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Chapter 10 - Deck Drainage

10.1 Common Types of Deck Drainage Systems

The bridge deck drainage system includes the bridge deck, sidewalks, railings, gutters, scuppers/inlets and open or closed piping. The primary objective of the drainage system is to remove runoff from the bridge deck before it collects in the gutter, shoulder or lane thus exceeding the allowable design spread as defined by the bridge owner. Properly designed bridge deck drainage should incorporate features to facilitate and minimize maintenance activities. The benefits of a properly designed and maintained deck drainage system include the following:

- Efficient removal of water from the bridge deck which decreases the risk of hydroplaning and enhances public safety
- Long-term maintenance and service life of the bridge is improved
- Preservation of structural integrity of the bridge
- Enhanced aesthetics by elimination of superstructure and substructure staining
- Minimized or eliminated erosion on bridge end slopes

10.1.1 Open vs. Closed Deck Drainage Systems

Open deck drainage systems are typically horizontal or vertical penetrations thru the bridge barrier/curb or the bridge deck at the bridge barrier/curb line. Horizontal penetrations (drainage slots) are typically formed as part of the bridge barrier curb construction and closely spaced based on the small opening of the slot. This system is prone to clogging with debris and often requires constant maintenance. In addition, this system allows chloride and chemical-contaminated runoff to come in direct contact with the bridge deck fascia overhang and superstructure below. Such runoff may result in premature spalling of concrete or corrosion of steel. Vertical penetrations are typically constructed with a circular hole thru the bridge deck, or a scupper or inlet with pipe extension thru the bridge deck. Open deck drainage systems are typically only used where there are no concerns with environmental impacts or runoff below the bridge and possible flooding, and no active facilities below the bridge. Figure 10.1 shows the two open deck drainage systems described above.

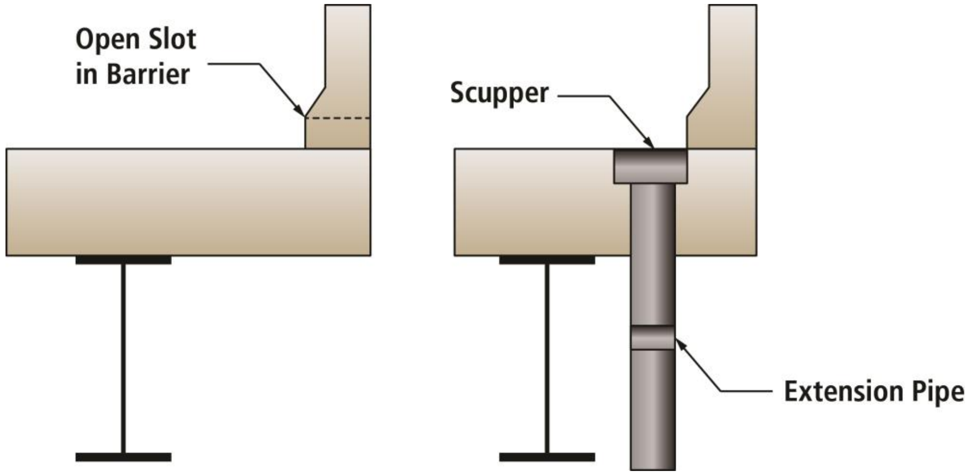

Figure 10.1 Schematic of an Open Deck Drainage System. Horizontal Penetration (left) and Vertical Penetration (right).

Closed deck drainage systems typically are comprised of scuppers or inlets at the deck surface with a closed piping system which extends from the base of the scupper/inlet down a substructure element (Pier or Abutment) and into a ground based drainage inlet, as shown in the schematic in Figure 10.2. The pipe is typically attached using supports to the substructure element and includes cleanouts at proper locations for maintenance. Closed drainage systems are typically used where there are concerns with environmental impacts, such as flooding below the structure and possible erosion, or active facilities below the structure. A photograph of a closed deck drainage system is shown in Figure 10.3.

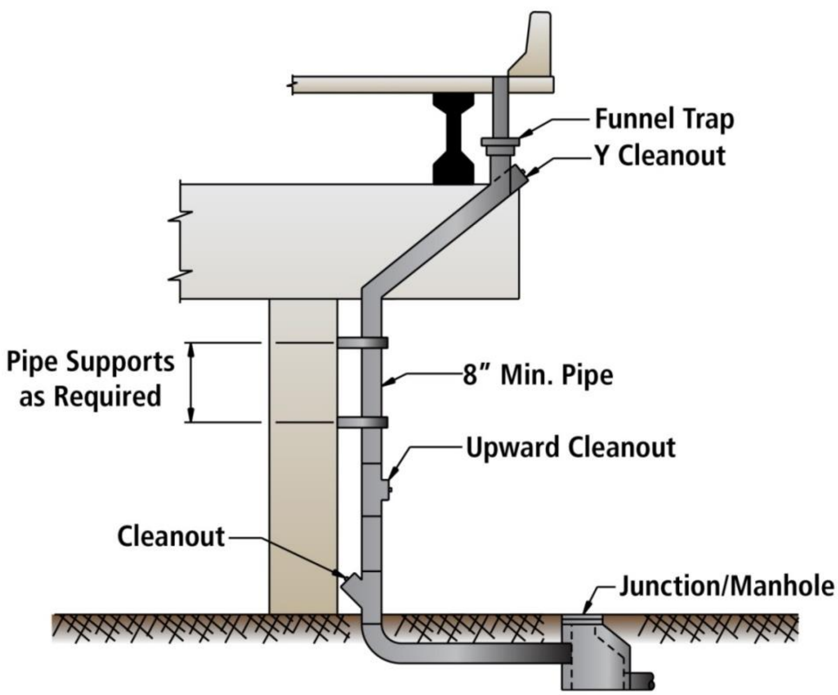

Figure 10.2 Schematic of a Closed Deck Drainage System

Figure 10.3 Photo of a Closed Bridge Drainage System – Fiberglass (Courtesy of FRPbridgedrainpipe.com)

10.1.2 Scuppers

A scupper is defined typically as a vertical hole through a bridge deck for the purpose of deck drainage. However, a horizontal opening in the curb or barrier is also considered a scupper as it serves the same purpose of deck drainage. A scupper can be as simple as a circular penetration in the bridge deck, with or without an insert pipe in the bridge deck. Or it can be a combination of a small steel-grated casting typically with a steel pipe extended below the superstructure. Examples of vertical and offset scuppers are presented in Figure 10.4 and Figure 10.5, respectively. Additional example scupper details are provided in the drawings in Figure 10.6 and Figure 10.7.

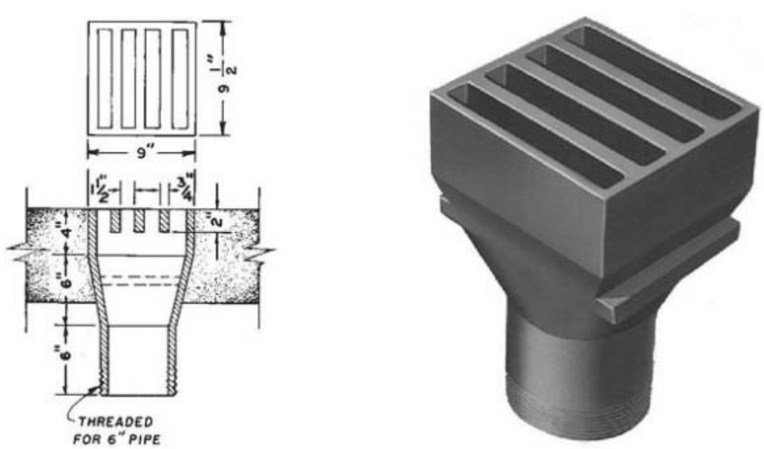

Figure 10.4 Heavy Duty Vertical Scupper with Integral Cast Bars (Courtesy of Neenah Foundry Company)

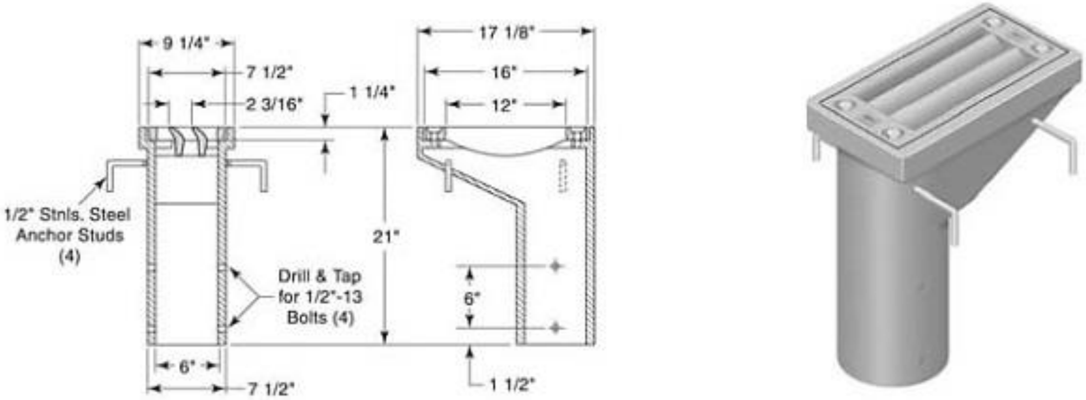

Figure 10.5 Offset Scupper with Frame and Bolted Grate
(Courtesy of Neenah Foundry Company)

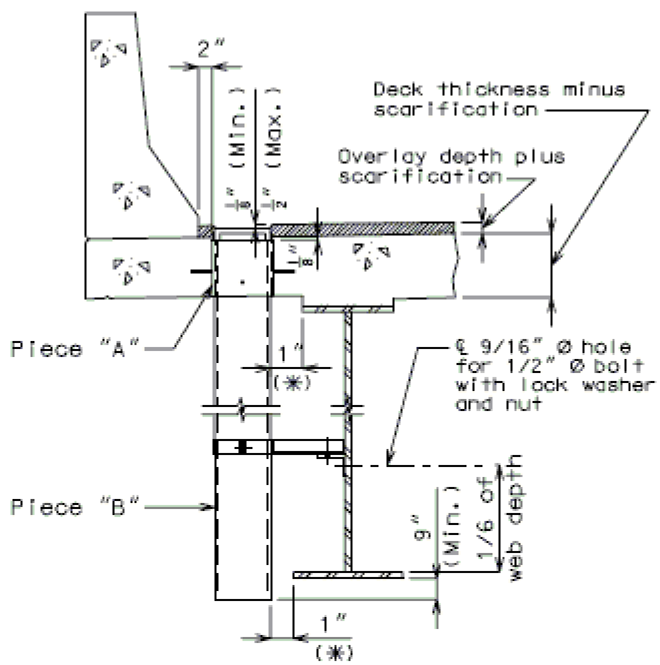

Figure 10.6 Example Bridge Scupper Detail with Pipe Extension
(Courtesy of the Missouri DOT)

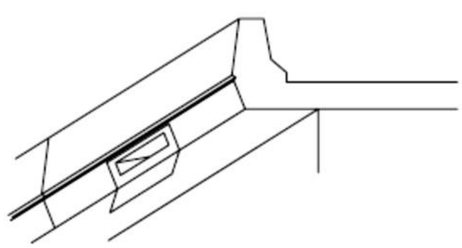

Figure 10.7 Example of a Horizontal Bridge Scupper through a Bridge Parapet
(Courtesy of the Maryland DOT)

10.1.3 Inlets

An inlet may be defined as a bridge inlet or bridge end inlet. Some agencies use the term bridge inlet and scupper interchangeably. In general, a bridge inlet has a larger opening than a scupper and is comprised of a casting or fabricated inlet base with a cast or fabricated grate. Example drawings of a bridge inlet are presented in Figure 10.8 and Figure 10.9. The larger bridge inlets allow for collection of greater runoff and typically collect less debris and require less maintenance. A bridge end inlet is usually a precast roadway inlet with grate which is placed at the end of the bridge approach slab to collect bridge runoff on bridges which have no bridge deck scuppers or inlets, or for longer span bridges where spacing between inlets may be long. The drawings provided in Figure 10.10 and Figure 10.11 provide examples of bridge end inlet design.

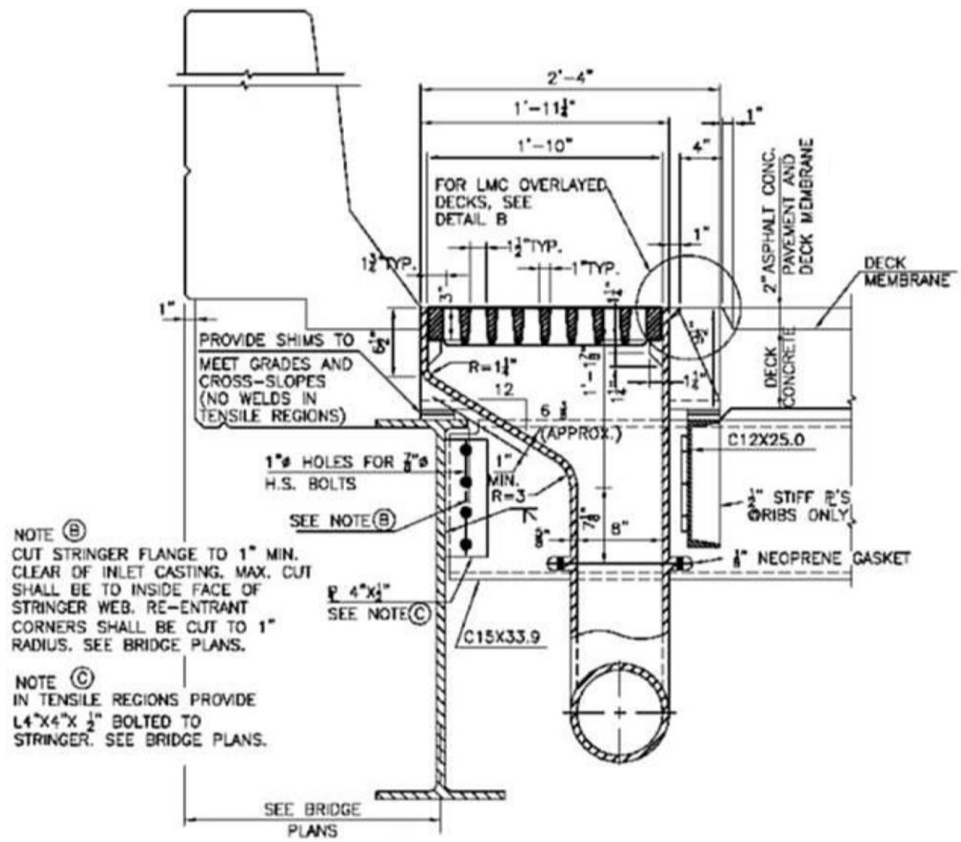

Figure 10.8 Example Bridge Inlet Detail – Cross Section View
(Courtesy of the New Jersey Turnpike Authority)

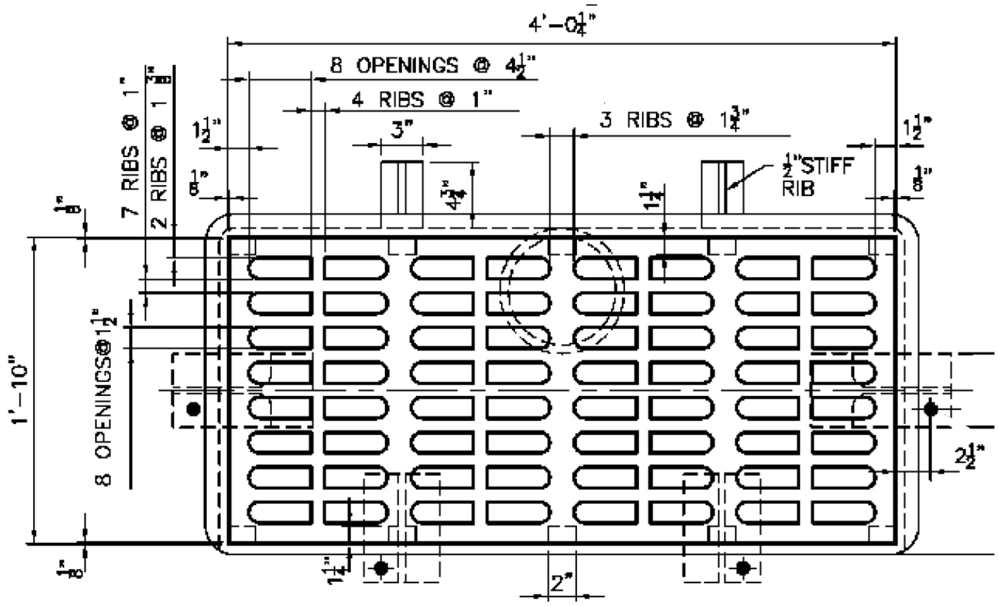

Figure 10.9 Example Bridge Inlet Detail – Plan View (Courtesy of the New Jersey Turnpike Authority)

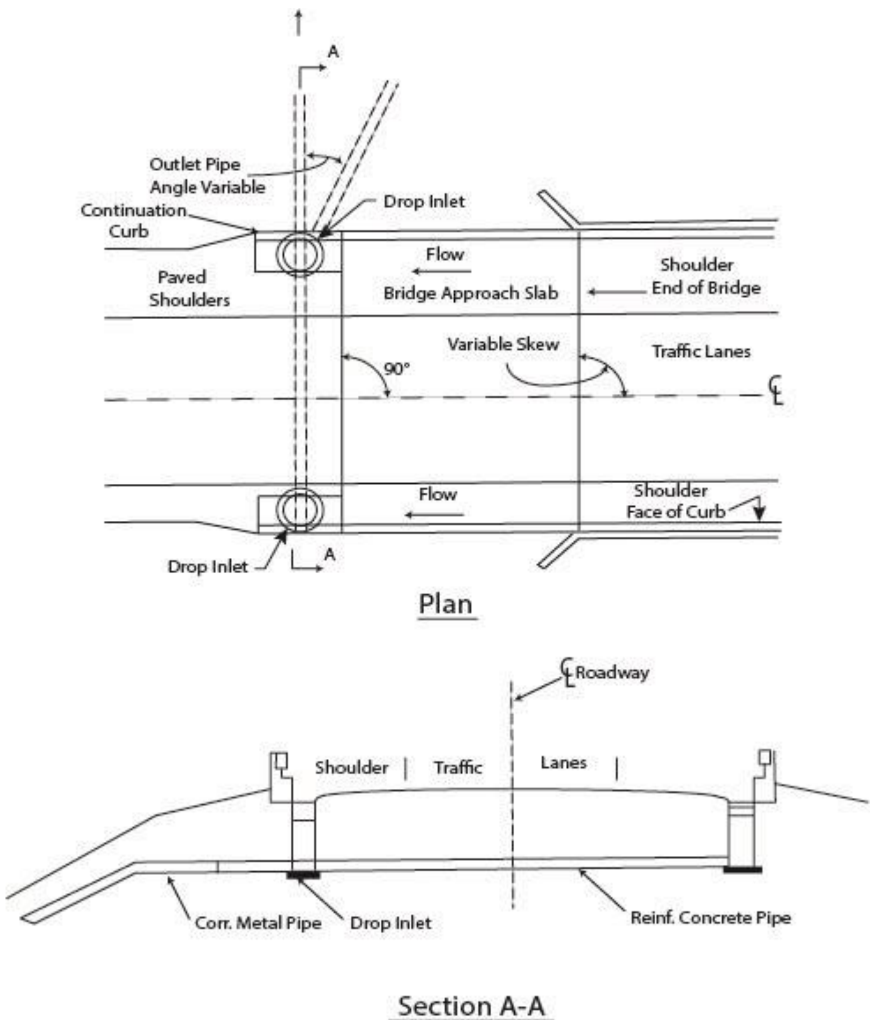

Figure 10.10 Bridge End Inlet Plan & Section Example Drawing

When to Call the Engineer

Call the Engineer if there are sink holes, voids, or other evidence of erosion in the approach embankment in the area of drop inlets or buried pipe locations.

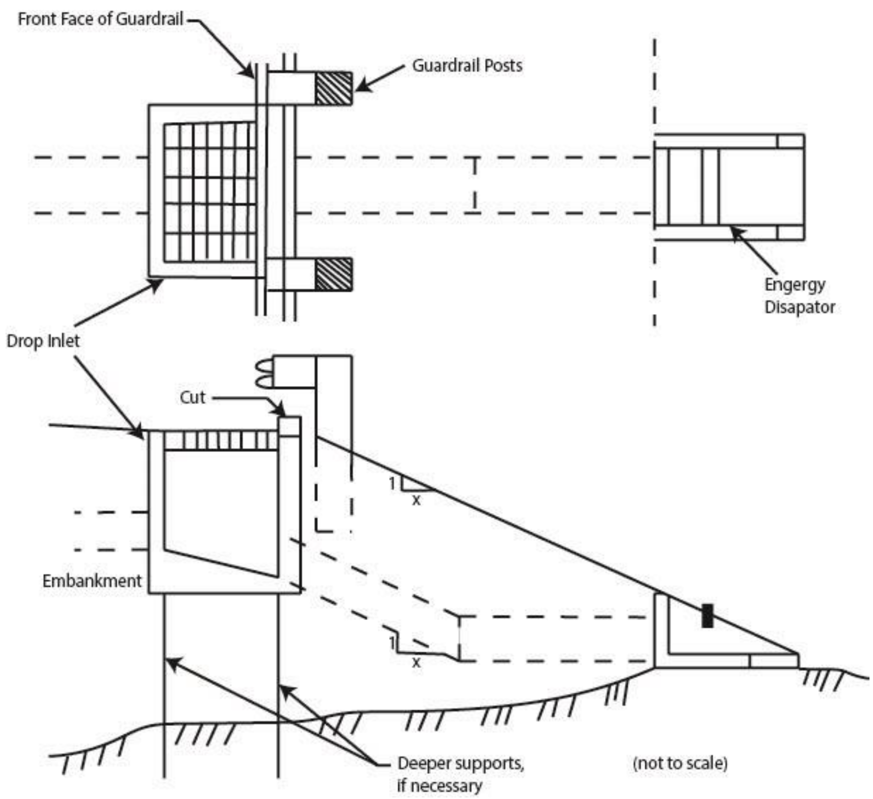

Figure 10.11 Bridge End Inlet Detailed Plan & Section Example Drawing

10.1.4 Troughs

A drainage trough is typically used under open deck joints, such as finger joints, to divert runoff and associated debris away from underlying superstructure, bearings and substructure members. Drainage troughs on older bridges were made of steel and required significant maintenance based on flat slopes which allowed for the easy collection of debris and replacement or repair due to corrosion. A photographic example of a steel drainage trough is shown in Figure 10.12. Drainage troughs on new bridges are typically made of elastomeric sheet, as shown in the schematic in Figure 10.13. These troughs are considered self-cleaning if designed and detailed properly. Examples are shown in Figure 10.14 and Figure 10.15, as they are flexible and will move laterally and vertically under bridge expansion/contraction and live load. Photographic examples of a clean elastomeric sheet trough and also a clogged trough are shown in Figure 10.16 and Figure 10.17, respectively.

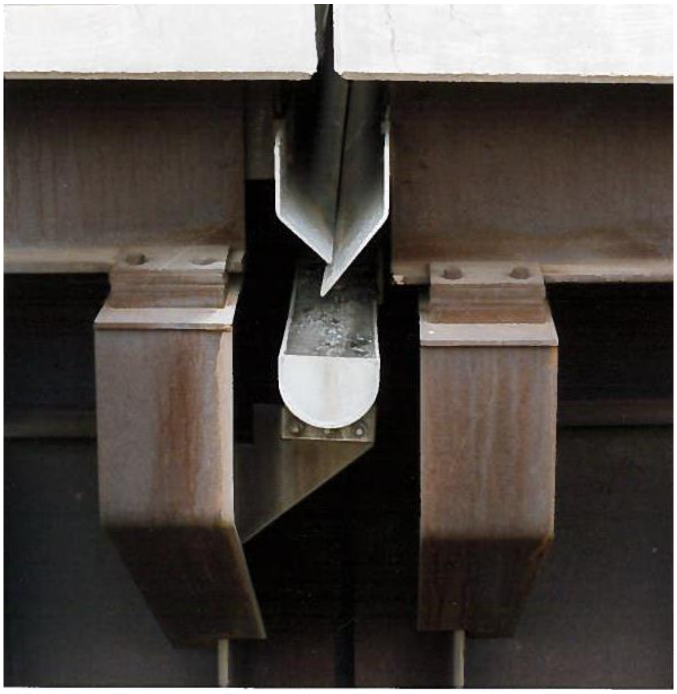

Figure 10.12 Unmaintainable Steel Trough and Drainage Deflection Plates (Courtesy of the New Jersey Turnpike Authority)

Figure 10.13 Schematic of a Drainage Trough

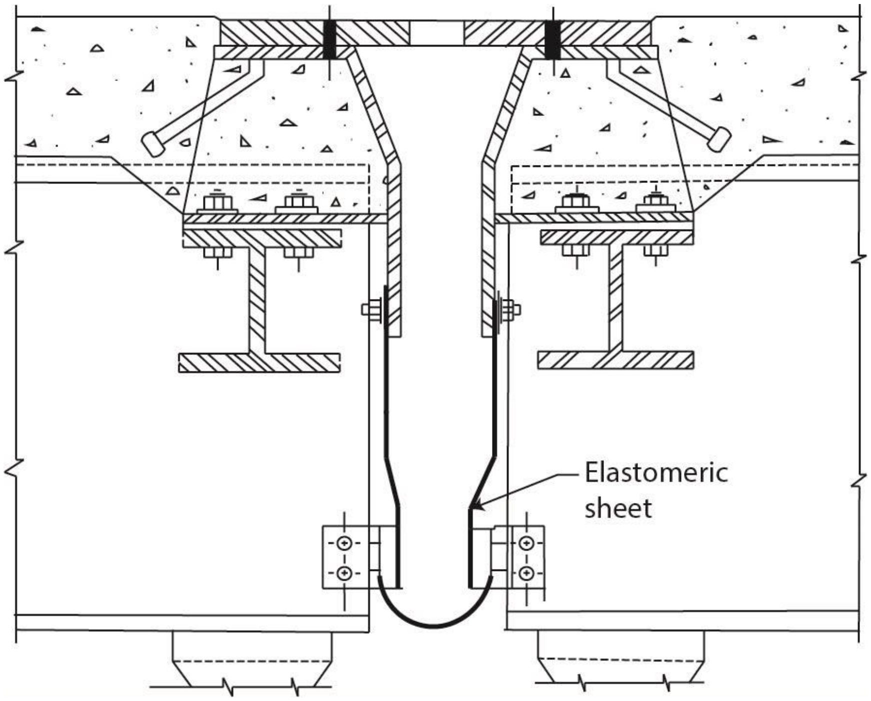

Figure 10.14 Drawing of a Drainage Trough

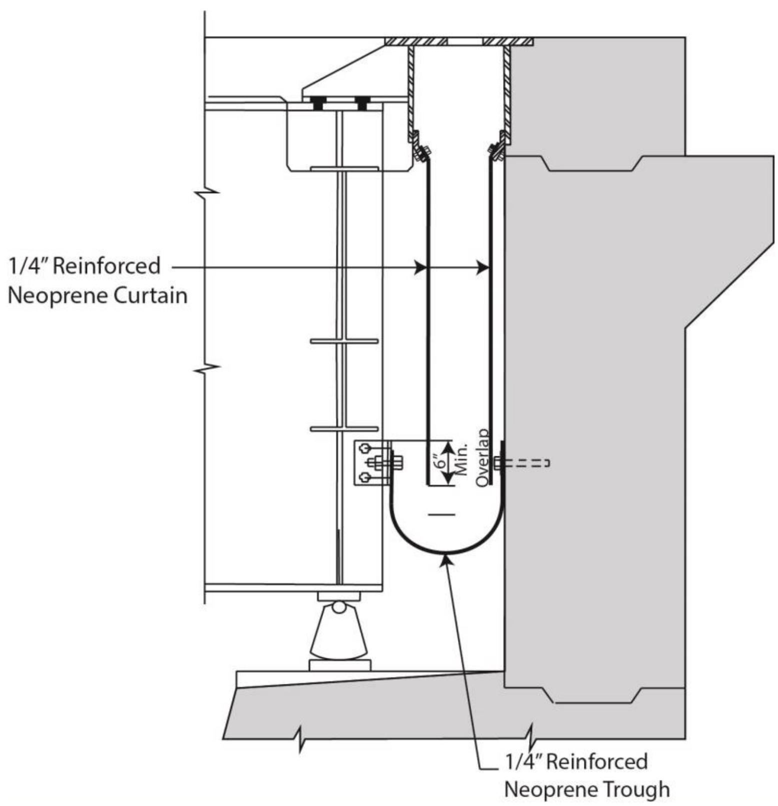

Figure 10.15 Drawing of Finger Joint with Elastomeric Trough

Figure 10.16 Elastomeric Trough

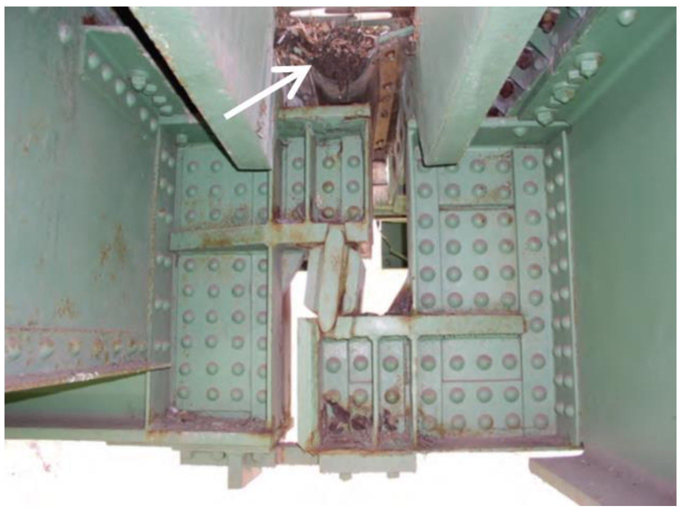

Figure 10.17 Clogged Elastomeric Trough

10.2 Preventive and Basic Maintenance of Deck Drainage

What To Look For

- Debris
- Clogged elements
- Evidence of ponding
- Leaks
- Broken frames
- Broken piping/fittings
- Loose hardware

Regardless of the bridge deck drain type, size, or shape, cleaning is required as part of Preventive Maintenance. Frequent sweeping and flushing of the bridge deck will remove sediment and debris which collects in the bridge shoulder and bridge inlets. The end result of frequent cleaning is less required bridge deck drainage system maintenance.

10.2.1 Cleaning

The necessary cleaning of bridge deck drain systems can be accomplished by several methods. These methods include:

- Shovel
- Rodding
- High pressure water jetting
- High pressure jetting with auger
- Plumber snake

These cleaning methods should be coordinated with proper traffic control above and below the bridge to ensure traffic is not affected by the cleaning operation and resulting water or debris. In addition, crews should be provided with proper personal protective equipment for cleaning operations and possess appropriate equipment to collect and properly dispose of the resulting slurry and debris from the cleaning operations. A typical procedure for cleaning bridge inlets and piping follows:

Suggested Procedure

Cleaning Bridge Inlets and Piping

1. Remove grating from inlet and remove debris from inlet base with shovel or vacuum truck. If grating is frozen, may need to remove some debris with high pressure water to free grate.
2. Use snake to remove clog or debris from pipe.
3. Depending on extent of clog use high pressure jet with auger to remove clog or debris from piping (Removal of clogging or debris should be done from cleanout sections where available).
4. Flush the inlet base and piping with high pressure water to fully clean the surfaces of the system.
5. Replace grating and cleanout plugs (where available).

Cleaning of elastomeric troughs typically only requires the use of high pressure water jetting from the deck level and thru the open deck joint. Depending on the design and construction of the joint, rodding of the debris combined with jetting may be required.

10.2.2 Flushing

Flushing of closed bridge drainage systems is typically accomplished by high pressure jetting with water or compressed air. For high pressure jetting with water, two basic nozzle styles are used for drain pipe cleaning applications. Rear jets provide propulsion of nozzle while cleaning the drain pipe wall surface. Forward jet is used to penetrate blockages in the drain pipe for the nozzle to pass and through cleaning by rear jets. Flushing may also be accomplished with compressed air. When flushing with compressed air, a plug is typically installed at the lower end of the drain pipe to make it airtight. The debris in the pipe is then saturated with water from the deck level. Next a small diameter pipe is inserted thru the plug and introduces high pressure air which will loosen any obstruction in the drain pipe. Figure 10.18 shows nozzle jet heads used for flushing drain pipe.

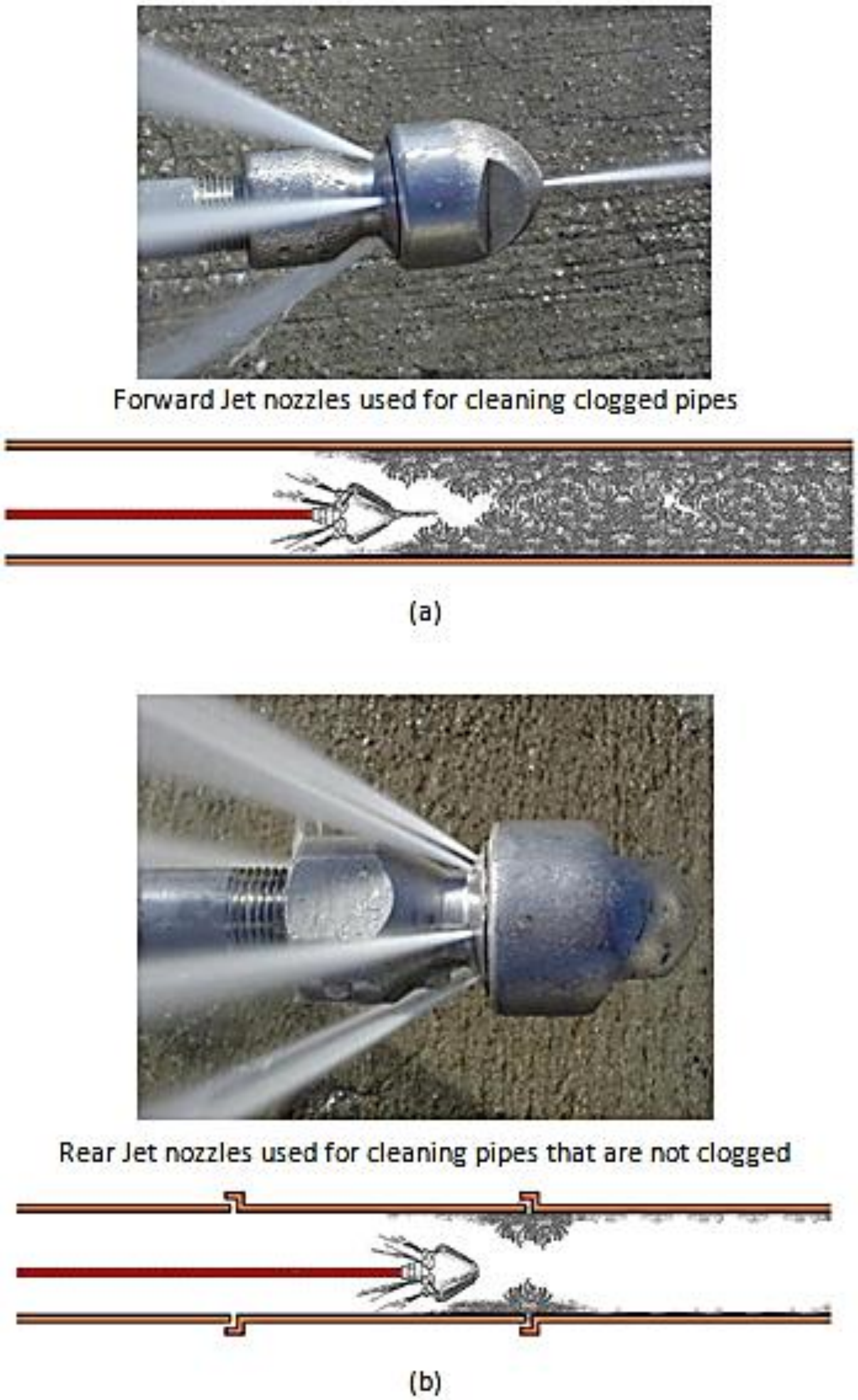

Figure 10.18 Jet Nozzles Used for Cleaning (a) Forward Nozzles for Clogged Pipes and (b) Rear Nozzles for Non Clogged Pipes (Courtesy of US Jetting, LLC.)

10.3 Repair and Rehabilitation of Deck Drainage

Deck drainage systems will require repair, rehabilitation, and possibly retrofit in order to restore functionality to proper collection and discharge of runoff from the bridge deck. There are several approaches to address maintenance repairs or retrofits to deck drainage systems. Any scupper or inlet penetration within the deck should have the perimeter sealed after the cleaning operation to ensure water and chlorides do not migrate along the interface between the scupper/inlet and the bridge deck. For decks with asphalt wearing surfaces, an asphalt cement sealer is adequate. For bare concrete decks, a methacrylate sealer is appropriate.

10.3.1 Redirecting Flow off Bridge Deck

One solution to addressing a poorly designed and unmaintainable bridge deck drainage system would be to redirect flow off the bridge deck to bridge end inlets, and may only be suitable for short to medium span bridges. This would require plugging of existing bridge scupper/inlets (deck or barrier penetrations) and construction of bridge end inlets near the ends of the bridge approach slabs. In addition, all bridge deck joints should be evaluated and repaired or replaced to ensure properly/effectively sealed to eliminate substantial runoff thru the deck joint systems. Prior to implementing this solution, a hydraulic analysis should be performed to confirm that the resulting spread with no bridge deck inlets was within allowable limits. Refer to Figure 10.9 for a typical bridge end inlet configuration.

10.3.2 Drain Extensions

On many older bridges, pipe scuppers were installed at the curb line to remove runoff from the bridge deck. The penetrations typically terminated at the bottom of the bridge deck which allowed the runoff to come directly into contact with the superstructure and substructure, resulting in accelerated corrosion of steel and spalling of concrete. Several agencies have developed drain extension retrofits to eliminate the direct exposure of superstructure and substructure elements to the deck runoff. If the penetration terminates at the underside of the bridge deck, these retrofits involve the installation of a new pipe (PVC or Fiberglass) from the deck level to a distance of about 3 inches below the superstructure member. Refer to Figure 10.19 and Figure 10.20 for photographs of PVC drain extension retrofits. The extension below the superstructure should be maximized to ensure that wind will not blow the runoff back onto the superstructure elements; 2-3 feet has been used by certain agencies and was found to be effective. If an existing downpipe has been provided but terminates just below the deck level, the retrofit would involve the extension of the downpipe so that it terminates below the superstructure member. Refer to Figure 10.21 for an example of a drain extension detail. Depending on the height of the downpipe above the ground and conditions below, consideration should be given to the installation of scour pads at the ground level to eliminate soil erosion. This may be accomplished with riprap stone and a filter fabric, or with a precast concrete pad.

Figure 10.19 PVC Drain Extension Retrofit at Fascia

Figure 10.20 PVC Drain Extension Retrofit Beneath Deck
(Courtesy of the New Jersey Turnpike Authority)

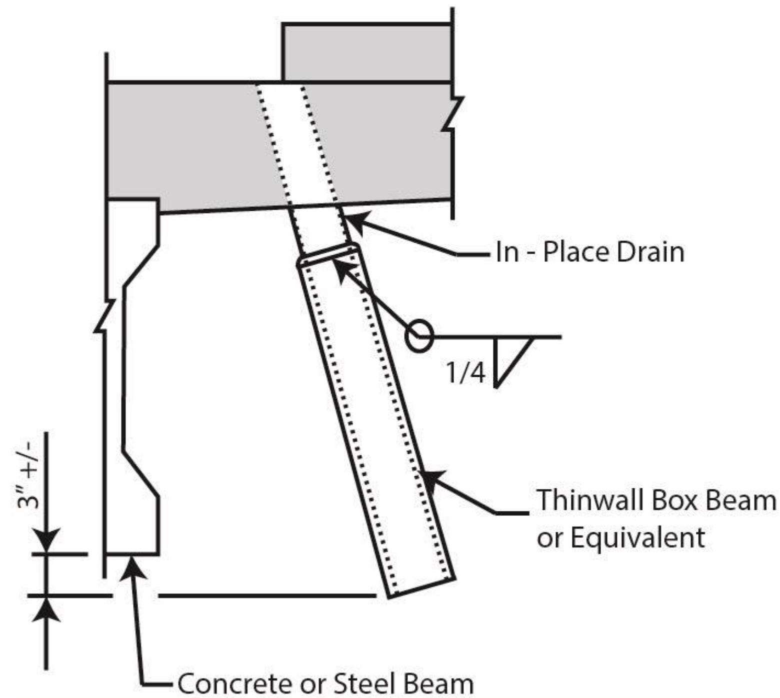

Figure 10.21 Steel Pipe Drain Extension

10.3.3 Inlet Grate Replacement

Scupper or inlet grates should be evaluated for grate opening size and effectiveness in blocking large debris from entering the bridge drainage system. Larger grate openings are a primary reason for inlet clogging. Replacement with filter grates with smaller openings will eliminate larger debris which ultimately allow for clogging of the inlet and piping system. As part of the grate replacement process, consideration should be given to cleaning the inlet frame and coating with a cold applied galvanizing material to provide a smoother surface. The coating will minimize small debris and sediment collection on shallow frame surfaces. Figure 10.22 shows an inlet with large grate openings filled with debris. The drawing in Figure 10.23 provides retrofit filter grate details. Installation photos are shown in Figure 10.24 and Figure 10.25.

Figure 10.22 Bridge Inlet Grate Which Permits Clogging of Inlet
(Courtesy of the New Jersey Turnpike Authority)

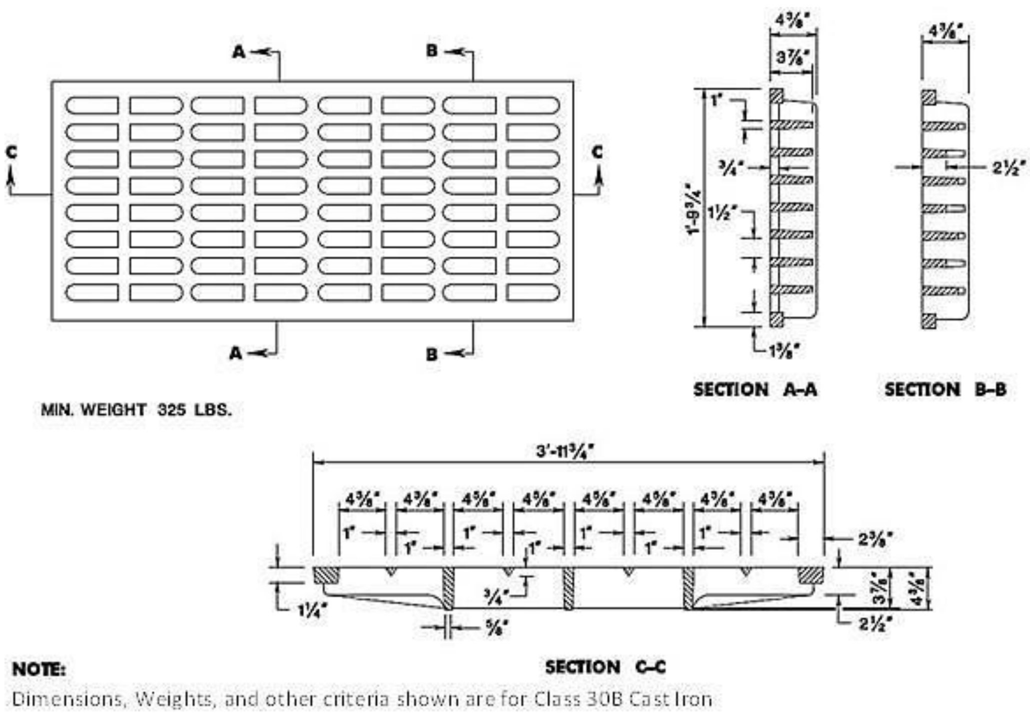

Figure 10.23 Drawing for a Bicycle Safe Grate (Cast Iron)
(Courtesy of the New Jersey Department of Transportation)

Figure 10.24 Bridge Inlet Grate Retrofit (Filter Grate)
(Courtesy of the New Jersey Turnpike Authority)

Figure 10.25 Bridge Approach Inlet Grate Retrofit (Filter Grate)
(Courtesy of the New Jersey Turnpike Authority)

10.3.4 Piping Replacement

Many closed bridge drainage systems were built with small diameter piping, using either orthogonal (90 degree bends), or small radius bends, with flat slopes, limited or no cleanouts, and drain hopper systems. These systems as designed and constructed are prone to severe clogging. Maintenance retrofits to these systems could include replacement of orthogonal piping, or small radius bends, with large radius bends to improve water flow and decrease clogging, installation of cleanouts to allow for proper maintenance, increasing the slope of the drain pipe, elimination of drainage hoppers, and if necessary replacement with larger diameter pipe (6 inches minimum or larger). Many agencies are now using fiberglass materials for maintenance drainage retrofits as they are much lighter and easier to install given weight reduction over steel pipe, and the materials are not subject to corrosion. Refer to Figure 10.26

which shows a closed bridge drain system with orthogonal piping, smaller diameter pipe with flat slopes, and drainage hoppers. Compare this to Figure 10.27, which is a newer fiberglass bridge drain system with larger diameter pipe with steeper slopes, long radius bends for transitions, and easily accessible cleanouts for maintenance.

Figure 10.26 Closed Bridge Drainage with Orthogonal Piping Prone to Clogging (Courtesy of the New Jersey Turnpike Authority)

Figure 10.27 Closed Bridge Drainage System with Steeper Pipe Slopes, Long Radius Bends and Cleanouts (Courtesy of FRPbridgedrainpipe.com)

10.4 Chapter 10 Reference List

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