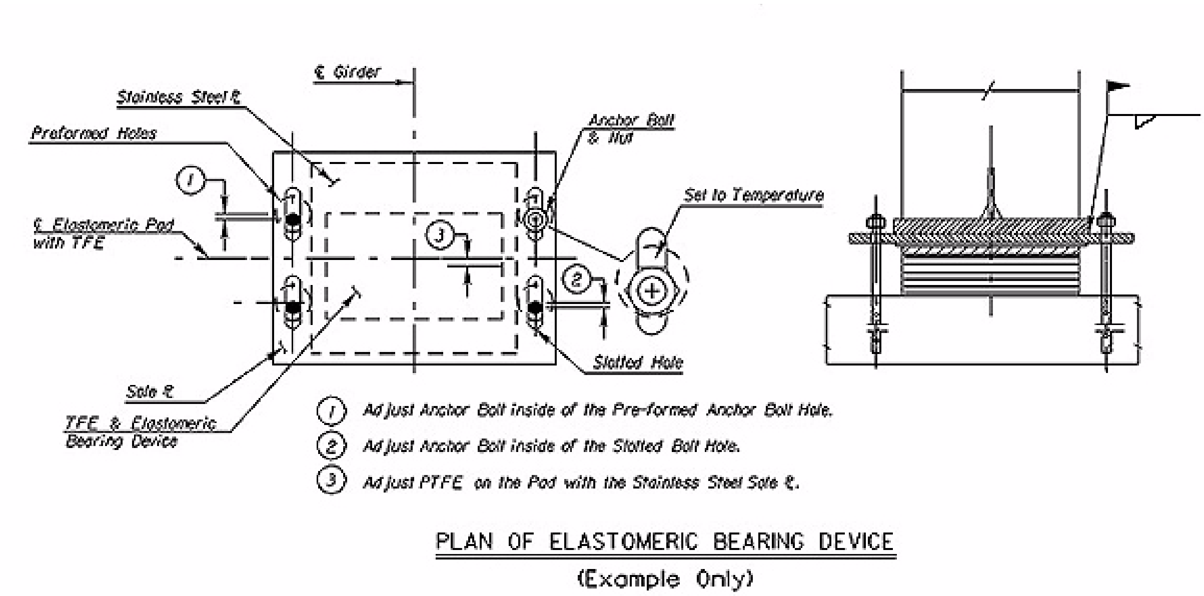

Figure 17

Figure 17: TFE and Elastomerics also have to be 'told' what temperature it is by setting the anchor bolt inside of the slotted hole according to the temperature so that the device moves correctly relative to the abutment or pier. If the bolt runs out of slot it will bind and fail.

Finished Surfaces: Before the pin is put in the cradle the Contractor will apply an approved dry film lubricant on all finished surfaces. This material can be found on the pre-qualification list from Bureau of Materials and Research and is basically graphite. The pre-qualification is PQL 18.2 under the heading "Coatings for use on machined surfaces of structural steel bearing devices".

Anchor Bolt: Anchor bolts are grouted to the supports using non-shrink grout from the KDOT approved prequalified list. The PQL number for non-shrink grout is 12.0 and is found under the heading "Non-Shrink Grouts for Grouting Anchor Bolts and Reinforcing Steel into Previously Poured Concrete." Anchor Bolts are set according to Section 842 of the 2007 Standard Specifications.

Field Welding: The sole plate on elastomeric devices is field welded to the bottom flange or girder by a Certified Welder. The weld and welder will be certified for position and type according to AWS 1.5D. Do not place welds over rust or paint; clean to bare metal first. If the bottom flange and sole plate are both weathering steel, clean to bare metal, weld, and remove slag. The weld consumables will be from approved materials per AWS 1.5D. If either the sole plate or the bottom flange is painted, it will have to be cleaned to bare metal, welded, primed and painted. This material is mixed in the field according to the manufacture's instructions.

The anchor bolts are usually set in grout after the bridge is erected and the devices are set to the correct temperature. The bolts are set into preformed anchor bolt holes before the concrete is placed for the support or they are drilled later. Drilling the holes later requires the same planning before the concrete placement as the preformed holes. Also, drilling the holes after concrete placement requires planning to miss the rebar, and the use of a pacometer to locate the reinforcing steel. Do not drill through rebar, check with the State Bridge Office about options.

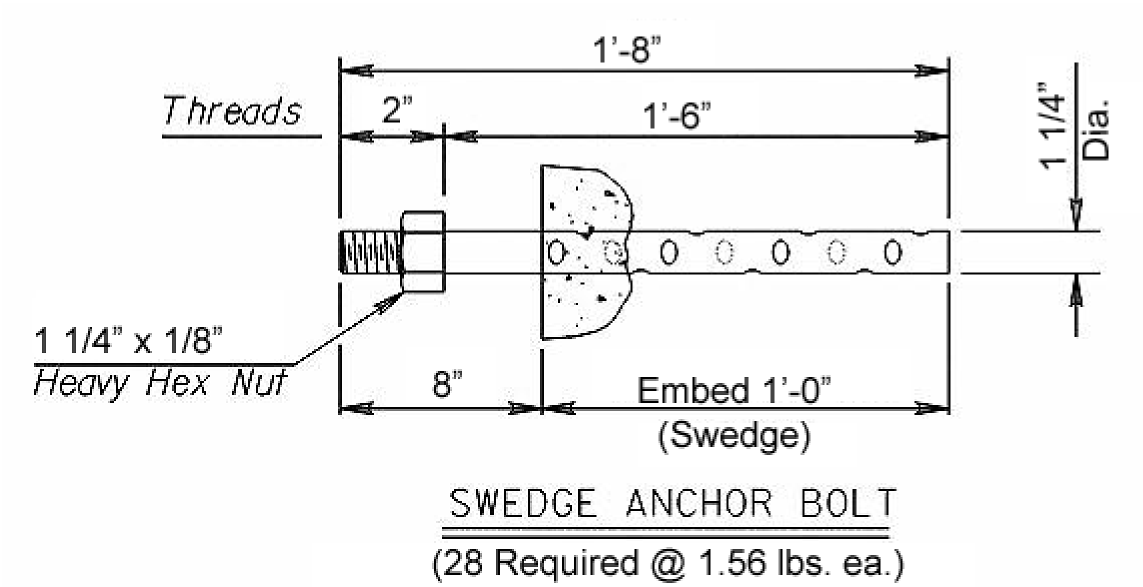

Figure 18: Typical Detail for Anchor Bolt (note: embed into support 12")

Figure 18 shows a typical detail for an anchor bolt. Notice that the embedment of the bolt is shown. This is usually dimensioned so that the device will have about 1" of a gap between the top of the device and the bottom of the nut. If this is not the case or the bolt is threaded so that the nut can be tightened down on the device, make sure this does not happen. In the case of having too many threads, a double nut, lock nut or a bur on the threads will stop the nut from being tightened down on the device. Do not leave anchor bolt holes open (ungrouted) if there is a possibility of freezing temperatures; the expansive forces of water will break the concrete around the hole.

Adjustments: If the bearing device can not be located exactly as shown on the plans due to a minor construction error, adjustments will be required. To adjust a mechanical device, the tabs on the sides of the masonry plate are field welded (Figure 19 and 20) enabling this to be a source for adjustment. For an elastomeric device, the sole plate is field welded to the bottom flange (Figure(s) 9, 17 and 21) and can be adjusted. These adjustments are limited to sum of the bottom flange thickness and the sole plate. Adjustments greater than this will require communication with the State Bridge Office.

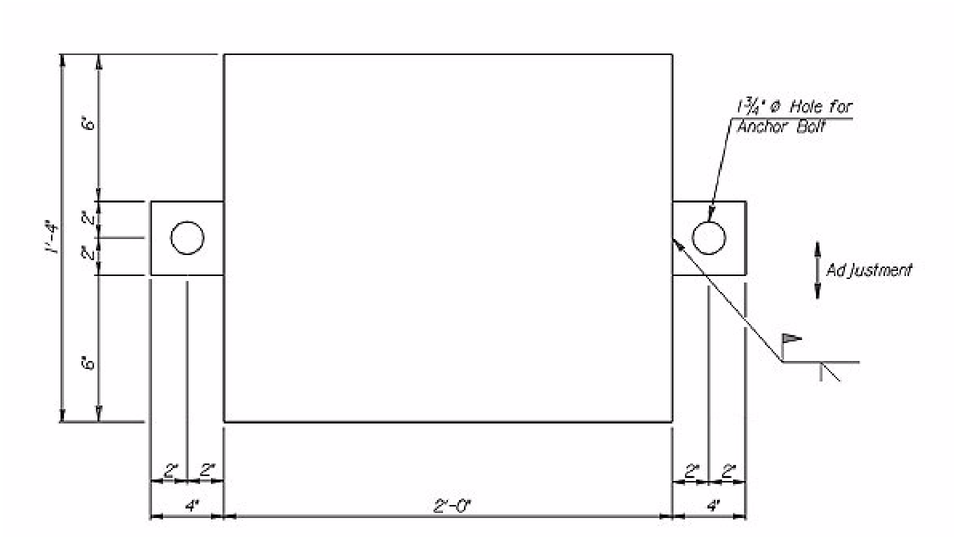

Figure 19 Masonary Plate with tabs for adjustment for mechanical devices

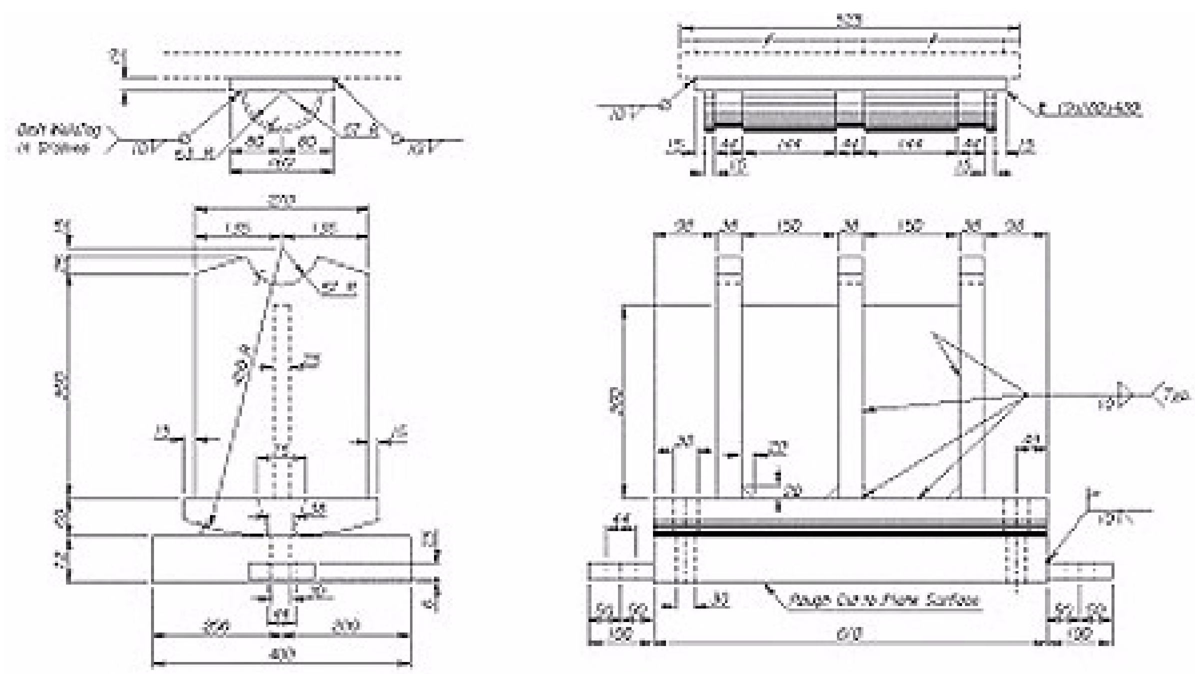

Figure 20 Typical Detail of Rocker (Note: field weld of tabs to the masonary plate)

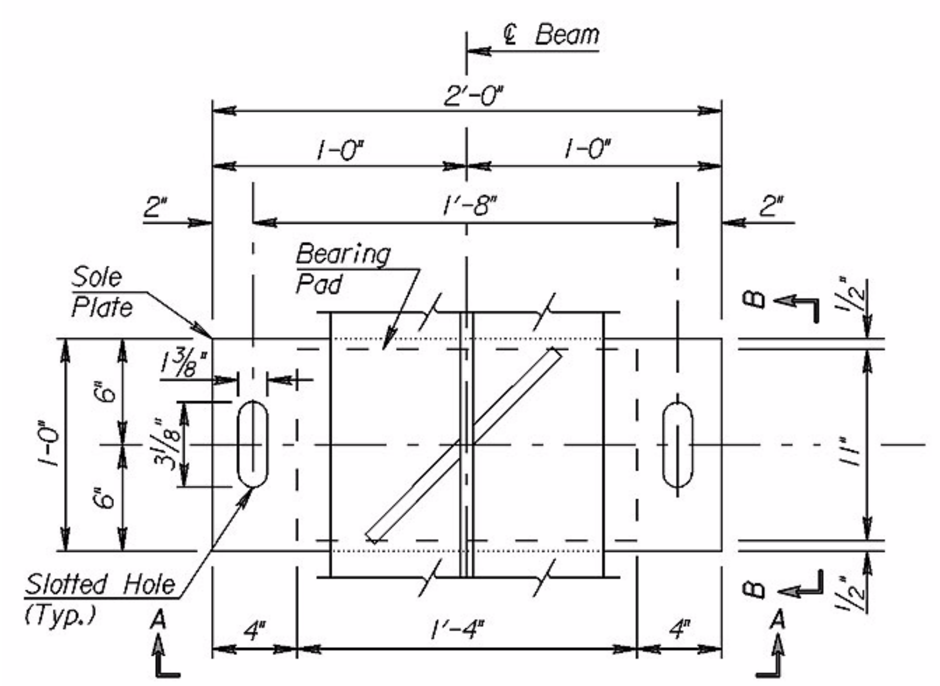

Figure 21 Masonry plate for elastomeric device

Jacking Beams or Girders: To set the devices according to temperature may involve jacking or sliding the bridge. The Contractor will take care that the proper procedures are followed. For most cases, a jacking plate on top of the jack will sufficiently spread out the load along the flange. In some cases (tall plate girders) jacking stiffeners are added (figure 22). If jacking is required, call the State Bridge Office to review the Contractors procedures.

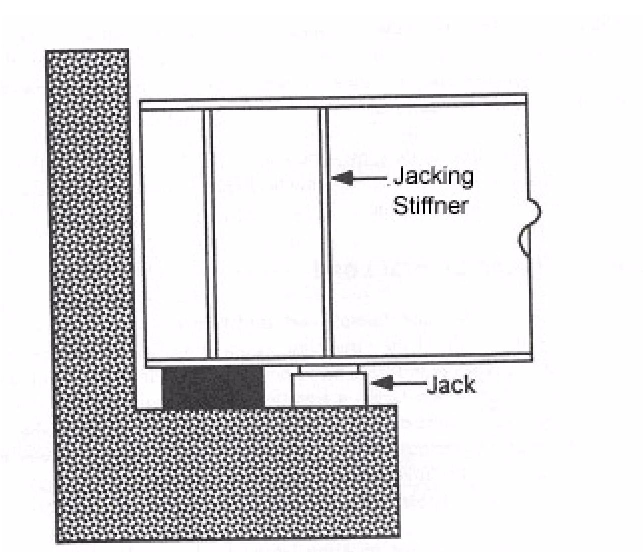

Figure 22 Jacking the Beams or Girders requires pre-approved procedures

As a general rule, great care is taken in jacking girders or beams because they are being lifted or supported at locations other than where they were designed. Usually, the Contractor will be required to move all of the beam or girder lines at the same time if the cross-frames or diaphragms have been installed.

Overview: Bearing devices will work as designed if they are installed correctly. A bearing device properly installed, will operate over the full temperature range without binding.