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Chapter 8 - Deck Expansion Joints

8.1 Purpose and Significance of the Expansion Joint

The purpose of an expansion joint on a bridge is to provide a gap for bridge movement with a smooth riding surface for motorists. The primary movement of the bridge is related to temperature changes; bridges will expand in warm weather and contract in cool weather. There are secondary movements associated with the material properties of the bridge components, such as creep and shrinkage. A bridge also moves under live load.

Bridge deck joints often refer to the system that spans the opening to provide a smooth riding surface over the gap, and protects the portion of the bridge directly below the opening; these types of joint systems are called closed joints. Open joints were often used in older bridges and they frequently allowed drainage to flow through the joint and down onto bridge components below. However, sometimes open joints relied upon drainage troughs below the joints to protect the bridge beneath from debris and water. Newer flexible materials used in the last 50 years have made open joints rare, and many have been retrofitted to include materials which allow for movement but prevent water and debris from flowing freely through the opening. Fixed joints which do not provide for movement should also provide a smooth riding surface and protect the portion of the bridge directly beneath it.

Faulty bridge deck joints contribute to the deterioration of every major bridge component (deck, superstructure, and substructure) by allowing corrosive deicing salts, water and debris through the gap. Deck ends, beam ends, abutment seats, pier caps and bearings can be at risk for serious deterioration through this exposure. The significance of keeping bridge joints in a good state of repair cannot be overemphasized.

The purpose and significance of expansion joints should be at the forefront of the maintenance of these bridge elements. Generally, none will be completely watertight, so vigilance in assessing, maintaining, and replacing deck joints is key to keeping bridges in a good state of repair.

8.2 Nomenclature of Expansion Joints

The nomenclature for the components of expansion joint systems varies among the many users and so a brief discussion describing the various terms is provided.

- Joint/Gap—the distance between the deck or superstructure ends which allows for joint movement. It is important to note that this distance changes with temperature.
- Backer Rod—a foam-like material commonly used to span the gap and prevent liquid sealers from falling through the space. Typically shaped as a long cylinder it is compressed into the joint. Used in pourable joints and asphaltic plug joints.
- Bridging/Gap plate—a plate covering the gap beneath an asphaltic plug. It is used to keep the plug seal from moving into the joint.
- Asphaltic Plug/Plug—a flexible material that forms the road surface atop the joint and seals the joint. The material is a specially formulated asphaltic binder mixed with

aggregate to withstand cracking at low temperatures and tracking/softening under wheel loads at high temperatures. Typically used with Asphalt Overlays.

- Header/Nosing—the material bonded to the deck/approach slab which resists the wheel loads prior to the gap, and provides a vertical surface for the attachment of the expansion joint system. Sometimes made of hydraulic cement concrete and sometimes made of elastomeric concrete.
- Pourable Seal/Silicone Seal—a flowable material placed directly in the gap upon a backer rod which adheres to the vertical faces of the header material to seal the expansion joint. More recently used with elastomeric headers. The Silicone Seal is the most commonly used pourable seal today.
- Compression seal—a preformed joint seal squeezed and inserted into the gap using lubricants which also serve as adhesives that bond the seal to the header material. There are open cell compression seals which are typically preformed neoprene semi-hollow rectangular shapes and closed cell compression seals with solid rectangular shapes with a foam-like appearance. The joint systems must remain in compression to be water tight.
- Inflatable Seal—a preformed neoprene open cell seal which is inserted into the gap and air pressurized. The seal profile and epoxy adhesive provide a tight bond to the header (typically elastomeric concrete) during the inflation process. This is a sole source seal.
- Extrusions/Armor Plate/Metal Runner—a steel material anchored to a header/nosing joint face to which the expansion joint seal is attached.
- Anchorage—steel studs welded to armor plates to anchor the plate in the header.
- Strip/Gland/Membrane Seal—a preformed neoprene V-shaped seal that is rigidly attached to an armor plate with a rail profile. The seal will be water tight in tension or compression.
- Cushion/Plank Seal—a steel reinforced neoprene pad recessed into the deck over the gap rigidly attached on both sides of the seal. The attachment consists of rods anchored in the deck and threaded on top with nuts holding the pad down.
- Modular/Modular Dam—an expansion joint system consisting of a series of rail profiles (called separator beams) which are rigidly connected to a series of neoprene shapes and are supported longitudinally by support bars.
- Separator Beams—beams that support seals in a series in a modular joint. The edge beam is the first in the series and attaches to the deck end usually an armor plate with a rail profile holding one side of a strip/block seal. The center beams are the beams in the series that do not attach to the deck. They are steel extrusions with a rail profile on two sides which provide attachment to strip/block seals.
- Support Bar—supports the separator beams of a modular expansion joint in the longitudinal direction.
- Finger/Tooth/Cantilever Joint—an open joint with interlocking steel fingers/teeth.

8.3 Common Types of Expansion Joints

8.3.1 Compression Seal

A compression seal is a commonly used joint system that relies on compression to maintain water-tightness. As described in Section 8.2, the seal is inserted into the joint using lubricants which may also serve as adhesives. There are two types of compression seals; open cell and closed cell foam.

Figure 8.1 illustrates an open cell seal. The open cell is made of a neoprene elastomeric material with internal webbing, which allows it to compress yet gives it a stable interface with the deck end. The deck end may be armored or may contain a header to which the seal is attached. Typically a stop bar or block out is provided directly beneath the seal to keep it in place. Movements up to 2-1/2 inches or more can be accommodated with this type of open cell seal. Because compression seals work in compression, sizing the seals becomes particularly important when constructing or replacing these seals in warmer temperatures. The seals must be large enough for the joint opening required for the coldest temperatures. Guidance regarding the placement of these seals is provided in Section 8.6.2.1.

Closed cell foam compression seals are another type of compression seal that agencies use. The seal is typically a preformed low density ethylene vinyl acetate polyethylene (foam) material that is bonded into place with a two component epoxy adhesive. The deck ends may be armored or may contain a header to which the seal is attached. Because of the epoxy bonding, closed cell foam seals do not rely solely on compression to prevent water and materials from flowing through the joint. These foam seal typically have a working range of movement of about 60 percent compression and 30 percent tension. Movements of up to 4 inches can be accommodated by some closed cell foam seals. Sizing the seals becomes particularly important when constructing or replacing these seals in warmer temperatures. The seals must be sized and installed properly for the joint opening required at both the warmest and coldest temperatures. Other important considerations when placing both types of compression seals include ensuring a uniform joint width and ensuring that the joint seal faces are vertical with no spalls. It is also important that the seals are set at the proper distance below the deck.

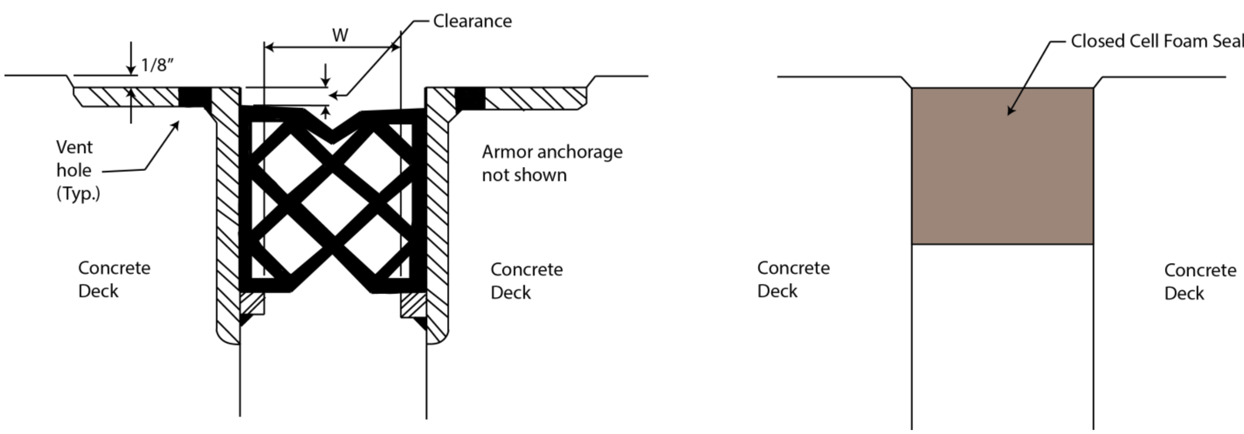

Figure 8.1 Compression Seals. Open Type (left). Closed Cell Foam Type (right).

8.3.2 Pourable Joint Seals

Pourable joint seals have been used for many years for small movement joints. Figure 8.2 shows a schematic detail of an older version of this joint type (generally used for small movements up to 1 inch). A pre-molded backing material is placed below the sealant to keep the sealing compound from falling through the joint. Early sealers were heated asphalt or coal tar products; these sealers tended to split, debond, and become damaged by non-compressible debris lodged into the joint. They were also damaged as a result of deck edge damage.

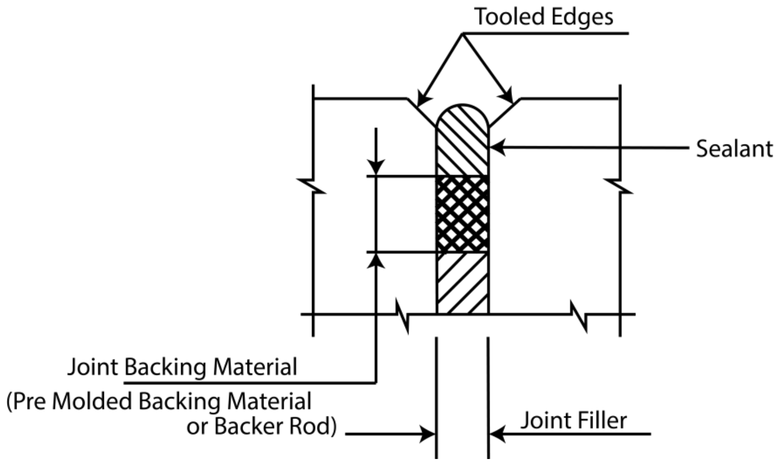

Figure 8.2 Poured Joint Seal

Newer pourable seal joints are shown schematically in Figure 8.3 (they can be used for movements up to 3 inches). The sealer is made of a self-leveling, rapidly curing silicone material. The headers are typically elastomeric concrete, which reinforces the deck ends and is more durable material. The poured shape is advantageous if the joint walls are not perfectly parallel or vertical, particularly when bonded to the elastomeric header. This type of joint is also relatively easy to repair, to remove a section, to clean the vertical walls, and to pour a new section into place with little traffic interruption or work zone hazards.

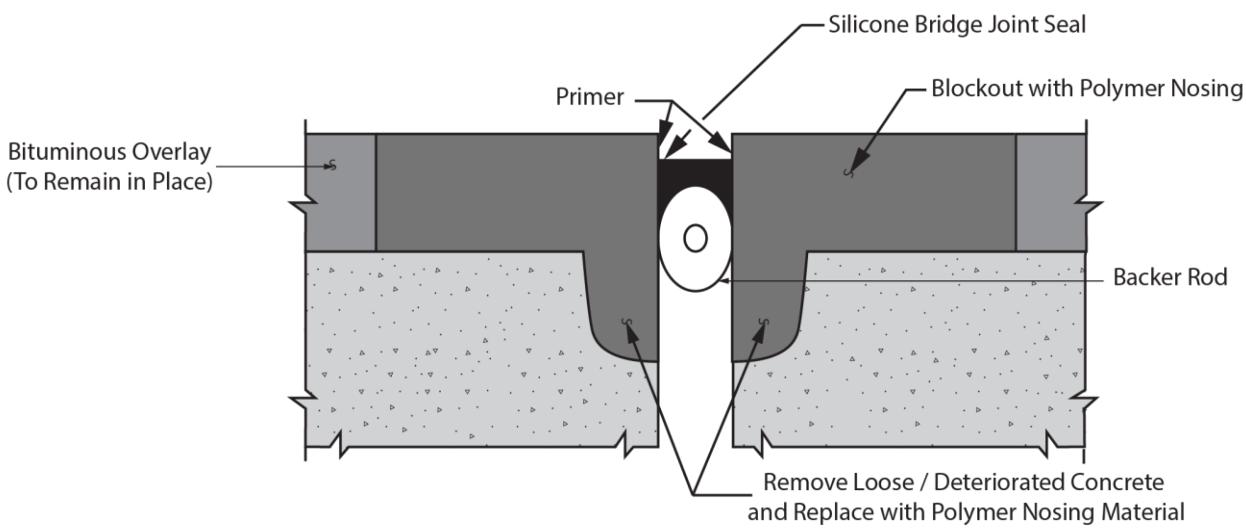

Figure 8.3 Newer Pourable Joint Seal

It is important that the silicone does not bond to the backer rod and that the sealer is thinner in the middle than at the deck end. This is because as the joint opens, the seal is forced to stretch within its thinnest cross-section at its middle to accommodate the movement rather than stretching at its ends and possibly breaking its bond with the deck or header resulting in future joint leakage. The sealant material should be applied along the existing concrete joint faces or applied to a clean and sound header and placed slightly below the riding surface (1/2 inch). If the silicone sealer is applied along the existing concrete joint faces, the existing concrete should be cleaned using abrasive blast cleaning. The silicone should be placed at the mid-portion of the temperature range it is likely to experience (or mid-portion of the expected joint opening range) but above 40 °F.

8.3.3 Asphaltic Plug Seal

An asphaltic plug seal is a flexible material that forms the road surface atop the joint. It is used for small movement joints (up to 1.5 inches). The material is a specially formulated asphaltic binder mixed with aggregate to withstand cracking at low temperatures and tracking/softening under wheel loads at high temperatures. It is typically used with asphalt overlays. Figure 8.4 provides a schematic of this seal type, and a detail is provided in Figure 8.5. The sealer shown in Figure 8.5 is typically a silicone or polymer bridge joint sealer. A series of locating pins that keep the bridging plate in position during placement of the asphaltic plug material is also shown.

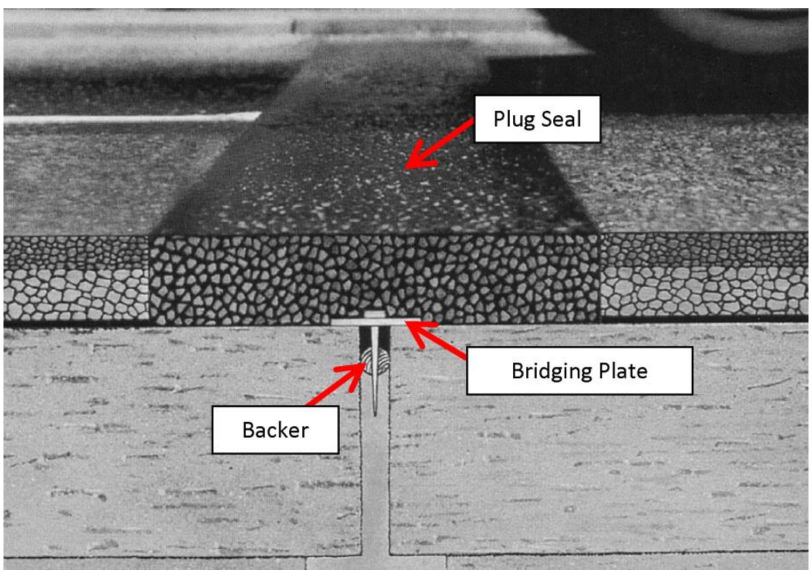

Figure 8.4 Asphaltic Plug Seal

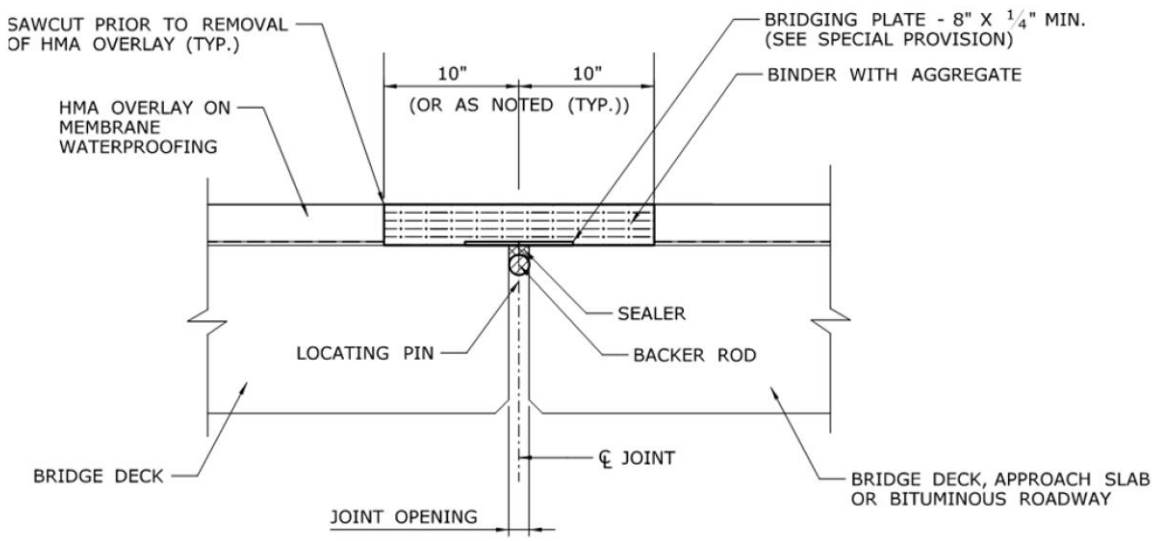

Figure 8.5 Detail for Asphaltic Plug Joint

The asphaltic plug seal offers many advantages including ease of installation, low cost of installation and repair, and a smooth riding surface with a low-frequency of snow plow damage.

The disadvantages lie in the fact that the system doesn't work in vertical applications, so alternate seals need to be provided at curbs and parapets. Additionally, problems noted on some installations include softening in hot weather and cracking in cold weather, which may cause debonding at the seal/pavement interface. This joint is not recommended in high volumes of stopping traffic or in skews over 45 degrees. One manufacturer suggests using this joint on secondary roads.

Some agencies are conducting tests for the use of elastomeric concrete in plug joint systems. This type of joint system would be similar to the asphalt plug joint except the specially formulated asphaltic binder mixed with aggregate would be replaced with elastomeric concrete.

8.3.4 Strip Seal

The strip seal expansion joint system is characterized by a preformed v-shaped neoprene seal which is rigidly attached to an armor plate with a rail profile. The armor plates are anchored to the deck. The seal will be water tight in tension or compression. A schematic detail is shown in Figure 8.6. This joint type can accommodate up to 4 inches of movement.

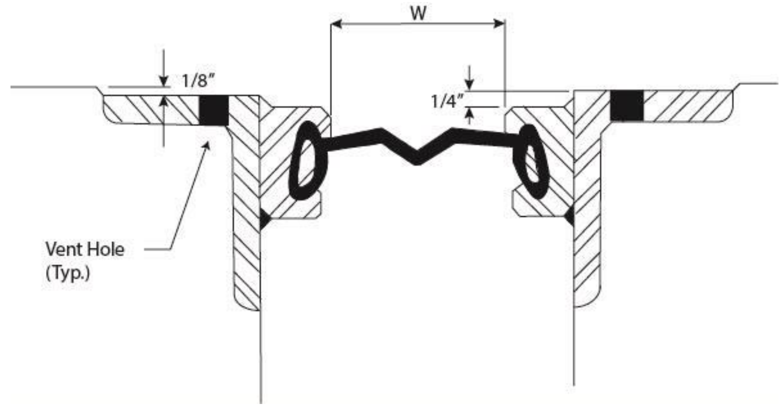

Figure 8.6 Strip Seal

While the strip seal is more durable than other seals, debris accumulation creates problems for this type of joint since its exposed surface area can be larger than other seal types. Non-compressible material accumulates in the joint crevices as the joint expands. Rupture of the seal then occurs as it closes in warmer temperatures. Traffic impact over debris filled joints can also wear down the membrane. This can result in the loss of water-tightness which may not be easy to see when looking at the seal. There are also problems along vertical and horizontal changes in cross-section such as along curb lines. Replacing the seal can also be difficult. Skews can also be problematic particularly when the skew angles are similar to plow blades. Dislodged and damaged armor plates can create traffic safety problems as well.

When installing strip seals in existing concrete decks, it is often required to field adjust the anchorage to avoid conflicts with deck reinforcement. An example of problems that can develop when installing a strip seal is shown in the sequence of Figure 8.7 through Figure 8.9. Figure 8.7 shows conflicts between shear studs and K bars in diaphragms. In Figure 8.8, the contractor initially bent shear studs to avoid conflicts with existing steel. Angles with bent shear studs were rejected. With congested steel, finesse is needed to put angles into place and not force them down. To help secure the rail in place until the concrete hardens, an angle support as shown in Figure 8.9 can be used. Also shown in Figure 8.9 is a vertical installation of the armor plate near the curb. This type design detail capability can allow the vertical installation of the strip seal so the joint can be completely closed at the curb, fascia or at a barrier wall.

Figure 8.7 Conflicts with Bottom Shear Studs and K bars in Diaphragms

Figure 8.8 Bent Shear Studs

Figure 8.9 Angle Support Bolted to Metalized Angles for Support Until Concrete Hardens

8.3.5 Modular Expansion Joint

Modular Joints are needed to accommodate large joint movements openings, e.g., those over 4 inches and as large as 24 inches. The modular expansion joint system is made up of 3 major components including:

1. Seals
2. Separator beams (edge and center beams)
3. Support bars

A typical schematic is shown in Figure 8.10. The seals and beams form the roadway riding surface. The edge and center beams are steel shapes often referred to as rail profiles to which the seals are attached. The separator beams are supported on support bars which are spaced at frequent intervals. Modular joints can handle movement in the longitudinal, transverse, and vertical direction, as well as vertical rotations. Bearings and springs are also used to accommodate movement. A photograph of a modular expansion joint installation is shown in Figure 8.11.

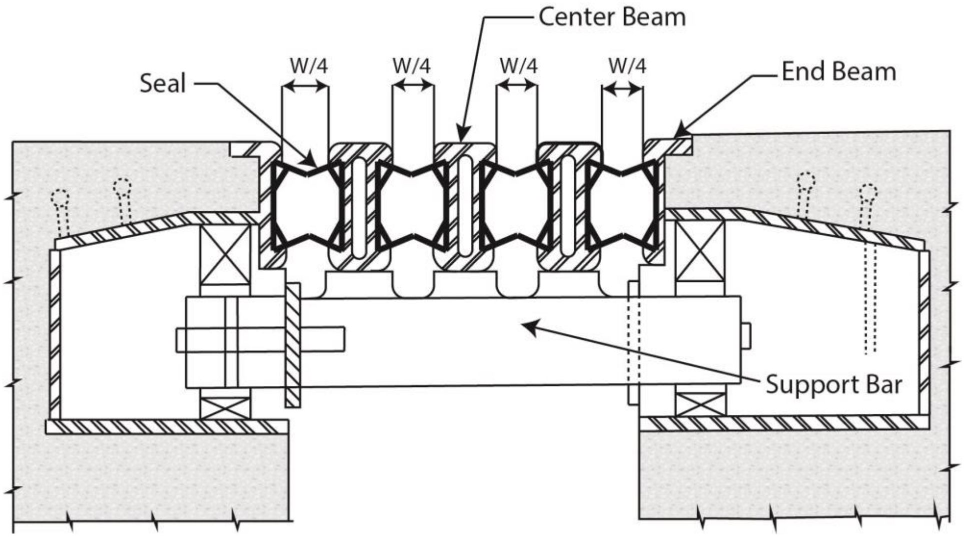

Figure 8.10 Modular Expansion Joint

Figure 8.11 Installation of Modular Expansion Joint

It is obvious that there are many parts to this joint system, and as such it cannot be considered maintenance friendly. These joints are subjected to millions of high dynamic stress cycles due to passing vehicle loads, so the framing system must be designed for large fatigue stresses. The seals must also be very durable. When welds crack, equalizing springs are damaged, and seals pull-out or rupture; these pieces are difficult to repair. The initial install is also difficult, including setting to the proper line and grade and joint opening; ensuring the proper block out reinforcement and concrete consolidation; and proving field splices when necessary for stage construction; these installation difficulties add to the concern of future maintenance. Although these joint types are fraught with inherent complexities, engineering improvements are continuing to be made, particularly in the realm of fatigue resistant detailing. There are not many joint types available for long continuous bridges which can handle the anticipated movement. As such, we can expect there will be more modular expansion joints as we build new bridges with fewer traditional expansion joints.

8.3.6 Finger Expansion Joints

Finger joints are typically classified as open joints. Most agencies resist using open joints, but finger joints offer the ability to handle large movements (greater than 4 inches) and are often an alternative to modular joints. A schematic of a finger joint is shown in Figure 8.12, and a photograph is shown in Figure 8.13. Because this is an open joint, some agencies install a drainage trough to capture water and debris which protects the bridge elements below the joint. The slope of the trough system should be steep enough to ensure adequate drainage. Easy accessibility is also required. Alternatively, closed drainage systems can be installed if the joint is placed behind the backwall (this concept will be discussed in Section 8.7.1). The maintenance of the drainage trough is critical and is considered a disadvantage of this joint type.

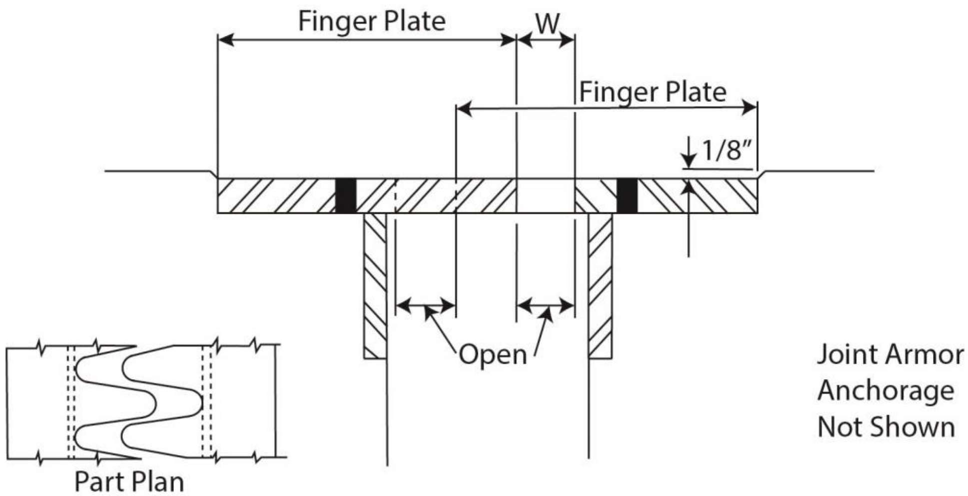

Figure 8.12 Cross-Section of a Finger Joint

Figure 8.13 Photo of a Finger Joint

Other maintenance problems associated with finger joints include: misalignment (vertical and horizontal direction), broken finger plates, broken securing bolts, and concrete anchors. Although an open joint, debris can still become lodged in the gap, thus preventing the longitudinal movement. This scenario imposes undesired forces on the bridge and may cause damage to the teeth. Finger joints require relatively flat grades for proper installation.

Despite the potential issues of finger joints, this joint is easier to maintain than its large movement counterpart (the modular joint) with fewer moving pieces.

8.4 Expansion Joint Defects

Typical joint disadvantages have been described in the previous section for common joint types. In this section, the methodology for evaluation of common defects and understanding their significance and severity is described.

Although many of the joint defects are described here in visible and measurable ways according to the function of their components, it is important to remember that an expansion joint's performance is compromised when it is failing to do what it is meant to do: withstand traffic loads and allow bridge movement, provide a smooth riding surface and safe surface for pedestrians and bicyclists (where they are allowed), provide some skid resistance, minimize noise and vibration (which are defect indicators), and prevent water from infiltrating and damaging other bridge components.

8.4.1 Leakage

Joint leakage is the clearest indicator that the joint system is not functioning properly. Joint leakage is best determined from the joint underside. It may be difficult to determine joint leakage if the weather has been dry for a period before the inspection. Deterioration of the components beneath the bridge is the best indicator that there is water leakage. What to look for:

What To Look For

- Water staining, ponding water on the abutment shelf, pier cap or abutment backwall—minor deterioration
- Water leakage is obvious and there is damage to protective systems—moderate deterioration
- Water is passing through the joint freely and there is damage to bearings (Figure 8.14), abutment shelf/pier cap, abutment backwall or girder ends (Figure 8.15) and end diaphragms (Figure 8.16)—major deterioration

Figure 8.14 Damage to Bearings – Major Deterioration

Figure 8.15 Damage to Steel Beam Ends – Major Deterioration

Figure 8.16 Damage to Concrete End Diaphragms – Major Deterioration

8.4.2 Condition of Road Surface Adjacent to Joint

The condition of the road surface adjacent to the joint can deteriorate to the point that the joint system will also fail. What to look for:

What To Look For

- Transverse cracking along the roadway that is narrow and shallow, riding surface is good—minor deterioration
- Transverse cracks are deeper (not yet the full depth of the pavement structure) and pot holes are occurring or likely to occur, headers are exposed—moderate deterioration
- Longitudinal and transverse cracking along the roadway that is narrow and shallow, riding surface is good—minor deterioration
- Longitudinal and transverse cracks that are deeper (not yet the full depth of the pavement structure) and pot holes are occurring or likely to occur, headers are exposed—moderate deterioration
- Partial/full depth deterioration of the roadway surface, pot holes exist adjacent to the joint, the headers and/or armor plates are exposed—major deterioration

8.4.3 Condition of Seal

The condition of the seal is a primary indicator of the degree of leakage to expect. What to look for:

What To Look For

- The seal has some cracks, minor tears and some breaches and only a small amount of debris is evident—minor deterioration.
- The seal is missing or substantially breached at some point, with a significant amount of debris—moderate deterioration.
- The seal is missing, significantly pulled out and filled with debris—major deterioration.

8.4.4 Asphaltic Plug Joint Defects

8.4.4.1 Wearing Surface to Plug Interface

Like other joint systems, the wearing surface to the asphaltic plug interface should be well bonded to prevent water infiltration. What to look for:

What To Look For

- The plug/wearing surface has debonded with narrow transverse cracks which are relatively shallow (less than an inch)—minor deterioration.
- The plug/wearing surface shows wider transverse cracks which are also deeper (although not the full depth of the wearing surface) and the adjacent wearing surface is showing some signs of distress—moderate deterioration.
- The plug/wearing surface is debonded the full depth of the interface and both the plug and the wearing surface are breaking up from the lack of support, leakage is evident—major deterioration.

8.4.4.2 Plug Seal

The condition of the plug seal is a primary indicator of its effectiveness. The seal can break up and lose material in cold weather or shove/ track in hot weather; both will compromise water tightness. What to look for:

What To Look For

Plug Material Loss

- Small, shallow (less than 1 inch) potholes in the plug—minor deterioration.
- Larger, deeper (2 inches) potholes exist in the plug, and there is noise as the driver traverses the joint—moderate deterioration.
- Potholes to the full /partial depth of the joint, plug material is breaking up —major deterioration.

Plug Material Shoving/Tracking

- Small depressions and limited material tracks outside the joint, purely aesthetic and doesn't appear to affect the water-tightness of the joint—minor deterioration.
- Depressions and tracked material are evident, small mounds of binder can be seen along the curb line, and rideablity has been affected—moderate deterioration.
- The plug material has been displaced to the point that the plug is no longer effective—major deterioration.

8.4.5 Condition of Header Material

The condition of the header can deteriorate to the point that the joint will become ineffective. What to look for:

What To Look For

- Cracking in the header is minor and is not affecting the joint effectiveness—minor deterioration
- Cracks in the header are fairly extensive and are compromising the header interface with the road surface and the interface with the joint—moderate deterioration
- Header material is breaking up to the extent that other elements of the joint are compromised and leakage is the result—major deterioration

8.4.6 Condition of the Armor Plates and Steel Rails

The condition of the armor plates and rail elements may deteriorate to the point that the joint will not function properly. Failure of these components can become a serious traffic hazard.

What To Look For

- Slight deformities in the rails exist but there is no vertical deflection—minor deterioration
- Crack or tear < 20% of the rail width; or deformation with no vertical deflection—moderate deterioration
- Crack or tear > 50% of the rail width; or a deformation creating vertical deflection—major deterioration
- Loose or missing hardware anchoring armor plates/angle to slab
- Loose or vibrating components under traffic

Recognizing defects in joint systems can be particularly important in applying Preventive Maintenance. Bridge Joints that are in perfect condition and those that are failed are the easiest to distinguish. It is important to recognize joints with minor to moderate deterioration to apply Preventive Maintenance or repairs before the leakage is completely unrestrained.

8.5 Preventive and Basic Maintenance of Deck Expansion Joints

In this section, Preventive Maintenance refers to the on-going scheduled activities aimed at extending/maintaining the service life of bridge deck expansion joints. Scheduled maintenance activities become important to keeping the expansion joints performing properly. Most small movement joints do not have long service lives (average 5 years) and they are typically only inspected every two years. The amount of detail regarding expansion joint defects will vary from inspection to inspection and within various agencies. This makes annual maintenance activity a necessity. If maintenance is proactive and done at an appropriate frequency and time of year much can be gained.

8.5.1 Washing to Remove Debris

8.5.1.1 Bearing Seats

Although not a part of the expansion joint, the bearing seats should be cleaned and all debris removed and disposed. Debris should be manually removed by brushing, chipping and scraping. Then the bearing seat should be flushed with pressurized water to remove chemicals, deicing salts and debris that cannot be removed manually. This is a step that allows the bridge maintainer to see if damage is occurring as the result of leaking joints and prevent further damage. The bearing seat drainage should be checked and cleaned as well.

It is important when flushing is performed in the vicinity of water bodies to limit the debris entering the water body. Use sedimentation control devices to limit stream bank erosion.

Cleaning of the bearing seats should be performed annually after the snow season.

8.5.1.2 Cover Plates at Parapets and Curbs

Cover plates should be removed and the joint should be cleaned and debris removed. There may also be vegetation in this area which should also be removed.

8.5.1.3 Compression Seals, Strip Seals, and Silicone Seals

These seals should be high-pressure jet washed to remove all debris annually (higher frequencies should be considered for high volume roads). This should be done in the early spring after the snow season.

8.5.1.4 Modular Joints

The seal should be cleaned as described above. The systems below the seal should also be cleaned annually; this service may need to be supplied by the manufacturer.

8.5.1.5 Finger Joints

These joints should be high pressure jet washed including all components above and below the road surface to remove debris. Because debris not only affects the condition of the joint and the bridge components directly beneath, but can restrict movement of the bridge imposing undesired forces on the bridge, it is recommended that the washing be semi-annual in the fall and early spring. An example of a finger joint trough assembly is shown in Figure 8.17.

Figure 8.17 Finger Joint Trough Assembly

8.5.2 Cleaning out Drainage Systems

All troughs should be cleaned and flushed, in addition to pressure washing other cleaning tools such as rods and shovels should be used to ensure that all debris is removed including any deposits outside the trough. The troughs should be examined for soundness and be replaced if torn or punctured. Troughs should hang freely. The slope should be self-draining; a 5 percent grade is recommended. The cleaning of the troughs should be performed annually in the spring after the snow season.

8.5.3 Replacing Seals

In this section the replacing of seals relates to small movement joints where there is no seal or a pourable joint seal is missing or ineffective. A suggested procedure for replacing hot or cold poured seals is shown below.

Suggested Procedure

Pourable Seal Installation

1. Remove old sealants and debris from joint.
2. Sandblast the joint surfaces to remove any remaining joint sealant residue and roughen the surfaces to provide a surface to which the sealant will bond.
3. Inspect the joint surfaces to assure complete removal of prior joint material and that the surfaces are sound and undamaged.
4. Apply primer to the joint surfaces in accordance with the sealer manufacturer's recommendations.
5. Install backer rod.
6. Pour sealant over the backer rod between the joint surfaces to the elevations required.
7. Allow sealant to cure in accordance with the manufacturer's recommendations prior to opening to traffic.

Replacing entire seals and joint systems will be elaborated upon in Section 8.6.

8.5.3.1 Hot Poured Sealant

Applying hot poured sealants should be performed at temperatures between 45 °F to 80 °F with no significant precipitation anticipated for a 24 hour period. Remove the remnants of the old seal and any debris to at least three times the width of the joint. Repair the joint as necessary. Ensure that the joint edge surfaces are dry. Install a backer rod to an inch below the roadway surface. Clean out the area with an air compressor and apply the sealant.

8.5.3.2 Cold Poured Sealant

Applying a cold poured silicone sealant should be performed at temperatures between 55 °F to 80 °F. There should be no anticipated precipitation for 36 hours. This repair should only be performed on joints with adjacent deck surfaces that are clean and sound. Old sealants and debris should be removed to 3 times the width of the joint. The joint surfaces should be sand-blasted and inspected to assure that no residue remains. Joint surfaces should be primed per manufactures recommendation. Install the backer rod. Install the silicone sealant in accordance with Figure 8.18. This Figure shows both correct and incorrect silicone sealer installation. It is noted the silicone sealer should be concave (filler convex upward) so that its cross section is the thinnest at its center. The purpose is to facilitate stretching of the sealer within a thin cross section at its center to thereby avoid creating stretching and/or larger forces at the sealer ends that could debond the sealer from the joint wall. Examples of before and after photographs of a silicone sealant installation are presented in Figure 8.19.

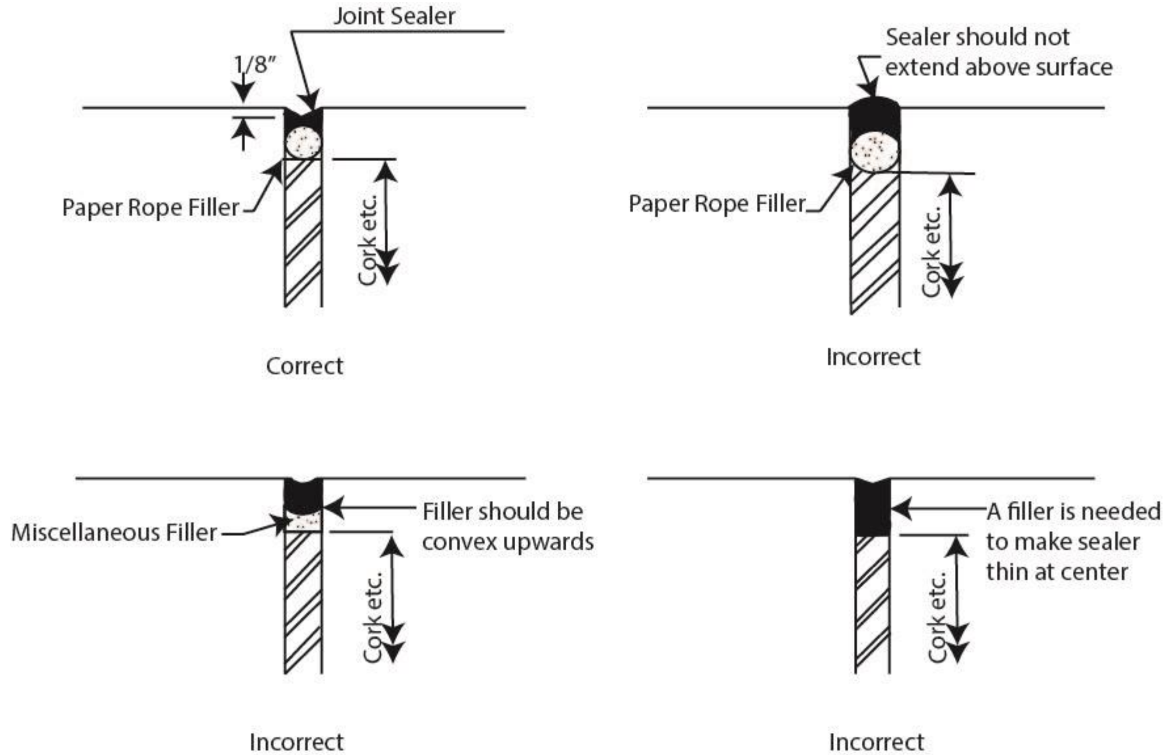

Figure 8.18 Silicone Sealant Installation

Figure 8.19 Before (left) and After (right) Photos of Silicone Sealant Installation

8.5.4 Sealing Headers

Concrete sealants are very effective in reducing concrete deterioration. Sealants must be applied properly to be effective. Concrete sealants are discussed in detail in Chapter 7. Consideration should be given to sealing concrete headers.

8.6 Repair and Rehabilitation of Deck Expansion Joints

A bridge maintenance crew will often be called upon to repair and rehabilitate bridge deck joints. This will go beyond simply replacing the seals of otherwise intact joints systems.

8.6.1 Replacing Joints with Damaged Headers

8.6.1.1 Replacing Armored Joint with New Concrete Headers

A suggested procedure for replacing armored joint with new concrete headers is shown below.

Suggested Procedure

Replacing Armored Joint with New Concrete Headers

1. Remove the armor plates, anchors, and deteriorated concrete.
2. The extent of the concrete to be removed should be marked out and saw cut approximately 1 inch deep. The concrete should be removed by hand tools and small pneumatic hammers (30 pounds above the reinforcing steel, and 15 pounds below the reinforcing steel).
3. Set and secure the joint edge form.
4. Clean the area by abrasive blast cleaning.
5. Place required new reinforcing steel and remove/replace/lap existing corroded rebar.
6. Take care to ensure that the concrete surface of the header matches the deck grade. Setting the joint too high or too low will create undesirable vehicle loads.

8.6.1.2 Replacing Headers with Polymer Concrete (Elastomeric Concrete)

A suggested procedure for replacing headers with polymer concrete (elastomeric concrete) is shown below.

Suggested Procedure

Replacing Headers with Polymer Concrete (Elastomeric Concrete)

1. Remove the armor plates and anchors (if they are present) and also deteriorated concrete.
2. The extent of the concrete to be removed should be marked out and saw cut approximately 1 inch deep. The concrete should be removed by hand tools and small pneumatic hammers (30 pounds above the reinforcing steel and 15 pounds below the reinforcing steel).
3. On occasion the surface will be an asphalt overlay; this surface shall be saw cut as well, and the asphalt removed.
4. Ensure the block out is cleaned of old joint seals, concrete debris, asphalt overlay, water proofing membrane, dirt, grease, and any other deleterious material.
5. Form the joint edge to achieve the proper opening. This is based upon the seal type, the span length, and the temperature.
6. The substrate to which the elastomeric concrete is to be placed against should be coated with a primer.
7. Place polymer concrete header in accordance with manufacturer recommendations. The header must be flush with the roadway surface and should be cured in accordance with manufacturer recommendations.
8. A number of seals can be used with this header type including compression seals, silicone seals, and strip seals.

8.6.2 Replacing Seals

8.6.2.1 Compression Seals

Compression seals offer the advantage of not requiring armoring or anchoring to their headers. The difficulty in replacing a compression seal lies in sizing the seal to be in compression when at its most contracted state.

Existing seals and other debris should be removed from the joint opening. The joint edges should be sand blasted and cleaned. Elastomeric or concrete headers are both suitable. The seal should be coated with an adhesive which will serve as a lubricant until the material becomes tacky. The seal size should be determined prior to placing the seal. It is best to install these seals in cooler temperatures. An easy to use Joint Calculator was developed by the New York State Department of Transportation for closed cell seals; it calculates the total joint movement expected based upon AASHTO guidelines for the temperature ranges for a given region. It then calculates the joint opening at three temperatures (high, low and 68 °F). The width and depth of a closed cell foam material can then by calculated using inputs that can be measured or known on the day of installation (temperature of the primary member, length of primary member contributing to the total movement, joint opening at the time, skew angle of the bridge, and the maximum compression limit percentage of the joint material). This type of spreadsheet can be used by any locality for closed cell compression seals. Figure 8.20 shows the inputs and outputs of the Expansion Joint Calculator.

The Expansion Joint Calculator spreadsheet has simple formulas to calculate the joint movements at various temperatures. All the green boxes are inputs that are known; either about the bridge or the seal characteristics provided by the manufacturer. The tan boxes contain the formulas relevant to calculating movements based upon the length of the span and the coefficient of thermal expansion and the degree of joint compression based upon the thermal expansion. This can be easily replicated for other localities.

NYSDOT Expansion Joint Calculator

Make selections for the following categories:

	NYSDOT Region	R7	
	Primary Member Type	Steel	

Input values for the following categories:

	Exist Temperature of Primary Member	55	°F
*	Length of Member(s) contributing to total movement @ joint	124	Feet
*	Exist Joint Opening (perpendicular to header) ⊥	2	inches
*	Skew Angle (0° ≤ θ < 90°)	18	Degree Skew
	Max. Compression limit % of joint material (from Manufacturer)	60	%

Results: (Perpendicular to header)

Joint Opening at 68°F (⊥)	1.88	inches
Joint Opening at Coldest °F (⊥)	2.69	inches
Joint Opening at Warmest °F (⊥)	1.54	inches
Total movement of Joint within full Temp range (⊥)	1.15	inches
Width of New Closed Cell Foam (use Coldest Temp width (⊥))	**2.69**	inches
Depth of New Closed Cell Foam (if Manuf. info. not available)	**2.50**	inches
Acceptablility based on Manufacturer's Compression limit	**OK**	
Compression @ Warmest Temp	42.75	%
Compression @ Exist Temp	25.65	%

Results: (Parallel to primary member)

Joint Opening at 68°F (//)	1.98	inches
Joint Opening at Coldest °F (//)	2.83	inches
Joint Opening at Warmest °F (//)	1.62	inches
Total movement of Joint within full Temp range (//)	1.21	inches

Procedure B Temperature Ranges - AASHTO

Coldest Temp for Primary Member used in your Region	-20	°F
Warmest Temp for Primary Member used in your Region	+105	°F

* See Diagram for clarification

Expansion & Contraction relate to Primary Member
Tension & Compression relate to Joint Material

Figure 8.20 NYSDOT Expansion Joint Calculator

Figure 8.21 and Figure 8.22 are used to help field personnel determine the inputs to the expansion joint calculator in Figure 8.20. Note that Joint A = 150 LF since Span 2 bearing is fixed, therefore no movement and since Span 1 bearing is expansion, the full movement of Span 1 (150 LF) contributes to the movement of the joint.

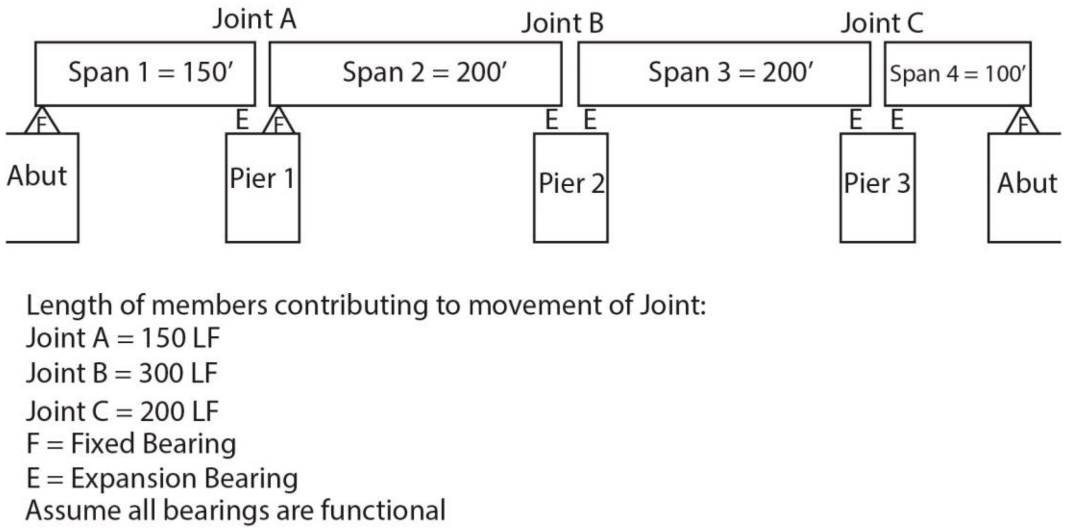

Figure 8.21 Length of Member Contributing to Joint Opening

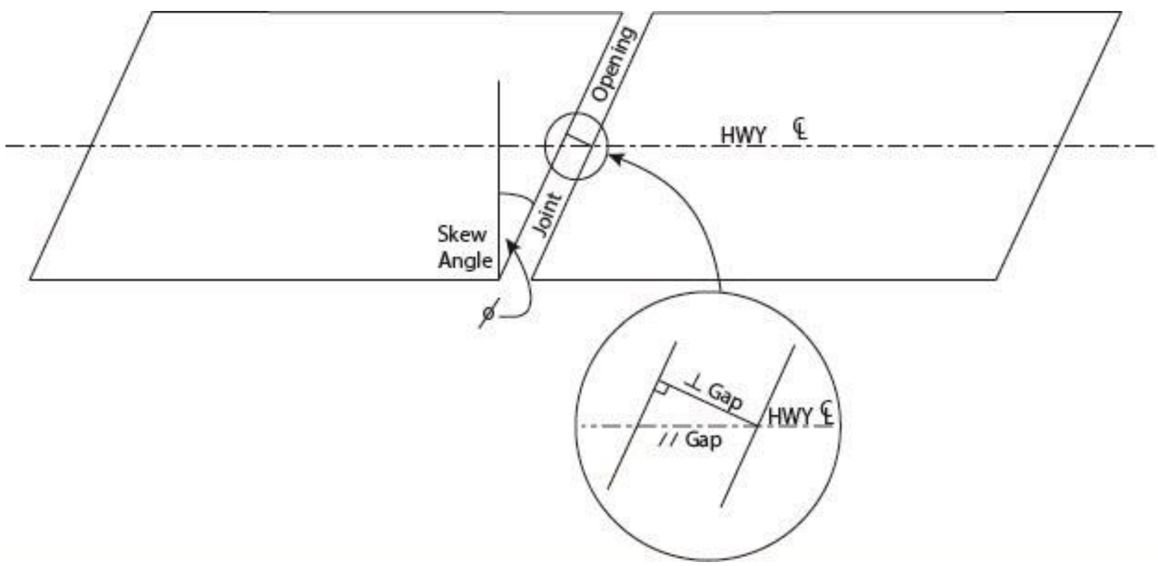

Figure 8.22 Joint Opening and Skew Angle

Compression seals can also be modified to turn up a curb or parapet. Figure 8.23 shows how holes can be drilled into the seal and cuts made to the holes to provide upturns, and 90° wedges can be cut to make 90 degree downturns. The seal installation at the curbs and parapets follows a similar procedure to the deck joint opening.

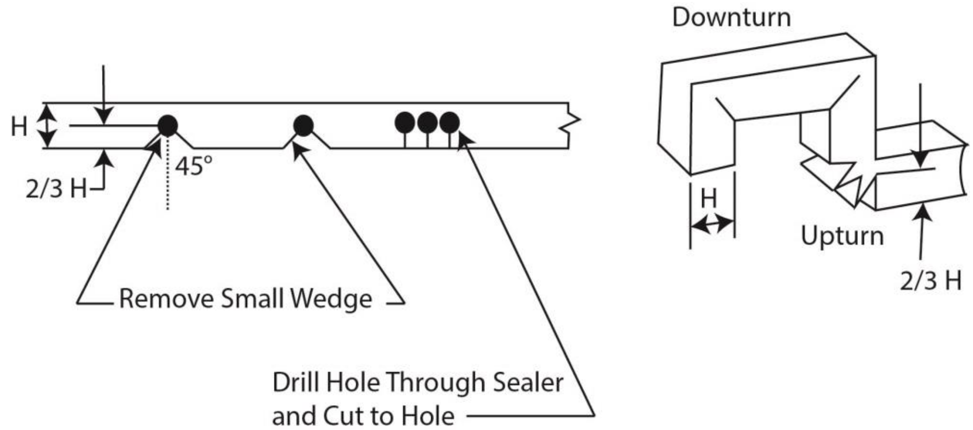

Figure 8.23 Schematic of Upturn/Downturn

8.6.2.2 Asphaltic Plug Joints (APJ)

Asphaltic Plug Joints are easily installed and a low cost bridge expansion joint type. They can replace joints used with an asphalt wearing surface. Although they are easy to install, careful attention to the placement of the plug is required to obtain its desired performance characteristics (Figure 8.24).

Figure 8.24 Asphaltic Plug Joint with Binder Placed Atop Backer Rod Prior to Bridging Plate Installation

A block out for the plug joint should be provided. The overlay should be saw cut at the block out limits. It is desirable to saw cut freshly laid asphalt, this will require that the existing APJ be milled out and temporarily paved over. The block outs are typically 20 inches wide. The depth of the saw cut should be established by drilling holes to determine the pavement depth. The existing pavement is then removed with jackhammers and hand tools. Care should be taken to ensure the existing deck is not damaged during the process. Once exposed the concrete deck should be repaired and should be level to ensure the levelness of the bridging plate, it should not rock or deflect. The horizontal and vertical faces of the block out should be abrasive blast cleaned, and dried. The backer rod should then be installed 1 inch below the top of the deck surface. Once the backer rod has been installed the asphalt binder is placed above the backer rod and applied to all surfaces of the block out. Bridging plates are then installed; the plates should be centered over the joint and secured with locating pins along the centerline. The joint is then tanked (flooded) again with the binder material.

The aggregates and binder are prepared for mixing. The aggregate should be heated and then placed in a separate drum to be coated with the asphalt binder (this method ensures best results for coating the aggregate). The coated aggregate should then be loosely placed in the cut out, then leveled and compacted in 2 inch lifts. The aggregate mixture is then tanked (flooded) with the binder material to fill the voids, only the tips of the aggregate should be seen. The next lift is placed in a similar manner. In the final lift the aggregate should not protrude above the wearing course surface. The binder is applied to the final lift ensuring there are no voids and no stones protruding (Figure 8.25). The final course is topped with a thin anti-tracking layer to provide skid resistance.

Figure 8.25 Plug Installation Showing Coated Aggregate and Binder

The temperature at the time of installation, as well as the temperature of the binder and the aggregate, is important to the installation of this joint. It is critical to know the temperatures of the materials and to calibrate any temperature monitors. The cleanliness of the block out and the aggregate are also important to monitor.

A suggested procedure for asphaltic plug seal installation:

Suggested Procedure

Asphaltic Plug Seal Installation

1. Saw-cut and remove the wearing surface and waterproofing membrane (if applicable) from the deck.
2. The block out is then cleaned and dried, repairing concrete as necessary.
3. The backer rod is then placed allowing at least 1 inch depth of binder material from the top of the deck. Note: the binder material is typically polymer modified asphalt that is commercially available for asphalt plug seal installation.
4. Then the joint is tanked (flooded) with binder material heated to manufacturer specifications.
5. Next the bridging plate is installed (Figure 8.26), centered over the gap with locating pins, and the binder is placed atop the bridging plate.
6. The aggregate must be clean and graded properly then heated to the appropriate temperature. The heated aggregate is then mixed with heated binder to provide a coating.
7. The coated aggregate is then placed in the block out in a maximum of 2 inch lifts.
8. The binder is heated to the appropriate pouring temperature and poured/flooded into the block out with the coated aggregate.
9. This process is repeated until the block out is filled.
10. A thin layer of anti-tracking material is placed upon the top surface to provide skid resistance.

Figure 8.26 Bridging Plate Installation

8.6.2.3 Strip Seals

A strip seal, also referred to as gland or membrane seal depending on the agency, is shown in Figure 8.27. Strip seals may need to be replaced if the headers are deteriorated or the extrusions are bent, loose, deformed or corroded. The seals may also need to be replaced if they are missing or significantly detached. To replace, first remove the remaining sections of the gland; heat may be necessary to melt the adhesives. Remove and replace deteriorated extrusions (see Figure 8.28 left) and re-anchor to new concrete header per steps provided in Section 8.6.1. Replace the gland using adhesives and tools suggested by the manufacturer, as shown in the example in Figure 8.28 right. A detailed strip seal replacement procedure published by Michigan DOT can be found at http://michigan.gov/documents/mdot/StructureMaintenanceBulletin4_Final_381367_7.pdf.

Figure 8.27 Strip/Gland/Membrane Seal

Figure 8.28 Removing the Old Gland (left) and Installation of New Gland (right)

It may be necessary to replace the entire joint system. A photo example and an example detail for installing a joint with a new strip seal are shown in Figure 8.29 and Figure 8.30. The complete header and steel extrusion system should be replaced as described in Section 8.6.1.

Figure 8.29 New Strip Seal Joint

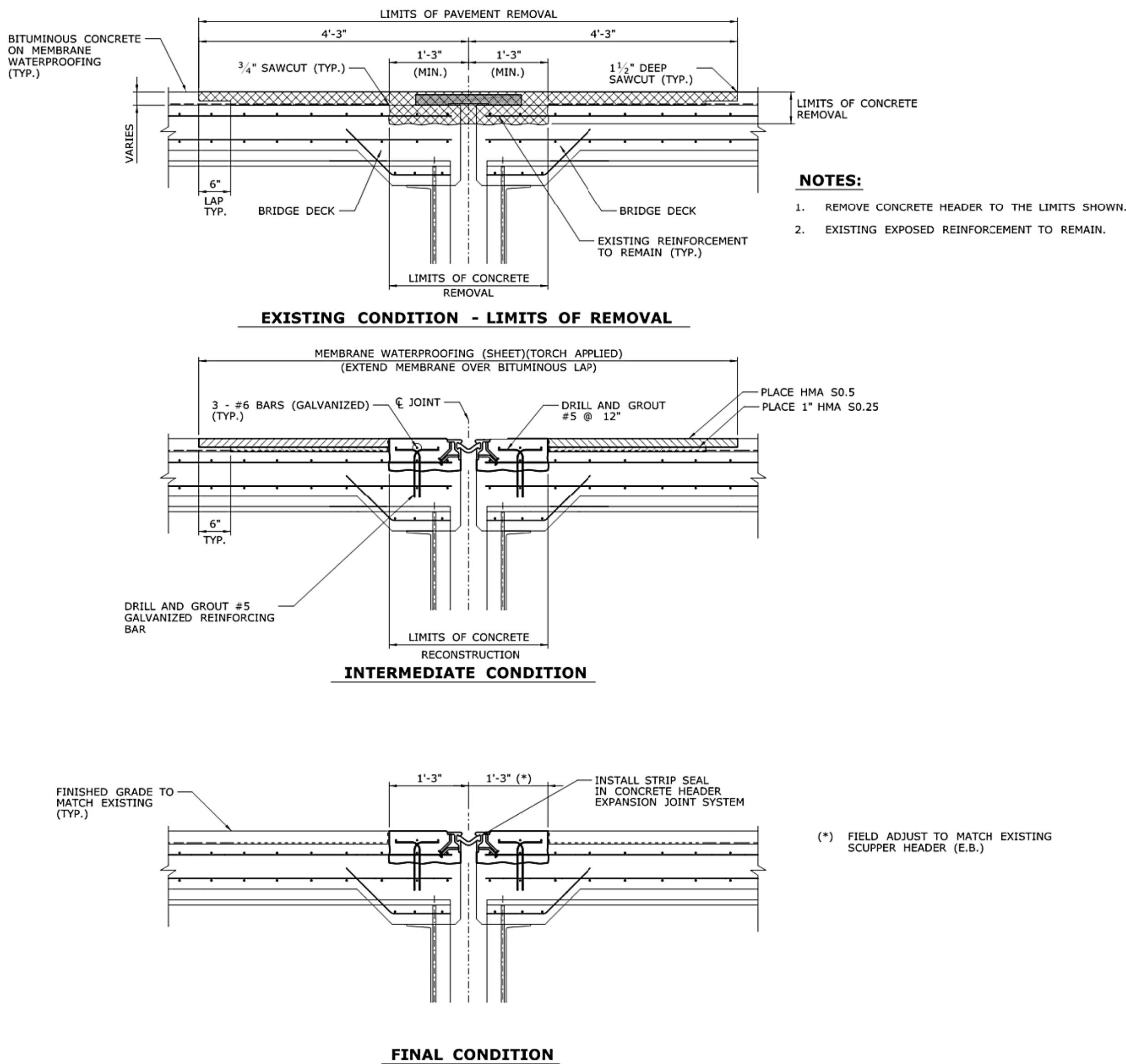

Figure 8.30 Detail for Installation of Joint with New Strip Seal

8.6.3 Rehabilitating Finger Joints

Maintenance of these joints can be required to restore the correct spacing between fingers, replace damaged or deformed fingers or restore deteriorated headers or anchorage systems.

Finger joints can be rehabilitated under stage construction since the plates can be cut and welded back together. The first step is to saw cut the concrete and remove the old anchors and create the block out for the joint system. The plates should be rehabilitated and new anchors fabricated and attached. Rebar should be threaded through the anchors prior to repositioning the plate into the deck. This plate should be repositioned back on the deck and the rebar previously threaded through the anchors connected to the existing deck rebar. It is important to install the drainage trough before both plates are positioned. The corresponding plate is then positioned and attached. Shims are used as spacers to provide the proper joint opening.

The joint spacing is determined by the span length and temperature range appropriate for the region, and the temperature at the time the plates are installed. The new plates and anchors should be recast taking care to ensure proper consolidation under the plates. A series of photographs are shown in Figure 8.31 through Figure 8.33 to illustrate the rehabilitation of a finger joint.

Figure 8.31 Damaged Finger Joint

Figure 8.32 Saw Cut and Remove Concrete to Create Block-Out

Figure 8.33 Rehab Plates and Add Anchors

Figure 8.34 Shims Used to Provide Proper Joint Spacing Prior to Casting the Joint

8.6.4 Replacing Joints with Alternative Joint Types

Although Compression Seals and Silicone Seals have been discussed in Sections 8.5.3 and 8.6.2, this section will discuss the process by which these joints can replace other types of joints, such as open joints or hot pourable seals (typically less-desirable small movement joints).

8.6.4.1 Upgrading Joint with Compression Seal

A water-tight compression seal can replace a small movement open joint. First step is to size the compression seal. The deck is then saw cut to the proper dimensions. Existing seals and other debris should be removed from the joint opening, as shown in Figure 8.35. Once the concrete has been sawcut and removed the joint edges should be sand blasted and cleaned. The seal should be coated with an adhesive which will serve as a lubricant until the material becomes tacky. Place the compression seal in the new opening, as shown Figure 8.36. This technique can be used to replace other joint types as long as the anticipated movement is in the same range as the compression seal (2-1/2 inches).

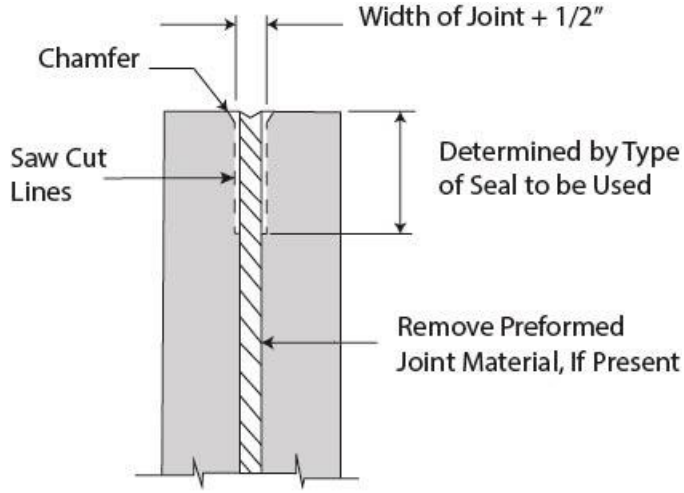

Figure 8.35 Joint Preparation for Compression Seal

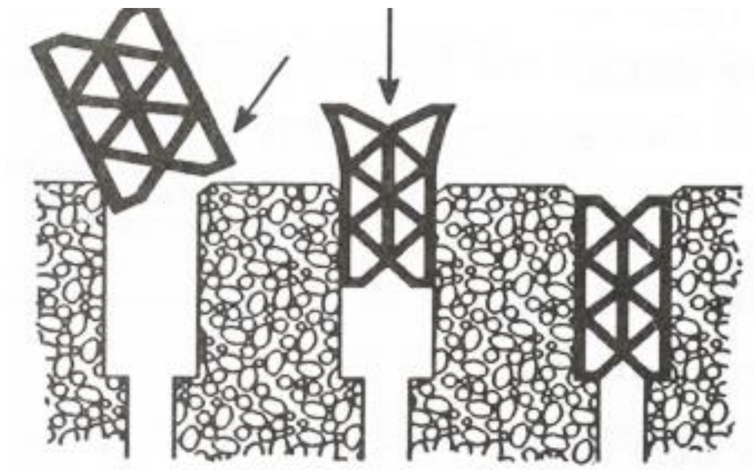

Figure 8.36 Insertion of Compression Seal

8.6.4.2 Upgrading Joint with Silicone Sealant

Silicone sealant can be used to replace hot poured sealants; this is desirable because the silicone system is more durable if applied properly. Other joint systems can be replaced with a silicone expansion joint system as long as the anticipated movement doesn't exceed the movement capacity of the silicone system (3 inches). A typical detail for the silicone expansion joint system was shown in Figure 8.3. This system can be used with or without asphalt overlays.

8.7 Elimination of Deck Expansion Joints

The best way to eliminate the problems associated with leaking bridge expansion joints is to eliminate the joint. In this section we will discuss various ways in which deck joints can be eliminated.

8.7.1 Slab over Backwall

Reconstructing the deck slab over the backwall can be a simple way to relocate the expansion joint to a more desirable location, particularly for small movement joints. Approximately 2 feet of the slab and a portion of the backwall are removed. A schematic of this detail is shown in Figure 8.37. There are several ways to detail constructing a slab over a backwall; Figure 8.37 shows one way and is provided as an illustration. Care should be taken to preserve the deck and backwall rebar. The slab is then extended past the backwall. New rebar is provided for the deck extension. Often a portion or the entire approach slab is removed and reconstructed. In Figure 8.37, note there is no approach slab. There is typically a bond breaker provided atop the backwall to allow for the slab to move. Photographs of the construction of a slab over a backwall are shown in Figure 8.38 and Figure 8.39.

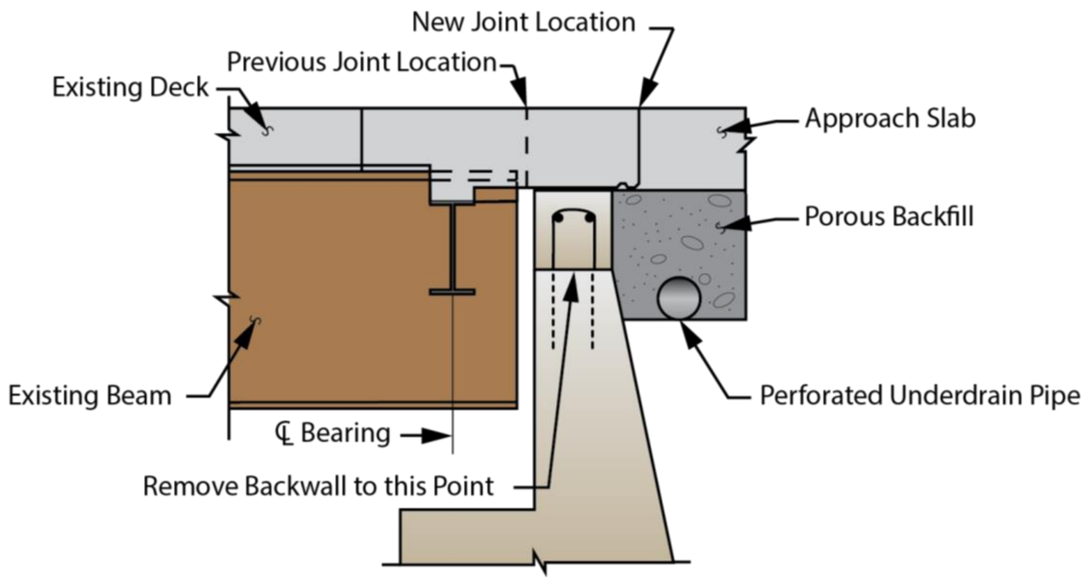

Figure 8.37 Slab Over Backwall Schematic

Figure 8.38 Construction Photo of Backwall Rebar

Figure 8.39 Construction Photo of Completed Slab over Backwall at Bridge Railing

When to Call the Engineer

Call the Engineer if slab over backwall is going to be done in conjunction with an approach slab.

8.7.2 Continuous Deck over Simple Span Piers (Link Slab)

Another relatively simple way to eliminate joints over a pier is by means of a link slab. A schematic detail is shown in Figure 8.40. A portion of the deck is removed from both spans sitting on the pier. The link slab portion of the deck is made non-composite by eliminating the shear studs; additionally the superstructure is ground smooth and a bond breaker is placed atop the girders. The length of slab to debond is L/20 (where L is the length of the span). The link slab can be designed in a simplified manner (Caner-Zia method) by treating the link slabs as a simple span (since the continuity provided by a continuous deck is negligible compared to the discontinuity of the stiffer superstructure). The length of this simple span is the length of portion of the slab that is debonded from the first span (L/20 span 1) + the length of the span that is debonded from the second span (L/20 span 2) + the distance between the girders. Moments in the link slab span can be computed by determining the end rotations in the adjacent spans which is a constant if they are multi-girder simple spans less than 100 feet. Moments for longer adjacent spans require computing end rotations for the simple spans under the calculated service loads. Reinforcement can be designed accordingly. Photographs of the construction of the link slab are shown in Figure 8.41 and Figure 8.42.

When to Call the Engineer

A structural engineer should be consulted to design the link slab reconstruction.

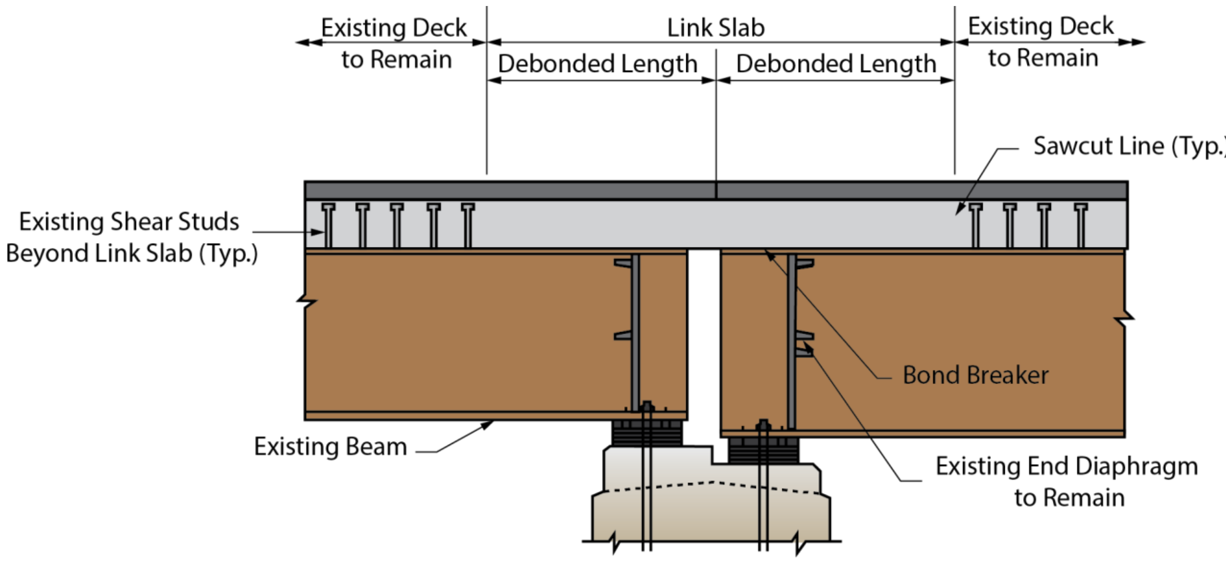

Figure 8.40 Link Slab, Or Continuous Deck over a Pier, Schematic

Figure 8.41 Link Slab Showing Bond Breaker and Elimination of Shear Studs

Figure 8.42 Link Slab Construction Showing New Slab Over the Pier and Link Slab Over the Girders

8.7.3 Integral/Semi-Integral Abutments

New bridges are now often designed using integral or semi-integral abutments. Although this is outside the Bridge Maintenance realm, it is important to be able to recognize these features and their purpose and function. The purpose of integral and semi-integral abutments is to eliminate bridge deck expansion joints, the movement associated with thermal expansion, and the material properties of the bridge components (namely creep and shrinkage) is accommodated in the abutments along with a joint in the pavement or adjacent to the approach slab.

8.7.3.1 Integral Abutments

These are bridges whose superstructure is cast integrally with the substructure. They typically have capped pile stub type abutments and a single row of vertical piles. A schematic is shown in Figure 8.43. As shown in the detail the end of the superstructure is encased in the abutment, which eliminates the expansion joints and bridge bearings. In integral abutments, the upper portion of the abutment which encases the beam ends is connected to the lower part of the abutment, which allows the abutment to rotate but not slide.

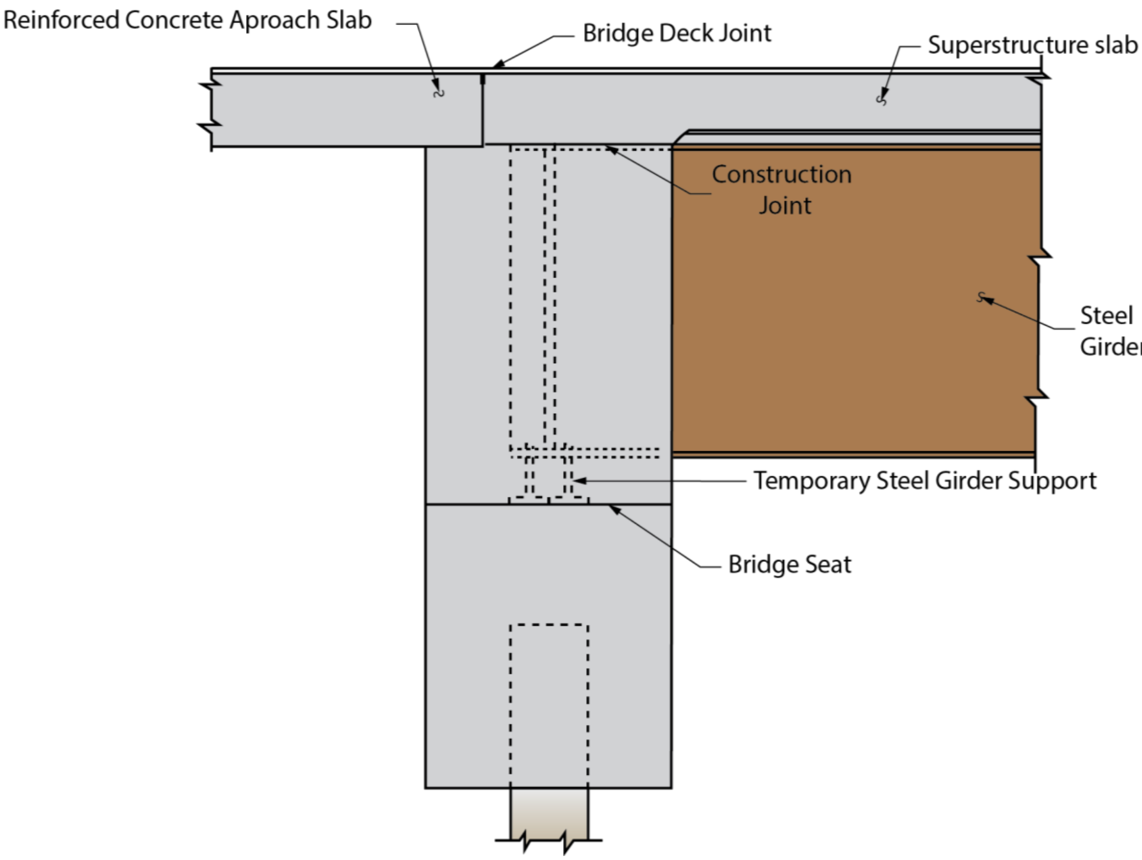

Figure 8.43 Integral Abutment Schematic

8.7.3.2 Semi-integral abutment

The semi-integral abutment is very similar to the integral abutment in that the superstructure is still cast into the substructure, thereby eliminating deck expansion joints, but the superstructure bears on the abutment thereby not eliminating the bearings. A schematic is shown in Figure 8.44.

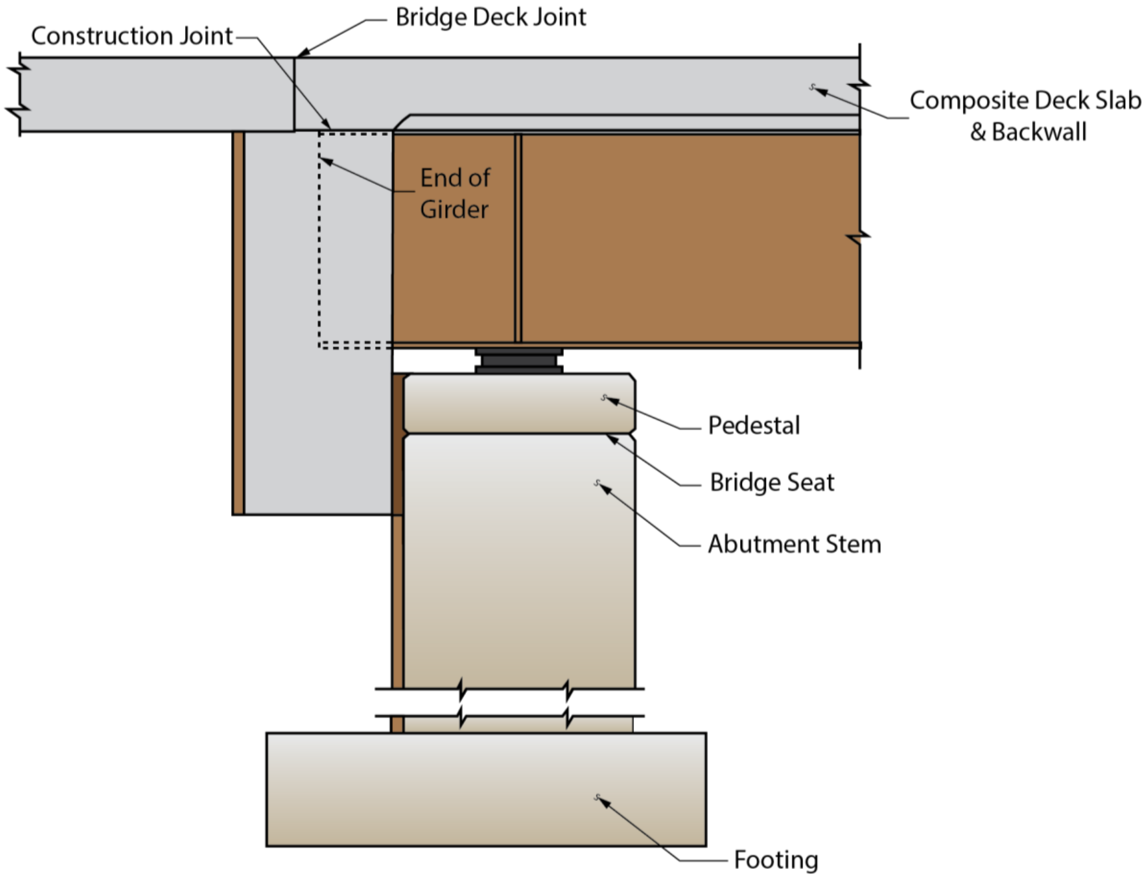

Figure 8.44 Semi-Integral Abutment Schematic

8.8 Chapter 8 Reference List

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