CHAPTER 16
BRIDGE MAINTENANCE

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16.1 INTRODUCTION

Bridge preventive maintenance is extremely important in extending serviceable life of structures throughout Pennsylvania as well as the nation. Structure condition has been cited as one of the most pressing transportation problems facing the nation and one of the major contributing factors to these problems is insufficient or deferred maintenance.

Structure condition deteriorates for many reasons. Among them are increased truck volume and weight, environmental elements and the lack of preventive maintenance. Preventive maintenance can, and should, be used extensively to arrest or delay deterioration of bridge elements.

This chapter will discuss the bridge inspection procedures, the flow of bridge inspection reports and the required actions and responsibilities. In the belief that most problems can be prevented or minimized by timely preventive maintenance, the problems normally experienced in the various bridge elements will be identified and the preventive maintenance activity that could prevent or minimize the condition will be discussed. This chapter is intended to serve as the basis for bridge preventive maintenance across the Commonwealth and is expanded upon in Publication 55, Bridge Maintenance Manual. Pub. 55 provides means and methods for performing the maintenance items discussed in this chapter as well as rehabilitation and replacement work that may be completed by Department Forces (DF). To ensure cleaning is occurring on a routinely scheduled basis across all state-owned structures on the inventory, a Maintenance Accreditation Performance Index (MAPI) is used to provide a score to evaluate counties on the cleaning of bridge decks, scuppers and bearing areas.

Additionally, the MAPI "FOM05" - Completed Bridge Work Metric was established to ensure proper asset management of state structures, through monitoring and scoring for completion of assigned bridge maintenance repair needs, designated at the PennDOT Priority 2 and 3 levels of severity.

The goal of this chapter is to identify elements or areas of structures that can substantially benefit from preventive maintenance, and to provide policy and guidelines to accomplish this very important activity. In accordance with Pub. 55, all Districts should have an annual Preventive Maintenance Plan that covers the activities discussed within this chapter.

In addition to bridge preventive maintenance, emergency event such as floods require additional resources to monitor scour critical bridges. Refer to section 9.11 of this manual for specific guidance on flood events.

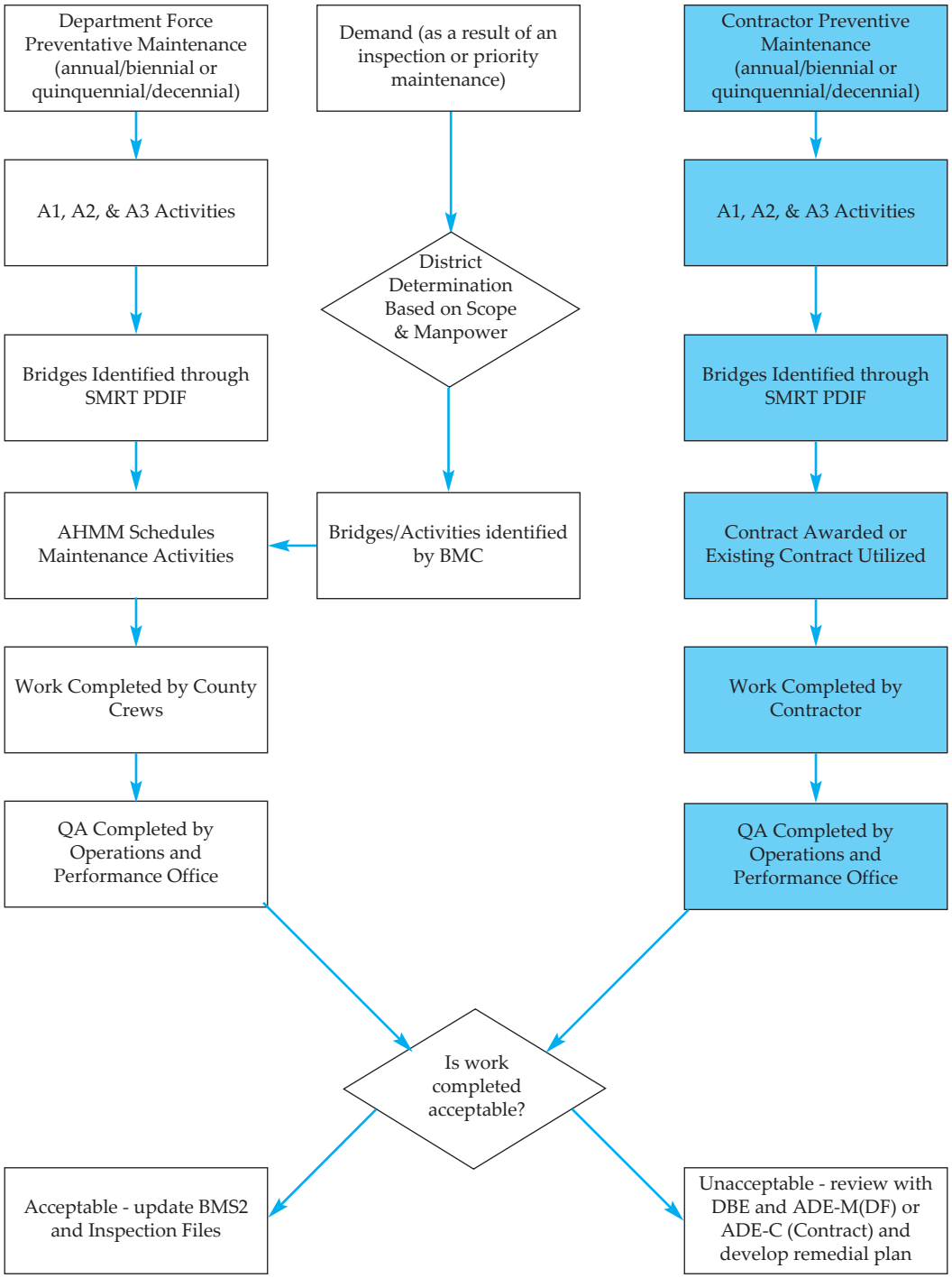
16.2 BRIDGE INSPECTION PROGRAM

The Federal Highway Administration requires that all bridges greater than twenty (20) feet in length on public highway systems be inspected at regular intervals, not to exceed two (2) years, by inspectors having necessary qualifications (Certification). The Department follows the National Bridge Inspection Standards, and additionally, has established a policy of inspecting all bridges under its jurisdiction eight (8) feet or greater in length, also on a two (2) or four (4) year cycle. In some instances, a more frequent inspection frequency is required based on the condition of the structure and/or the posting status.

Bridge inspections are done by a team of inspectors headed by a team leader. The inspection forms (iForms) used for the review, with supplemental photographs, generally serve as the bridge inspection report.

The inspection reports should note all observations relative to the need for corrective maintenance as well as preventive maintenance. These reports can, and should, be used to trigger preventive maintenance activities. The flow of this information and the responsibilities are shown as follows:

bridge improvement activities flowchart



A1 - 711-7431-01 Clean Deck & 711-7431-01 Clean and Flush Scuppers and Downspouts

A2 - 711-7431-02 Clean and Flush Bearings/Bearing Seat & 711-7431-02 Clean and Flush Steel Horizontal Surfaces

A3 - 711-7431-03 Clean and Flush Open Grid Decks and their Supporting Structure

16.3 RESPONSIBILITIES

DISTRICT EXECUTIVE (DE)

The District Executive is responsible for the total operating function of the District, which includes design, maintenance, and construction of bridges.

DISTRICT BRIDGE ENGINEER (DBE)

The District Bridge Engineer is responsible for coordinating the design, construction, and maintenance of the bridges within the District. This includes the coordination of the Bridge Inspection Program and the identification of structure maintenance needs. The Bridge Engineer should convey those needs to the Assistant District Executive for Maintenance, and together should prioritize the needed work.

ASSISTANT DISTRICT EXECUTIVE - MAINTENANCE (ADE-M)

The Assistant District Executive for Maintenance is responsible for the administration of the District Roadway and Bridge Maintenance Program. In this capacity, the Assistant District Executive should be cognizant of the maintenance needs of structures within the District, and in coordination with the Bridge Engineer, should prioritize and schedule the required work to be done by the Department and by contract.

BRIDGE MAINTENANCE COORDINATOR (BMC)

The Bridge Maintenance Coordinator is responsible for coordinating the preventive maintenance efforts on the bridges within the District. The Coordinator should be working with the District Bridge Engineer and Assistant District Executive – Maintenance to ensure the District is in compliance with the MAPI. Additional responsibilities may include SAP notifications and work orders, creating the Structure Needs Inventory, as well as ensuring maintenance activities completed within the District are acceptable (quality assurance) in accordance with this publication and Pub. 55.

HIGHWAY MAINTENANCE MANAGER (HMM)

The Highway Maintenance Manager is directly responsible for ensuring the integrity of the roads and the bridges within his or her jurisdiction. The manager should be cognizant of the preventive maintenance needs of the structures, and schedule and prioritize sufficient preventive maintenance to enhance the life expectancy of the structures.

ASSISTANT HIGHWAY MAINTENANCE MANAGER (AHMM)

The Assistant Highway Maintenance Manager shall assist the HMM and is responsible for all maintenance activities occurring in an assigned area of a county maintenance organization. The Assistant should be involved with the development of plans and programs for the county maintenance organization to accomplish during planned and emergency maintenance activities. The Assistant is also responsible for quality control monitoring of the bridge activities performed by the county maintenance crews and provide a report of their findings to the BMC for review. The AHMM should also notify the BMC and/or Assistant District Bridge Engineering for Inspection when work is completed to ensure data in BMS2 is updated accordingly.

16.4 MAINTENANCE RESPONSIBILTIES OF BRIDGES

The maintenance responsibility of bridges built to carry local, or "off system", roads over or under limited access highways is as follows:

OVERPASS

Where a limited access highway passes over an off system road, the Department will maintain the entire substructure and superstructure. The local jurisdiction will be expected to assume maintenance responsibility on the off system road itself.

UNDERPASS

Where a limited access highway passes under an off system road, the Department will maintain portions of the superstructure and the entire substructure. This will avoid the necessity of having maintenance forces from the local jurisdiction enter the limited access facility to maintain the substructure. The local jurisdiction will be expected to assume maintenance responsibility for the roadway areas including: the wearing surface, sidewalks, parapets and railings, lighting, light standards (if any) and snow removal.

The theory underlying this policy is that any maintenance responsibility the local authorities would have had, if the road had remained at grade, remains their responsibility after construction of the bridge.

If the Department had constructed a road in a Township that required a bridge to be placed over the Department's road, then the Township would be responsible for only the wearing surface on the bridge. The reason for this is that the wearing surface is part of the Township's road. However, the bridge structure is the responsibility of the Department since the Department's roadway resulted in a need for the bridge. Additionally, if the Township neglected to maintain the wearing surface and this results in damage to the structure, the Department could recover the damage incurred from the Township's neglect.

16.5 BRIDGE MAINTENANCE PLANNING

Developing and maintaining a plan for completing bridge maintenance is a vital step to ensuring continued serviceability of bridges. Highway Maintenance Managers must work with the District Bridge Unit and District Maintenance Unit in developing a strategic plan that prioritizes bridge maintenance activities in the annual county maintenance work plan. Publication 23, Chapter 16, provides a very basic scheduling outline that defines when specific work is to be completed. The strategic plan should include both Bridge Preventative Maintenance and Bridge Demand Maintenance as follows:

PREVENTIVE MAINTENANCE

The District and County should schedule and complete the following Preventive Maintenance activities annually. All required cleaning activities shall be completed from March 1st through October 31st. "Cleaning" is defined in this section as "manually and/or mechanically sweeping of the bridge deck and shoulders, debris removal from the deck joint system(s) and drainage system(s)." For Interstates and Expressways, the deck surface cleaning must be completed by Memorial Day. Districts and their respective Counties are not responsible for new bridges constructed and maintained under the governance of P3.

1. 711-7431-01 Clean Deck (A1)

   A. Clean - 100% of state-owned bridge decks per year, except structures under fill (refer to Publication 100A, Item 6A38 = 01).

   B. For structures constructed via a P3 project, counties are responsible for the preventive maintenance each CY until the P3 contractor receives an actual Notice to Proceed (NTP) P3 date within the current CY for the structure.

   C. Flushing is no longer mandatory as part of A1 deck cleaning.

   D. No bridge flushing operations shall be performed during these periods:

      1) On any "Pre-Season" trout stream stocking day(s),

      2) During the first two (2) weeks of trout season,

      3) On any "In-Season" trout stream stocking day and two weeks thereafter

Outside of the periods listed above, flushing can be performed during the PFBC stocked trout stream restriction period of February 15th through June 1st, when the following requirements are satisfied:

1) Prior to any flushing operations all heavy materials, e.g. dirt, debris, anti-skid aggregates, etc., shall be removed from the deck or horizontal surfaces and bearing areas by manual or mechanical methods and be disposed of by environmentally sensitive means.

2) Physically block all deck drainage facilities with sand-bags or other mechanical devices to not allow deck joint(s) flushing water to enter the stream directly and follow the requirements outlined in No. 4 below.

3) Bridge decks that do not have drainage facilities can be flushed when requirements outlined in No. 4 below are provided during the deck flushing operation(s).

4) Place "Hay-Bale" Erosion & Sedimentation Controls (Best Management Practice) at the bridge deck termination, where the flushing water flows onto the roadway embankment(s). Hay-Bale placements are not required where the existing roadway embankments provide a vegetative filter for the flushing water to flow through prior to entering the stream.

The Counties can use the PA Fish and Boat Commission website information to determine if and when a waterway is "stocked" with trout or to determine the statewide trout season "Opening Days" (PA Fish and Boat Opening Day & a Trout Stocking).

Districts should coordinate with the Pennsylvania Fish and Boat Commission (PFBC) for spawning periods prior to initiating work.

2. 711-7431-01 Clean and Flush Scuppers and Downspouts (A1)

   A. Scuppers - 100% functional annually, regardless of programming schedule.

   B. Downspouts - 100% functional annually regardless of programming schedule.

   C. Stocked trout stream restrictions outlined in 1.D above apply.

3. 711-7431-02 Clean and Flush Bearings/Bearing Seat and/or 711-7431-02 Clean and Flush Steel Horizontal Surfaces (A2)

   A. Clean and flush – minimum of 20% of all state-owned structures with bridge deck joints (e.g. expansion devices on the bridge or open joints, refer to Publication 100A, Item D.10) annually except the following eleven structure types:

      1) Concrete Arches
      2) Metal Plate Arches
      3) Adjacent Box Beams
      4) Concrete Rigid Frames
      5) Slabs
      6) Encased I-beams
      7) Culverts (Box, Frame, Arch, Pipe)
      8) Concrete Drainage Structures
      9) RC T-Beams
      10) Tunnels
      11) Timber

   B. The eleven (11) structure types listed above should be cleaned on an as needed basis.

   C. The DBEs shall populate and maintain VD31 and VD32 in BMS2/iForms to establish structures within their Districts that require an A2 cleaning and flushing. By December 31st in the preceding CY, the DBE can add structures to the Statistics, Measures and Results for Transportation (SMRT) PDIF list via VD31 and VD32 which need cleaning and flushing of bearing seats and/or horizontal surfaces as well as any other special cleaning and flushing directions based on knowledge of the structure's maintenance history and inspection reports. For bridges without deck joints, DBEs must indicate a count of bearing seat areas and horizontal surfaces in VD31 as well as a written description of specific locations in VD32 to be cleaned. These additional structures will be added to the SMRT PDIF count to ensure counties receive credit towards their MAPI score.

   D. These areas (bearings, seats and/or horizontal surfaces) shall be cleaned, unless the deck joints are removed via a rehabilitation or replacement project within the current CY or if the structure is a jointless bridge and not added to the cleaning list by the DBE.

   E. Each structure requiring cleaning shall be cleaned and flushed at least once every five years.

   F. Stocked trout stream restrictions outlined in 1.D above apply.

4. 711-7431-03 Clean and Flush Open Grid Decks and their Supporting Structure (A3)

   A. Clean and Flush- 100% of state-owned bridges which are not programmed for deck and/or superstructure rehabilitation or replacement within the current CY; task is to be completed annually.

   B. Stocked trout stream restrictions outlined in 1.D above apply.

NOTE: The MAPI measures county performance in activities 1-4 above.

All preventive maintenance activities should be performed in accordance with the performance standards listed in the Bridge Maintenance Manual (Publication 55).

Preventive maintenance is considered to be a primary deterrent to premature deterioration of critical structural elements of bridges, and as such, commands high priority in the realm of work planning, scheduling, and accomplishment.

The preventive maintenance activities (cleaning and flushing) can be performed by a crew other than the bridge crew at the discretion of the HMM. This would be preferable as it affords the bridge crew more time to concentrate on specialized bridge maintenance activities, such as miscellaneous steel repairs, joint repairs and replacements, and epoxy overlays.

DEMAND (PRIORITY) MAINTENANCE

A series of meetings should take place between the District Bridge Unit, the District Maintenance Unit and the County Maintenance Office. The first meeting should be held no later than December 15th, which should include the DBE, Assistant District Bridge Engineer of Inspection (ADBE-I), BMC, the Maintenance Programs Engineer and the HMM. In this meeting, a list of major and minor projects to be completed by the county should be prioritized and agreed upon by this group. The District Bridge Unit should identify Maintenance Items coded 2 (Priority) and 3 (Schedule) which exist for structures where preventive and demand maintenance is to be performed. The completion of these items should be scheduled concurrently with preventive and demand maintenance items scheduled for a particular bridge.

A second meeting should take place, before February 1st, among the BMC, Bridge Unit Representative, HMM, AHMM and the County Bridge Foreman. The purpose of this meeting is to develop an annual work plan from the prioritized list of bridge projects agreed upon during the initial meeting.

Counties shall schedule an annual work plan, allowing for a minimum of eighty percent (80%) of the available required Priority 2 and 3 maintenance repair items assigned annually by the District Bridge Engineer (DBE) or their designated representative; and for physical completion of 100% of assigned Priority 0 and 1 maintenance repair items. The Priority 2 and 3 maintenance items list (updated yearly and listed in the Bridge Management System (BMS), Inventory Links, Maintenance Screen, Field M.22-MAPI Plan Year) is to be completed annually by the Counties and shall be established and approved by the DBE no later than March 24th of each calendar year. The completion of the assigned Priority 2 and 3 bridge maintenance items will be monitored and scored in accordance with the MAPI Metric FOM05. This schedule may include Assembly 711- 7325-01 activities (Repair or Replacement of structures under 8' in length).

16.6 PREVENTIVE MAINTENANCE & PRESERVATION ACTIVITIES

Preventive maintenance is only required on specific elements of a structure, and it is likely that this chapter will be used by maintenance crews with little or no structural training. In the event maintenance crews find a high priority maintenance activities, the maintenance crews should report their findings to the AHMM and BMC. The following material will be presented with as little theoretical reference as possible.

DECKS

Proper maintenance of bridge decks is very critical, not only from a structural preservation viewpoint but also from one of public perception. Decks littered with antiskid materials contribute to the chloride contamination of concrete and corrosion of reinforcing steel which, in turn, accelerates the formation of potholes and the ultimate deterioration of highway structures.

Decks normally consume a large part of the maintenance dollar, and all efforts to reduce these sometimes unnecessary expenditures should be encouraged as much as possible by managers at all levels. A quality deck preventive maintenance program will go a long way in minimizing repair costs.

DEBRIS AND CHEMICAL ACCUMULATION

Cleaning: Winter snow and ice removal activities deposit antiskid materials and chemicals on bridge decks which normally tend to accumulate over the winter within the area of the water table near scuppers and around structural members (panel points of trusses, flange angles, and bottom flanges of plate girders). When the threat of snow has subsided to a reasonable level, this debris should be removed by sweeping (Assembly 711-7431-01 Clean Deck) and according to the performance standards listed in Publication 55, Bridge Maintenance Manual. Assembly 711-7431-01 Clean Deck activities should be repeated if additional weather events require re-application of anti-icing and/or anti-skid materials on bridge decks.

Care should be exercised when cleaning decks to prevent debris from entering the drainage system (scupper and downspouts) which could compromise the drainage system. Structural members of the superstructure such as end posts, diagonals and vertical web members, panel points of trusses and flange angles, stiffeners, web plates and bottom flanges of plate girders that lie within the wheel splash zone should also be cleaned of debris and salt residue by pressurized flushing, air blasting, scraping, brushing or mechanical devices. Areas that exhibit signs of corrosion should be noted, reported to the Bridge Engineer and scheduled for painting or repair.

PROTECTIVE COATINGS

Protective coatings for reinforced concrete surfaces are available that prevent or minimize scaling or spalling. Apply penetrating sealers to exposed concrete roadway surfaces of bridge decks, to curbs, sidewalks, divisors, concrete median barriers, inside and top surfaces of parapets and to abutments, pier caps and end walls. Materials which can be used are boiled linseed oil, epoxy-resin, and penetrating sealers. To be effective, these sealants should be applied before opening the roadway to traffic. For application rates and when to apply, refer to Pub. 408, Section 1019. Coordinate with the District Bridge Engineer before using.

CRACKING

Concrete Deck cracking is a linear fracture of the deck concrete. It may extend partially or completely through Chapter 16: Bridge Maintenance PUB 23 - MAINTENANCE MANUAL 16-8 the deck. The cracks are classified as longitudinal, transverse, diagonal, alligator, pattern, map or random.

Isolated longitudinal, transverse or diagonal cracks should be sealed using the procedures outlined in Pub 408, Section 1091.

Asphalt deck surface cracking is very similar to roadway pavement cracking and is classified as alligator or map cracking, where the edge cracks have joint cracks, reflection cracks, shrinkage cracks and slippage cracks. Alligator and slippage cracks should be repaired by removing the distressed area to sound material and patch using conventional pothole patching procedures. The remaining types of cracks should be sealed using the procedures outlined in Publication 113 for Assembly 711-7128-01. Early detection and repair of minor cracks is very important to prevent more serious defects. Frequent, close inspections should be made.

In some instances based upon the capabilities of the Bridge Crew, a new epoxy overlay may be applied by Department Forces if the condition of the deck warrants such activities; a determination shall be made by the DBE.

BRIDGE DECK JOINT SYSTEMS

Bridge deck joint systems are a very important part of the bridge superstructure and one that is very often overlooked by maintenance forces. Joints allow movements of the superstructure under live loading as well as thermal expansion and contraction. They, also provide protection to the substructure by waterproofing the area under the joint. Joint systems that are not properly designed or maintained allow chemically laden moisture and debris to reach critical structural elements beneath the deck road system. Bridge seats and bearings are very susceptible to corrosion by deicing chemicals and are normally located directly below the joint areas. Deck joints are classified as open or closed joints. Open expansion joints are designed to provide for longitudinal movement of the superstructure and perhaps some means of partially bridging the joint opening to permit traffic to cross smoothly.

Closed expansion joints consist of an arrangement of various materials to completely seal bridge joint openings and also provide for longitudinal movement of the superstructure. Such devices may or may not provide water proofing in their design.

Repairs of both open and closed expansion joints will provide a cost savings over the life of the bridge. When joints are deteriorated and allow leakage of water and associated debris to fall onto the superstructure and substructure units, additional cleaning will be required to prevent accelerated deterioration. Below, the left photograph is an approved method for cleaning the joint. The right photograph shows a joint where a repair is needed in addition to cleaning the joint.



Effective Cleaning Method



Joint Needs Repaired

OPEN JOINTS

Open joints chiefly consist of sliding plate, finger joints, normally on larger structures with long spans, and an open joint consisting of formed concrete edges or, in some cases, armored edges. Many of the latter use a mastic or other type of sealer to prevent the intrusion of debris and to waterproof the area below.

1. Finger joint

   Finger joints are not capable of being sealed but some may provide drainage control by placing a drain trough directly below the finger joint to collect and direct runoff to the bridge drainage system.

   The most common problem associated with this type of open joint expansion system is the clogging of the drainage trough with roadway litter, antiskid and other debris; and when a drainage route is not provided, the roadway drainage carries and deposits deicing chemicals and debris onto the support system as well as the flanges of superstructure members. This accumulation will often prevent proper operation of the expansion device by clogging the expansion finger openings which may cause the fingers to raise.

Drain troughs should be cleaned frequently to prevent clogging, and if extreme difficulty is experienced in cleaning, modifications should be made to the system to facilitate cleaning and flushing. The cleaning of the trough should be completed when the deck cleaning and flushing is completed. If the deck is kept clean, a minimum amount of debris will enter the drainage system and will reduce the need for frequent cleaning.

2. Sliding plate

   The sliding plate consists of a horizontally positioned flat steel plate anchored into the bridge deck at one edge and permitted to slide across an angle anchored to the opposite edge of the opening (armored edge). The major problems associated with this type of joint is that while the joint design deters the passage of dirt and debris through the joint, it fails to prevent water and dissolved chemicals from reaching the bridge elements underneath. Also, antiskid and road patching material, if permitted to accumulate and compact along the free edge of the sliding plate, will produce increased resistance to expansion and may eventually lead to deformation of the plate or to cracking of the deck.

   Little can be done to prevent this type of joint from leaking. If leakage is a problem, one solution to the problem is to install a drain trough beneath the expansion device to collect and drain water passing through the joint away from sensitive areas. Sheet metal deflectors may also be installed as an interim measure to prevent water from draining onto flanges, bearings, bearing seats, etc.

   Sliding plate expansion devices (properly designed and installed) are relatively trouble free. Occasional cleaning of the small trough between the fixed and sliding parts of the device prevents the device from binding. Frequent cleaning of the deck, especially after the winter season, will minimize the deterioration of the structure beneath the expansion joint subjected to water and dissolved contaminants.

3. Other Open Joint

   Other open joints that generally provide a mastic sealant material to prevent the intrusion of debris and to waterproof the areas beneath should be inspected during the structure preventive maintenance and if any signs of sealant failure are present, the joint should be cleaned and resealed. The work should be done as per the procedures outlined in Publication 55, Assembly 711-7433.

CLOSED JOINTS

The following types of closed joints are used in the Commonwealth: premolded filler, compression seal, and elastomeric expansion devices.

1. Elastometric Expansion Device

   Elastomeric expansion device is general terminology defining a sealed, waterproof joint system utilizing steel plates and angles molded into a neoprene covering. The steel provides for anchorage and load transfer while the neoprene serves as a protective covering for the steel and a waterproof material to prevent water from passing through the joint system.Little preventive maintenance is required of this expansion device other than frequent cleaning. Cleaning should be done each spring after the threat of snow has subsided.

   Little preventive maintenance is required of this expansion device other than frequent cleaning. Cleaning should be done each spring after the threat of snow has subsided.

2. Premolded filler (filled butt joint-hot poured sealant)

   A premolded joint material usually made out of rubber is used to seal butt joints. The joint material is usually attached to one face of the joint or supported from below by an offset in the vertical face of the slab. A sealing compound is poured from the roadway surface to seal the opening. Maintenance requirements include annual cleaning, replacement of the surface seal, replacement of the filler when necessary and repairs to the roadway surface adjacent to the joint. If the seal is not kept watertight, the filler below will deteriorate and make resealing difficult. Non-compressibles that work their way into the seal can cause the joint to jam.

3. Compression Seals

   Compression seals consist of various types of extruded neoprene (or similar material) whose design and elastic properties provide for the retention of its original shape. The seal is installed in a preformed joint opening at the span ends. An adhesive provides a bond between the joint face and the sealant to produce a waterproof system.

   Preventive maintenance of this type of seal mainly consists of frequent cleaning of the joints to remove antiskid material and other debris from the recess between the top of the joint material and the surface of the deck. The abrasive action from this debris will cause rapid wearing of the top surface of the seal if the debris is permitted to accumulate on top of the seal.

DECK DRAINAGE SYSTEMS

The operation and maintenance of bridge drainage systems is a very important element of bridge preventive maintenance. Deck drainage is required for proper maintenance of bridges since the lack of proper drainage affects many elements of the structure.

Poor drainage is normally due to the accumulation of antiskid material and other debris within the drainage system preventing proper operation. Backed up water might then freeze and rupture the pipe, and may contain corrosive chemicals which, when leaked through the rupture, will attack structural elements of the bridge. Bridge drainage systems consist of: scuppers–drop through and piped, gratings (open steel grid floors), open joints with troughs and all associated piping.

1. Scuppers

   Scuppers are provided in bridge decks to collect the water on the deck and direct the water through short-drop through pipes or into a closed drainage system of relatively small diameter. Each type of downspout pipe presents its own individual problems; these problems--long downspouts, horizontal runs with inadequate slope, sharp directional changes and small diameter discharge pipes--are all conducive to clogging. Short-drop through pipes that drain directly under the bridge may cause corrosion of structural steel and concrete surfaces of piers and abutments and possibly erode abutment earth slopes. Below is an example of both a clogged and properly cleaned scupper.



Before



After

   All scuppers should be examined frequently for proper operation and cleaned when necessary. Antiskid or other debris should be removed by water pressure or metal probes. Particular attention should be applied when flushing antiskid from decks to prevent it from entering the drainage systems and compounding the problem.

   Protective coating may be applied to piers, structural steel and any other elements exposed to the corrosive liquids from drop through scuppers to prevent or retard corrosion.

2. Gratings

   Open grid decks (open steel grid floors) provide very good drainage of the deck but don't protect the superstructure and substructure elements from the damaging corrosive elements that accumulate on the structural members below the deck.

   All debris should be removed from beams, girders, pier caps and bearings. Yearly inspection and cleaning is necessary to prevent this accumulation.

3. Open Joints and Throughs

   As mentioned under bridge deck joint systems, troughs under open joints are susceptible to debris accumulation with subsequent backup of drainage which contributes to the accelerated deterioration of concrete, corrosion of steel and erosion of earth. These troughs should also be inspected for tears and clogging at frequent intervals and repaired or cleaned as required.

SUPERSTRUCTURE SYSTEMS

Bridge superstructures in the Commonwealth are made of either steel, concrete or timber. Since the vast majority of the superstructures are made of steel or concrete, this section will concentrate only on those types.

1. Bearings

   Bearings are used to transmit and distribute the superstructure loads to the substructure while permitting the superstructure to undergo necessary movements without developing harmful stresses. The various types of bearings are: roller expansion bearings, fixed steel bearing, rocker expansion bearings, sliding bearings, pot bearings, elastomeric bearings or pin and hanger bearings.

2. Steel

   An effective preventive maintenance measure to control rust and resultant corrosion of steel bridge members is to spot/zone paint exposed members.

   It shall be Department policy to include spot and zone painting as an option in the District bridge painting program.

   Spot and zone painting should be scheduled on a four (4) or five (5) year cycle unless conditions warrant otherwise. Qualified bridge painting inspectors with training and/or knowledge related to the various paint systems shall be assigned to inspect the work. Reference Pub 55 for permit requirements.

3. Concrete

   Concrete deck structures have a common problem in that the riding surface is an integral part of the structure and any loss of bond between the reinforcement and concrete because of spalling, steel corrosions or wearing will reduce the load capacity of the structure. Unbonding of the reinforcement in the top mat of the slab is normally associated with chloride contamination of the deck and reinforcing steel. A waterproof membrane is normally provided to reduce or prevent this contamination. However, from a purely preventive maintenance approach, little can be done other than a regular program of deck cleaning and possibly the application of a penetrating sealant or an epoxy overlay.

4. Beam ends

   Beam ends, which would include the last five feet of the beam and the back side of the bearing at expansion joints, are most vulnerable to be damaged due to leaky joints. Beam ends should be flushed along with the cleaning of bearings and beam seats. Such cleaning will minimize deterioration and extend bridge life. Preventive maintenance procedures will vary depending on the type of beam and superstructure design at the bearing locations. See Pub 55, Chapter 11 for bridge cleaning procedures affecting beam ends.

   A. Have a program to clean dirt and debris off caps, seats, beam ends and bearings at regular intervals usually in the spring after the threat of snow and ice has subsided.

   B. Have a program to properly maintain deck joints that are designed to be sealed but are not functioning properly and are allowing moisture and debris to fall on the bearing areas.

SUBSTRUCTURE SYSTEMS

The substructure of a bridge is the portion that transmits the load and stresses from the superstructure or load supporting system to the ground. Substructures may be classified as abutments or piers. Footings, piles, columns, walls, pedestals, caps, and bridge seats are components of the substructure. While all of the above are important, the discussion in this section will concentrate on the problems associated with bridge caps, seats and bearings systems and how they relate to preventive maintenance.

1. Caps and Bridge Seats

   This element is the top of the piers, bents and abutments upon which the bearings rest. Any deterioration of this section could result in differential settlement of the superstructure and unanticipated stresses. The most common problem is the general deterioration of the concrete. This can be the result of chemical attack, poor aggregates, poor concrete, freeze/thaw damage, insufficient reinforcing steel coverage or various combinations of these. The damage is usually in the form of scaling, popouts or sloughing off at the corners. Due to the proximity of leaking joints which tends to deposit chemical-laden dirt and debris in this area, the depth of deterioration is likely to be greater at this location than at other locations.

   The most important step in preventing damage to the caps and seats is to reduce the amount of leakage from the joints. Runoff from scuppers and joints should be diverted by pipes or splash plates. The chemical-laden dirt and debris should not be allowed to accumulate on these surfaces. These surfaces should be flushed annually after the threat of snow and ice has diminished or passed.

   In the event the caps and seats are steel, the most common problem is rust and the resultant corrosion. The same preventive maintenance procedures outlined for concrete should be followed for steel and, in addition, proper painting schedules should be developed to prevent corrosion problems.

PRESERVATION ACTIVITIES

As bridge owners, PennDOT must continue our efforts to adapt and implement systematic processes for bridge preservation by expanding maintenance practices to include bridge preservation activities. Bridge preservation must be an integral component of our overall bridge asset management plan; opportunities to address bridge preservation activities cannot be overlooked. The “opportunity cost” of not performing preservation activities is increased life cycle cost to maintain bridges in a state of good repair.

A successful bridge program seeks a balanced approach to preventive maintenance, preservation, and bridge replacement. Focusing on replacing deficient bridges, while discounting preservation needs will be inefficient and cost-prohibitive in the long term. The objective of good bridge preservation is to employ cost effective strategies and actions to maximize the useful life of bridges. Applying the appropriate bridge preservation treatments and preventive maintenance activities at the appropriate time can extend bridge useful life at a lower lifecycle cost.

A County's bridge preservation maintenance work should be prioritized during all County and District bridge maintenance planning sessions. While our Counties annual plan focuses bridge maintenance efforts on immediate needs, the strategic bridge preservation plan must look forward several years to upcoming and anticipated large-scale needs. Bridge preservation activities must be balanced with sound preventive maintenance activities, structure replacements, and the necessary repairs required for unforeseen critical and high priority maintenance items. Some suggested frequencies for certain bridge preservation activities are listed below:

Bridge Component	Bridge Preservation Activity	Recommended Action Frequency (Years)
***Deck	Epoxy & **Polyester Polymer Concrete overlays	10 Epoxy 25 PPC
Deck	Concrete deck patching	As Needed
***Deck	Asphalt overlay with membrane	8 Asphalt Overlay 20 Membrane
***Deck	**Latex Modified Concrete overlay	15-25
Deck	Joint repair / replacement	20 (Periodic replacement of the gland or trough should be expected)
***Deck	**Structural Reinforced concrete overlay	15-25
Superstructure	*Painting - spot	10 (surface cleaned w/ power tools)
Superstructure	Bearing (steel) repair / replacement	50 or during a major rehabilitation project or deck replacement
Substructure	Pedestal / Bearing Seat repair / replacement	50
Substructure	Scour counter measure	10 or as required from inspection findings
Substructure	Channel restoration	10 or as required from inspection findings
Superstructure & Substructure	Superstructure & Substructure Component(s) repairs / replacements	50

* Before a final decision to spot paint is made perform an asbestos containing material and a lead paint / toxic heavy metal assessment. PennDOT Publication 408 (Highway Construction Specifications) – Sections 1060, 1070 and 1071, PennDOT Publication 55 (Bridge Maintenance Manual), and Publication 445 (Safety Policy Handbook) – Medical Surveillance Program Section, should be reviewed for additional information regarding lead paint / toxic heavy metals work requirements.

** This type of bridge preservation activity is typically performed by contracting.

*** Consult with the District Bridge Unit prior to completing deck preservation overlay activities.

16.7 BRIDGE CLEANING QUALITY ASSURANCE ACTIVITIES

The distinction between quality control and quality assurance is important since each function has a specific purpose and a different organizational level responsible for its administration.

Quality Control (QC) is the implementation, by a supervisor, of maintenance procedures outlined in Pub. 55 that are intended to ensure the quality of a product or service at or above a specified level. This includes ensuring preventive maintenance was completed in accordance with applicable publications. Quality control of the preventive maintenance of state bridges is a continuous operational function performed within each county under the supervision of the AHMM and HMM.

The Operations and Performance Office may perform Quality Assurance (QA) Reviews of the County's bridge cleaning operations under maintenance assemblies 711-7431-01 through 03. These bridge cleaning QAs will be completed utilizing Form M-7431 announced under Memo – "Bridge Cleaning and Flushing Quality Assurance Review" dated April 1, 2020. Specific details regarding the QA review(s) should be directed to the County's applicable Regional Manager.

16.8 STANDARDS FOR BRIDGE CLEARANCE, CHANNEL IMPROVEMENT AND BRIDGE REHABILITATION PROJECTS (PENNDOT)

Ensure that environmental permits or approvals are in place prior to beginning work. Different environmental permits or approvals are required depending upon the type of work to be undertaken. Refer to Publication 55 Bridge Maintenance Manual Chapter 3 Section "Stream Permitting Basics" to determine the appropriate permit or approval required for the type of work. Once the appropriate approvals are obtained, follow all conditions within the approval as well as the requirements in Publication 55 for the type of work being performed.

A portion of the work in a maintenance project may be performed through a contract. In the event that any part of the work is performed by a contractor, the District Construction Unit must manage the work to ensure the contractor is in compliance with the permit or approval at all times.

16.9 BRIDGE COMPONENT DEFINITIONS

Bridge - A structure including supports erected over a depression or an obstruction such as water, highway or railway and having a track or passageway for carrying traffic or other moving loads and having an opening of more than eight (8) feet between undercopings or abutments or spring lines of arches. The bridge approach slab is considered to be part of the structure.

Bridge Length - The greater dimension of a structure measured along the center of the roadway between backs of the abutment backwalls or between ends of the bridge floor.

Bridge Roadway Width - The clear width of structure measured at right angles to the center of the roadway between the bottom of curbs or, if curbs are not used, between the innerfaces of the parapet or railing.

LOADS ON STRUCTURES

Dead Load - The weight of the structure itself and the weight of any permanent fixtures which are supported by the structure. It is a fixed load which remains in position during the life of the structure unless removed and can be increased.

The most common cause of an increase in dead weight is the placing of additional wearing courses.

Live Load - The live load includes all loads or forces due to vehicular or pedestrian traffic which act on the structure.

Impact Load - This is an allowance, equal to a calculated percentage of the live load which is added to the live load of the structure to provide for the dynamic and vibratory efforts of traffic loadings.

Wind Load - The effect of wind blowing against the structure and the live load.

Longitudinal Forces - The effect of the forces created by traffic moving across the bridge. These forces act longitudinally; i.e., parallel to the center of the bridge.

Thermal Forces - This is a force applied to the structure due to temperature variation.

DECK ELEMENTS

Wearing Course - The wearing course provides the riding surface for traffic and is placed on top of the structural slab. There are also wearing courses poured integral with the structural slab. When this technique is used it is generally referred to as a monolithic deck.

Wearing courses can be either asphalt concrete or portland cement and are not considered to provide load carrying capacity.

Structural Deck - The structural deck or slab provides the load carrying capacity of the deck system.

Typical structural deck systems are:

- Reinforced concrete
- Precast concrete planks
- Steel Plates (Orthotropic decks) within thin wearing course overlay
- Wood Planking
- Prestressed concrete box beams
- Steel grid (open or concrete filled)

Sidewalks - Sidewalks are provided on structures where pedestrian traffic counts warrant their use. Otherwise, safety walks are generally recommended.

Typical sidewalks are:

- Reinforced concrete
- Steel plate
- Wood planking
- Filed grid

Curbs - Curbs are provided in conjunction with sidewalks and safety walks. Curbs can be constructed of reinforced concrete, pre-cut granite, timber or steel plate.

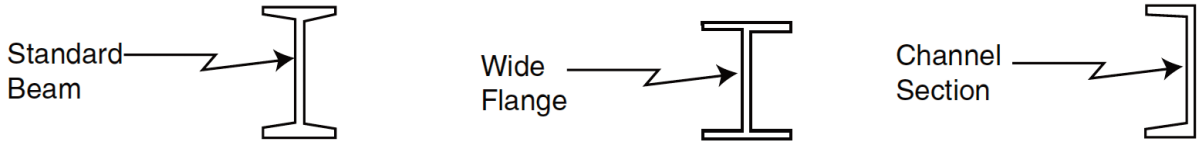
Railings - Railings are placed along the extreme edges of the Deck system and provide protection for traffic and pedestrians. There are a wide variety of railing materials and configurations. Some of the more common are:

- Metal multiple rail systems
- Box Beam
- W-Beam
- Reinforced concrete
- Timber

SUPERSTRUCTURE ELEMENTS

Rolled Beams The rolled beam is used for short spans. The beam comes from the rolling mill as an integral unit composed of two flanges and a web. The flanges resist the bending movement and the web resists shear.

The more common types of rolled beam shapes are:



The following illustrates a typical longitudinal section for a rolled beam span:

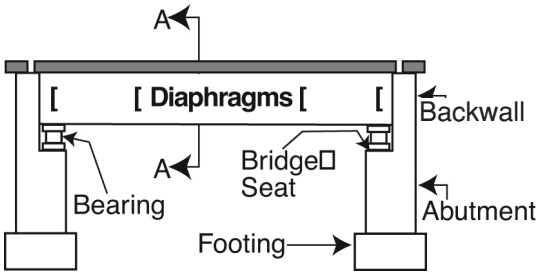
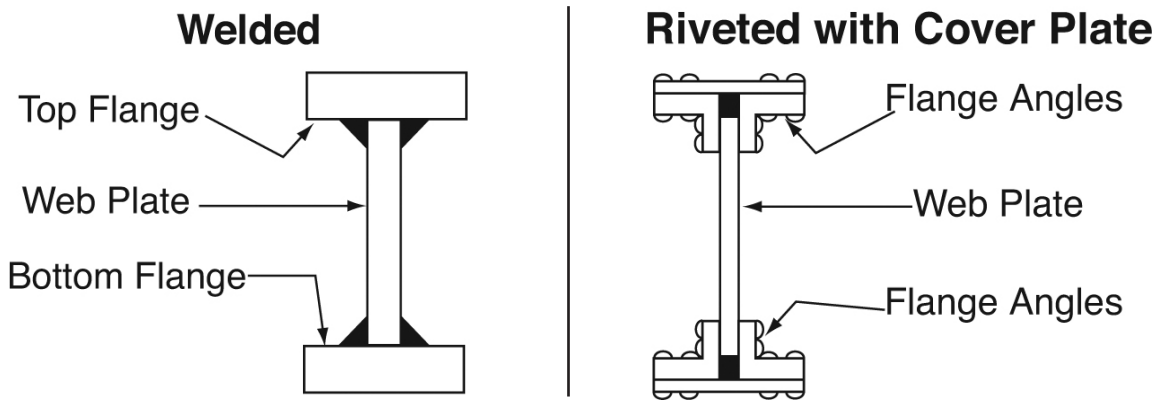
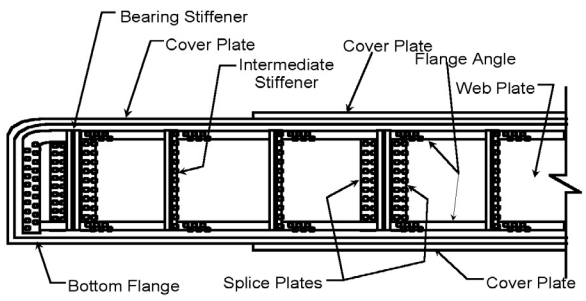


Plate (built up) Girders - This type of structural member is used for intermediate span lengths not requiring a truss and yet requiring a member larger than a rolled beam. The basic elements of a plate girder are a web to which flanges are riveted or welded at the top and bottom edges.

The most common forms of cross section are shown below:



The component parts of a typical plate girder are illustrated below:



The portion above the neutral axis of the plate girder will be in compression and the portion below the neutral axis will be in tension for simple span structures.

1. FLANGE ANGLES - Flange angles are used for riveted plate girders and carry tensile or compressive forces induced by bending.

2. COVER PLATES - Cover plates are welded or riveted to the top and/or bottom flanges of the girder to increase the load carrying capacity.

3. BEARING STIFFENERS - These are either plates or angles placed vertically at the location of the support and attached to the web. Their primary function is to transmit the shearing stresses in the web plate to the bearing device to prevent web crippling and buckling.

4. INTERMEDIATE STIFFENERS - Intermediate stiffeners are used at points of concentrated loads or for deep girders to prevent web crippling and buckling.

Reinforced Concrete Beams - Concrete beams are reinforced with steel reinforcement which carries the tensile stresses (whether resulting from bending, shear or combinations thereof produced by transverse loadings) are by design carried by the steel reinforcement. The concrete takes compression and shear only. These beams are commonly rectangular or T-shaped with its depth dimension greater than its stem width.

Prestressed Concrete Beams - The two main types of prestressed concrete beams are box beams and I-beams. The box beams are constructed with a rectangular cross section with a single void inside. The top and bottom slabs of the box act as the flanges while the sidewalls act as webs. The most common prestressed concrete I-beams are the AASHTO shapes. The cracking and tensile forces in the prestressed concrete are greatly reduced by compressing it with pretensioned strands, wire, or bars.

Pin Hanger Connections - These connections are devices put in bridges to permit expansion movement and rotation. When they are used in suspended span configurations in nonredundant two-girder bridges, they are fracture critical.

Trusses - The truss is one form of structural system which, because of its characteristics, can be used to span greater lengths than rolled beams and girders. The truss functions basically in the same manner as a rolled beam or girder in resisting loads--the top and bottom chords act as the flanges of the beam and the diagonal members act as the web.

Typical types of structural systems that are used for highway structures are illustrated as follows: (These truss types may be used as "Thru Type" or "Deck Type".)

1. CHORD - In a truss, the upper and lower longitudinal members extending the full length are termed chords. The upper portion is designated the upper or top chord and correspondingly the lower portion is designated the lower or bottom chord. For a simple span, the top chord will always be in compression and the bottom chord will always be in tension and should be considered a main structural member. Failure of either chord will render the truss unsafe.

2. DIAGONALS - The diagonal web members span between successive top and bottom chords and will either resist tension or compression depending on the truss configuration and the live load position. Most diagonals are also main structural members and their failure would be extremely critical and render the truss unsafe.

3. VERTICALS - Vertical web members between top and bottom chords which will resist either tension or compression stresses depending on the truss configuration. Most verticals are also main structural members and their failure would usually be critical and render the truss unsafe.

4. PANEL POINT - The point of intersection of primary web and chord members of a truss.

Items 5 through 11 below can be considered secondary structural members and, although their failure should receive immediate attention, an individual member failure will not render the structure unsafe.

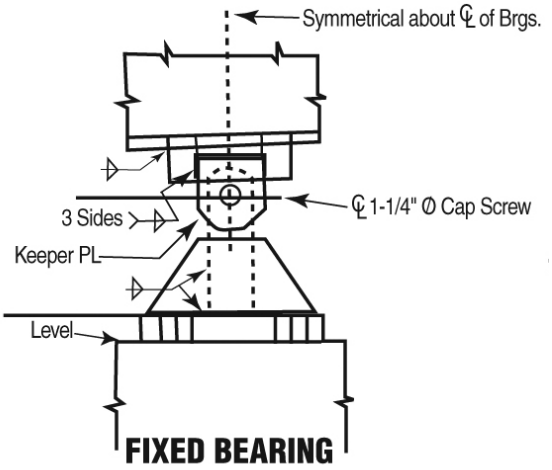
5. PORTAL BRACING - The portal bracing is found overhead at the ends of a thru truss and provides lateral stability and shear transfer between trusses.

6. SWAY BRACING - Sway braces are secondary structural members spanning between the trusses at interior panel points and provide lateral stability and shear transfer between trusses.
7. TOP LATERAL BRACING - The top lateral braces lie in the plane of the top chord and provide lateral stability between the two trusses and resistance to wind stress.
8. BOTTOM LATERAL BRACING - The bottom lateral braces lie in the plane of the bottom chord and provide lateral stability and resistance to wind stresses.
9. FLOOR BEAM - The floor beam spans between trusses at the panel points and carry loads from the floor stringers and deck system to the trusses.
10. STRINGERS - The stringers span between floor beams and provide the primary support for the deck system. The deck loading is transmitted to the stringers and through the stringers to the floor beams and to the truss.
11. GUSSET PLATES - These plates connect the structural members of a truss, on older trusses, pins are used instead of gussets.

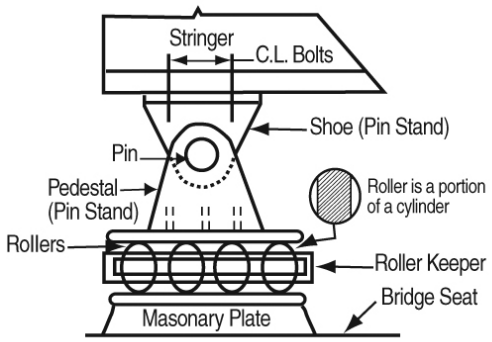
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Bearings - Bearings transmit the superstructure load to the substructure. They are also provided for longitudinal movement due to expansion and contraction and rotational movement due to deflection.

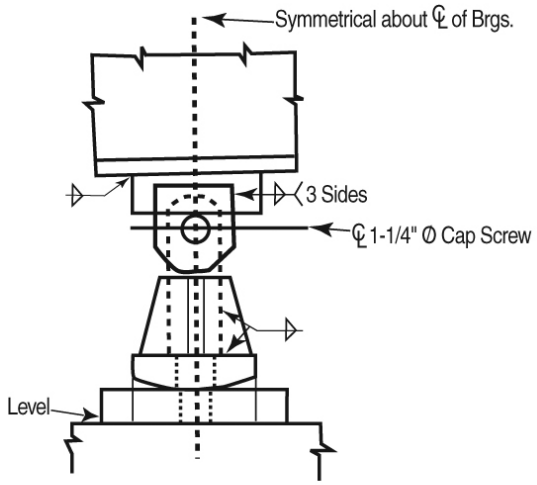
SOME TYPICAL BRIDGE BEARINGS



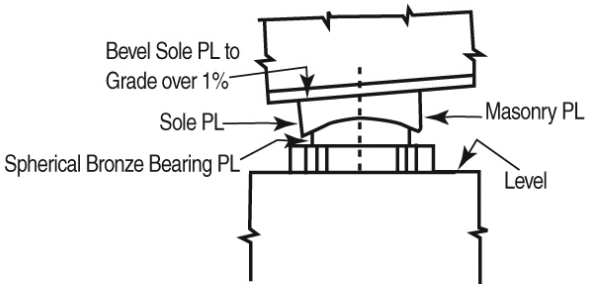
FIXED BEARING



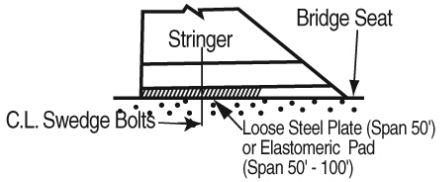
ROLLER EXPANSION BEARING



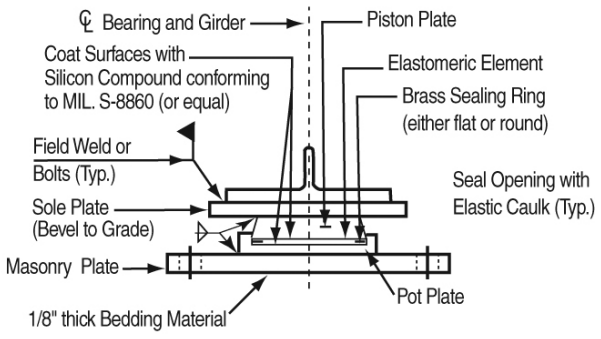
ROCKER BEARING



SLIDING PLATE BEARING



SIMPLE EXPANSION BEARING



MULTI-ROTATIONAL BEARING (POT BEARING)

SUBSTRUCTURE ELEMENTS

Abutments - A substructure unit which supports the end of a single span or extreme end of a multispan superstructure, and usually retains or supports the approach fill.

1. STUB ABUTMENT (Perched Abutment, Dwarf Abutment): An abutment set near the top of an embankment or slope and having a relatively small height. While often supported upon piles driven through the embankment or natural ground, stubs may also be founded on gravel fill, the embankment or the natural ground itself.
2. FULL-HEIGHT ABUTMENT (Shoulder Abutment): A cantilever abutment extending from the grade line of the road below to that of the road overhead. Usually set just off the shoulder.

These may be on piles or spread footings and of the open or closed design.

Piers - Bridge Piers transmit the load of the superstructure to the foundation materials and provide intermediate supports between abutments.

Piles - Piles are used to transmit the bridge loads to the foundation material when soil conditions are not suitable for receiving the load in bearing.

Typical pile types are:

- Steel H Piles
- Timber
- Concrete piles (both CIP and precast)
- Concrete filled pipe or shell piles

MISCELLANEOUS

Clearances - Clearances refer to the minimum distances that are provided by the bridge relative to the passage of traffic.

Camber - This is an initial upward curvature, built into a beam, girder or truss to allow for vertical curves or cross slopes in the road section.

Reinforcement for Concrete - Concrete cannot resist tensile stresses and therefore is reinforced with steel bars or wire. Two types are generally used for concrete reinforcement.

1. Deformed Bars - for main reinforcement. These bars may be epoxy coated or galvanized to resist corrosion.
2. Wire mesh for low stress areas, for example, temperature stresses.

WELDING

POLICY - Structural welding on all bridges shall be performed by qualified welders who are certified in accordance with AWS standards. All personnel classified as welders shall be qualified and certified.

PROCEDURE - Contact the District Bridge Engineer to obtain welder certification. The District Bridge Engineer will have one of his or her bridge inspectors verify that the welded test specimens are properly fabricated in accordance with the current version of ANSI/AASHTO/AWS D1.5 of the Bridge Welding Code as well as part C of the welding procedure specifications and welding procedure qualification tests. The fabrication is to take place in the presence of the inspector. Upon completion of the test specimens, the inspector shall properly identify the sample and forward them along with the completed Form D-479 to the Materials and Testing Division of the Bureau of Construction. The Division of Materials and Testing will issue a letter of certification for all positions in which the welder qualifies.

If an inspector or equipment is not available, the test specimens can be prepared at the Materials and Testing Laboratory, 81 Lab Lane, Harrisburg, Pennsylvania. Arrangements can be made with Materials and Testing Division to schedule the preparation of the specimens.

High Strength Bolts - These bolts develop a strong clamping force when tightened to a very high tension. The A325 high-strength bolt has become the prime field fastener of structural steel. The specifications call for a heavy hexagon structural bolt, a heavy semifinished hexagon nut, and either one or two washers. Bevel washers may be required. Approved methods should be used to assure proper bolt tension.

Fatigue - This term applies to the phenomenon whereby a structural member, subjected to alternating tension and compression stresses due to moving loads on the bridge, has its useful life decreased. A crack, very often minute, will develop and gradually enlarge on the member, thereby decreasing its load carrying capacity to a dangerous point at which a sudden failure is possible.

Expansion Joints - These are joints placed in the deck to accommadate for longitudinal movement expansion and contraction of the superstructure due to changes in temperature, creep, and shrinkage. They prevent cracking in the deck. Temporary expansion joint system for maintenance repairs include asphaltic plug, preformed silicone, and two-part silicone joint.

Scuppers - These are located along the curb line and provide drainage from the deck.

Downspouts - When it is not desirable to allow water from the scuppers to fall free, it is carried off by pipes (downspouts).

16.10 PRECAST REINFORCED CONCRETE BOX CULVERTS, BEAMS AND STRUCTURES PRECAST CONCRETE PRODUCTS - PROCUREMENTS

All precast reinforced concrete box culverts and appropriate precast concrete products will be procured using the PennDOT Electronic Construction Management System (ECMS). Precast concrete products are limited to precast concrete bridge beams and precast concrete bridge decks. Follow the procedures in SAP Circular 2011-10 for box culvert accounting coding.

16.11 ON-SITE REVIEW AND REMOVAL OF COMBUSTIBLE MATERIALS STORED UNDER STRUCTURES

Counties are required to survey the structures in their county which could potentially be subject to fire damage resulting from combustible material stored under or adjacent to a structure. Multiple Strike-off Letters have been issued directing personnel to survey structures under their responsibility and continue ongoing efforts to eliminate such sites. A list of structures will be populated in Maintenance IQ for County review based on data from bridge inspections, more specifically BMS2 Field 6B48 – Combustible Materials Under Bridge. This data can be found in Maintenance IQ by filtering the Bridges Layer for the Category "Material Storage Under" with values 00 through 12.

All identified PennDOT maintained structures shall have a quarterly on-site review completed to verify and monitor combustible materials stored under or adjacent to the bridge or other structure (e.g., retaining walls). County personnel shall record their photographs and description on the day of the on-site review. These findings are to be recorded and archived into Maintenance IQ via the "Under Bridge Storage" category of the "GeoSnap" application; GeoSnap is available in the PennDOT App Catalog. The structure Bridge Key (BRKEY) number must be entered into GeoSnap for each picture. The BRKEY is the unique identification number of a structure in the BMS2 system. The BRKEY number can be obtained from the structure list or the District Bridge Unit. The "Location Services" feature on state smart phones and other devices must be enabled when taking pictures.

If no material is found, the County personnel should enter a photograph and the description "No Materials Found" in GeoSnap. The District Bridge Unit shall be notified so that BMS2 Field 6B48 can be updated and the structure should be removed from the quarterly review list. If the County identifies a structure with combustible materials but it does not appear in Maintenance IQ, then the County must contact the District Bridge Unit to ensure BMS2 Field 6B48 is coded correctly so that quarterly on-site reviews can be completed using Maintenance IQ.

After the on-site review is complete and the information is recorded in GeoSnap, the data collected will be available for viewing in the Maintenance IQ system. BMS2 and on-site review data is available in Maintenance IQ under the "Bridges" and "Photo" layers, respectively. This data can be used for future county planning, combustible material removal, and future review preparations. Additional GeoSnap training materials relating to submitting and viewing combustible material photos, including BMS2 searchable information, can be found in the "Training Folder" of the Bureau of Maintenance and Operations Intranet site, within the Office of Operations and Performance's Maintenance Systems and Reporting section. (BOMO Intranet site > Office of

Operations and Performance > Maintenance Performance Section > Maintenance Systems and Reporting Section > Maintenance IQ Training Materials)

When a County identifies that combustible materials are being stored under or adjacent to a structure, the removal procedures and guidance found in Chapter 11, Signs, Work Zone Traffic Control, Guiderail, Section 11.4 – Right of Way Encroachments shall be followed.