BRIDGES

11.01 BRIDGE MAINTENANCE

This manual is intended for internal guidance only and is not intended to create a legal or moral duty. Supervisors have discretion, based upon their expertise and the particular circumstances, to deviate from this manual and to conduct additional research or receive input from experts in other areas, as needed.

The common types of bridges found within the road system of West Virginia are simple and continuous beam spans, girder-floor beam spans, concrete arches, pony trusses, deck trusses, through trusses, suspension or slab type.

A bridge is defined as any structure having a span of 20 feet or more. A span less than 20 feet is classified as a culvert.

Most bridges are composed of two basic parts, which are the substructure and superstructure. The substructure is the supporting parts, which are below the bottom of the main beams or the bottom of the truss, and are called abutment, backwall, piers, and bents. The superstructure includes beams, trusses, decking, railing and parapet.

Common parts of bridges of certain types are shown in Figure 11-1.

In the following pages, bridges are classified as concrete, timber or steel.

Casual inspection of these structures is covered in a very brief manner under their respective sections. Detailed bridge inspection is covered in a complete and detailed manner in Section 11.01.06 "General Inspection".

11.01.01 EMERGENCY PROCEDURES

11.01.01.01 GENERAL DUTIES OF COUNTY MAINTENANCE SUPERINTENDENT

Occasionally, accident, fire, flood or excessive load conditions will make a bridge unsafe for traffic or will cause the bridge to collapse. Every effort must be made to restore a safe stream crossing as quickly as possible.

Whenever a bridge cannot be used for any reason, the County Maintenance Superintendent must do the following:

1) **Place barricades and Bridge Closed signs.**

2) **Notify the District Office.**

3) **Consult State and County maps, and decide on an emergency route for detouring traffic until the use of the bridge can be restored or until suitable alternate routes can be established by the District.**

4) **Request sign crews to post detour signs, barricades and lights at the closest intersection of the road on which the bridge is located and the detour route.**

5) **Send flagmen to all bridge approaches to turn traffic from the bridge site.**

6) **Notify State, County and City police departments since the assistance of law enforcement personnel may be needed to control traffic.**

7) **Advise local radio and television stations of the conditions so they can make public announcements.**

As facts are gathered at the District Office, the District Engineer or the District Maintenance Engineer will inform the Director of Maintenance by telephone of the exact location of the bridge, type and span, reason for closure, detour route and the estimated length of time before traffic can be restored. If damage was caused by collision or overload, the appropriate claims personnel will be notified.

11.01.01.02. PREFABRICATED BRIDGE MATERIAL

To replace a damaged or washed-out bridge as soon as possible, each District must store, and have ready for use, a reasonable inventory of structural steel beams, angles, plates and timber decking. Prefabricated components for meeting common conditions generally found in the District will allow quicker response.

11.01.02 CONCRETE BRIDGES

Most concrete bridges are usually constructed in-place and are classed as slab, rigid frame, or arch type; however, some may be prefabricated in part or entirely.

A good example of a completely prefabricated bridge would be concrete cribbing substructure and prefabricated channel, slab or box shaped sections to form the deck. The use of these sections is especially desirable for the widening of existing short span concrete bridges.

Some bridges may consist of cast-in-place substructure, prefabricated concrete beams, and cast-in-place deck.

Individual prefabricated concrete bridge sections may employ standard reinforcing steel for short spans. Longer span sections may be pre-stressed or post-tensioned by the use of high-tensile steel wire.

The repair of these bridges is covered in the respective sections.

11.01.02.01 INSPECTIONS

11.01.02.01.01 STRUCTURAL DEFECTS

When a concrete bridge is inspected for structural defects the footings, surfaces

of members, drains and joints must be checked.

The areas around the footing of all concrete abutments and piers must be examined for scour.

The surfaces of all members of the bridge itself must be checked for unsound, spalled, or "honeycombed" areas. In some places the holes or cavities may be so deep that the steel reinforcement is exposed. It is especially important to look for cracks. Cracking of any part of the structure may show that the part is weak or overstressed. Any unusual conditions shall be reported to the District Bridge Engineer immediately.

Grates, downspouts, and other drainage openings must be kept free from dirt and other debris so water will not pond on the bridge deck.

Expansion joints and bearing assemblies must be checked to make sure they are working properly.

11.01.02.01.02 ARCH BRIDGES

Inspection of a concrete arch bridge should address the following possible defects:

1) **Moisture and seepage where parts of the arch ring are joined or where a spandrel wall joins the arch ring.**

2) **Leakage, due to lack of waterproofing, at the top of a lengthwise joint between parts of the arch rings or where a spandrel wall joins the edge of the arch ring.**

3) **Separation of a spandrel wall from the arch ring. If a spandrel wall breaks away, side support for the fill on top of the ring is removed. This type of failure may be the result of poor drainage or improper design.**

11.01.02.02 CONCRETE BRIDGE REPAIR

11.01.02.02.01 SCOUR CORRECTION

An area where slight scour has occurred, or where scour seems likely to occur, can be protected by placing rip-rap. In a place where there already has been serious scour, soundings may be needed to find the extent of the damage. Sounding can also show the depth below the ground surface to solid ground or rock.

Serious damage due to scour can be corrected by underpinning the pier or abutment with concrete. Figures 11-2, 11-3 and 11-4 show typical methods of underpinning.

11.01.02.02.02 UNSOUND CONCRETE

To repair an area of a member where the concrete is unsound or the steel reinforcement has been exposed, the first step is to remove all loose concrete. Special chemicals must be added to the sand-cement mortar used to repair such an area. These chemicals cause the mortar to swell or expand while it is setting. As a result, all

the space around the steel and the small spaces next to the old concrete will be filled with the mortar.

The "shotcrete" process of filling cavities is also very effective in making repairs of this type, particularly on the side of a pier or column or on the underside of a deck slab.

11.01.02.02.03 SPALLED AND BROKEN CONCRETE

To repair the surface of a concrete sidewalk, parapet wall or roadway, the first step is to remove all unsound material. The sides of the hole must be at right angles to the surface. Before the hole is filled with concrete, the exposed faces must be treated with an approved epoxy bonding agent or a bonding grout of sand, portland cement, and water.

In general, the same methods described in the Paved Surfaces Chapter of this Manual for patching spalls and sealing of concrete pavements must be applied for correcting surface defects on the concrete deck slabs of bridges.

11.01.02.02.04 CRACK REPAIR

Wherever possible, cracks in any part of a concrete bridge must be filled with an approved crack filler to seal out moisture. In winter, it is especially important to remove chemicals and chemical treated abrasive material from a concrete deck quickly. If salt water seeps into cracks, corrosion will attack the steel reinforcement with resultant damage to the concrete.

11.01.02.02.05 HANDRAILS

If existing handrails on any concrete bridge are found to be in bad condition and beyond economical repair, they may be replaced by deep beam type guardrail. Details for installation are shown in Figure 11-5.

11.01.02.02.06 ARCH BRIDGE CORRECTIONS

Defects in an arch bridge resulting from lack of water-proofing or from poor drainage, which were mentioned in Section 11.01.02.02.02, may be corrected as discussed in the following paragraphs.

Where a suitable drainage system was not provided during construction and seepage is observed, the source of the water must be tapped by drilling holes through the arch ring and the spandrel walls.

To place waterproofing along a joint in an arch ring or along the edge of the ring at the junction with a spandrel wall, it may be necessary to trench through the pavement and the fill as shown in Figure 11-6.

If it is seen in time that a spandrel wall is likely to become separated from the arch ring because of poor drainage, separation can be prevented by the use of spandrel-wall tie rods and improving the drainage. Figures 11-6 and 11-7 show this in detail.

11.01.03 TIMBER BRIDGES

In West Virginia many bridges have wood decks and a few are entirely constructed of timber.

All timber material should be treated with creosote, chromated zinc chloride, osmosalt, pentachlorophenol or chromated copper arsenate.

Untreated timber should only be used in temporary structures.

The substructures of timber bridges are usually constructed of timber piling, pre-cut timber or log cribbing. Decks are usually plank or laminated timber placed perpendicular to the centerline or along the skew of the structure. Occasionally a deck will be constructed of longitudinally laminated post-tensioned timber placed on either a timber or masonry substructure.

11.01.03.01 INSPECTION

11.01.03.01.01 WOODEN PARTS

Parts of wooden bridges to be checked during an inspection are the backwalls and end bents, piles, caps and braces, bearing areas, decking, stringers, wheel guards, abutments and wing walls, and the roof and sides when the bridge is covered.

11.01.03.01.02 BACK WALLS AND END BENTS

Back walls and end bents must be checked to determine that wooden stringers, and caps and braces, are protected from contact with the ground. Lack of a good back wall allows the earth in the fill to come in contact with the ends of stringers. Other trouble spots are the points where stringers rest on the abutments. At all these points, moisture can be held and decay can begin. Accumulation of dirt and debris which could hold moisture must be removed from the bearing area.

11.01.03.01.03 PILES, CAPS AND BRACES

It is important to look for signs of decay in piles, and caps and braces. Each pile must be carefully inspected, especially at the ground line and the water line. Decay usually starts at those points. Decay in a timber member may be spotted by tapping the member with a light hammer. A more certain method is to stick an ice pick into the timber or to bore holes in it. Any decayed piece of timber in a cap or brace must be replaced with a sound piece. If decay in a timber pile extends over as much as 20 percent of its cross section, it must be replaced with a section of sound piling.

11.01.03.01.04 BEARING AREAS

The condition of all contact and bearing areas of timber must be checked. The condition of a cap at each point where a stringer bears on it or where it bears on a pile is especially important. It is also necessary to make sure that braces are doing their job, wedges are tight, enough wedges are used, and that bolts, spikes and other fittings are tight.

11.01.03.01.05 STRINGERS

Decay in the decking and the stringers usually begins at the tops of stringers at the points where the decking comes in contact with the stringers, therefore, special care must be taken to look for signs of decay at those points. If asphalt is applied to the top edges of stringers before the decking is laid, decay can be delayed. Covering the tops of stringers with strips of asphalt roofing material when the floor is laid will serve the same purpose.

The stringers must be checked for canting, sagging, or cracking. Proper X-bracing will correct canting. The only way to correct sagging is to replace the stringer. Since sagging usually means that the stringer has been overloaded, in most cases a heavier stringer will be needed. It is also necessary to look for cracking at the ends of each stringer at the supports, especially where stringers are notched to fit the bearing areas.

11.01.03.01.06 FLOORING OR DECKING

Wooden flooring or decking must be inspected carefully for signs of decay. The flooring planks must be kept firmly nailed in place. Loose planks cause needless vibration and create a noise nuisance. If a plank comes completely out of place, the space left in the floor can be a real hazard to vehicles and pedestrians.

The use of wooden plank flooring should be eliminated where possible. Pressure treated, laminated 2" X 4" or 6" flooring is recommended.

11.01.03.01.07 MISCELLANEOUS

Wheel guards must be checked to make sure they are in good condition and that drainage of the bridge floor under the wheel guards is satisfactory.

The roof and sides of a covered bridge must be kept in a good state of repair at all times. Leaks in the roof or sides may cause decay of some vital supporting member of the bridge.

Abutments and wing walls of a timber bridge may be of wood, stone masonry, or concrete. If they are wood, they must be checked for decay or displacement and any cribbing or timber that is damaged or out of place must be removed and replaced. If abutments and wing walls are of masonry or concrete, they must be checked for scour and the other defects discussed in the section for concrete bridges.

11.01.04 STEEL BRIDGES

The majority of the existing steel bridges on West Virginia roads consist of conventional beam, girder, pony truss, through truss, and deck truss designs. Examples of these are shown in Figure 11-1.

Most steel bridges are supported on masonry substructure and have concrete or timber decks. In a few locations steel grid decking has been used.

Because vibrations tend to loosen the decking on steel truss bridges, the use of solid corrugated metal flooring with a surface of hot-laid bituminous concrete or wood planking decking is discouraged.

Probably the greatest single maintenance problem on steel bridges is the removal of ice control chemicals and adequate cleaning.

11.01.04.0l INSPECTION

11.01.04.01.01 STEEL TRUSS BRIDGES

The parts of a truss bridge that must be inspected are the truss members and connections, the deck, floor beams, abutments and piers, devices for supporting the trusses on the abutments and piers, handrails, and guardrails.

11.01.04.01.02 TRUSS MEMBERS

Truss members that are subjected to compressive stresses are subject to bucking or misalignment. These members are marked "C" in Figure 11-1. They include all members of the upper chord, the end posts, and some of the intermediate members connecting the upper and lower chords. All compression members must be inspected for general alignment. Also, the parts of all members near the deck must be checked for possible damage by vehicle impact. In addition, any member that vibrates excessively must be noted.

The tension members marked "T" in Figure 11-1 may fail if they are reduced in cross-section by rusting. They include the lower chords, main diagonals, hip verticals and, on some types of trusses, the intermediate floor beam hangers.

Another important part of the inspection of truss members is the condition of the paint. It is also necessary to look for corrosion on the top surfaces of chord members, at the lower ends of batter posts, and on or around the heads of rivets and bolts.

In an old pin connected truss, members subjected to tension must be checked to make sure that each bar or rod is carrying its share of the load.

11.01.04.01.03 FLOOR SYSTEM

When a concrete floor slab is used on a steel bridge it is necessary to look for cracks and signs of unsound concrete and to check the slab for good riding quality. Expansion joints in a concrete slab must be inspected to be sure they are in good condition. Repairs to a concrete slab are made by the methods described in the Paved Surfaces Chapter of this Manual. Potholes in a bituminous wearing course must be patched promptly. Cracks in such a course must be kept filled with bituminous crack sealer. A smooth surface is mandatory to reduce vibrations and impact caused by vehicles traveling across the bridge.

The top flanges of steel floor beams and stringers are also likely to become corroded. Such parts must be inspected carefully, even if close inspection is difficult.

11.01.04.01.04 ABUTMENTS AND PIERS

The ends of steel truss bridges are usually supported on abutments or piers of concrete or stone masonry. The area around the footing of each abutment and pier must be checked to make sure that it is free from dirt or debris. It is also necessary to note the condition of the back wall on an abutment.

The condition of the supporting plates, rockers, or rollers at the ends of a truss must be observed. The expansion end of the truss must be free to allow movement as the length of the lower chord changes. It is also necessary to check the anchor bolts that hold the supporting device for the truss in place on an abutment or pier, especially the bolts at the expansion end. In some designs each bolt at the end fits in an expansion slot in the supporting device. If a bolt is too tight, free movement of the truss on the abutment or pier will be prevented and movement will damage the bridge seat at the bolt.

11.01.04.01.05 STEEL BEAM BRIDGES

The procedures for inspection and repair of parts of steel beam bridges are essentially the same as those for corresponding parts of truss bridges. Signs of rust or corrosion on girders or beams must be looked for continually, and the steel must be protected by paint at all times. Particular attention must be given to the heads of rivets and bolts and to the exposed top flanges of all girders and beams. The general alignment of girders must be checked during each inspection.

A concrete floor slab must be kept in good condition. Expansion joints and bearing plates must be checked to make sure that they are working properly. Where a timber deck is used on a steel beam bridge, care must be taken to keep the top flange of each beam protected from corrosion. The condition of the expansion plate, rocker, or rollers at each end of a span must be observed to make sure that the necessary movement is permitted.

11.01.04.02 STEEL BRIDGE REPAIR

11.01.04.02.01 TRUSS BRIDGES

If an important member of a steel truss bridge has become buckled or damaged in some other way, the necessary repairs or replacement must be made under the direct supervision of the District Bridge Engineer.

It is not always easy to determine the cause of excessive vibration of a member of a steel truss; however, every effort must be made to do so. One common cause of vibration in truss members of a steel bridge with a timber deck is looseness in the decking. District Bridge Engineer will be able to provide advice regarding the reduction of vibration.

Painting of a major bridge structure is usually done by contract. Overall painting of a small steel truss is normally done by a special County or District painting crew. Spot-painting should be done by County forces. Often, such spot treatments will postpone the necessity of overall painting for several years.

In preparation for spot-painting, all rust spots must be cleaned with a wire brush or, preferably, by sandblasting. Then, the clean bare metal is coated with an approved primer. After the prime coat has thoroughly dried, a top coat of paint matching the original is applied.

For the best results, the air temperature must be 40° or higher and the surface dry when the paint is applied. If a spray gun is used for painting, care must be taken to prevent paint from falling on passing vehicles or nearby houses. It is important, whether painting with a hand brush or a spray gun, to prevent paint from falling on grass, foliage or into streams because of the environmental hazards.

Sometimes an old steel truss bridge has to be strengthened by installing bents under the floor system. Figure 11-8 shows where the bents must be placed to furnish proper support. It is necessary to provide support at each panel point of the lower chord. The bents should be placed at convenient locations in the stream channel to minimize the build-up of debris. The bents will be designed by the District Bridge Engineer. Where proper support of a bent cannot be obtained on the bed of the stream, piles must be driven.

11.01.04.02.02 TENSION MEMBER LENGTH ADJUSTMENT

The length of a tension rod in a steel truss can be adjusted by means of a turnbuckle, which is usually provided for that purpose. If it is found necessary to equalize the stresses in the bars of a tension member of a pin connected truss, the District Bridge Engineer should be consulted.

11.01.04.02.03 FLOOR SYSTEM

Cracks in a concrete floor slab must be filled with cement and mortar or an approved bituminous or epoxy sealer to seal out moisture. In general, the methods correcting surface defects on a concrete deck slab of a steel bridge are the same as those described in the Paved Surfaces Chapter of this Manual for patching spalls, scaling and sealing joints and cracks in a concrete pavement.

The timber in a timber floor must be kept spiked or bolted firmly in place. When a new timber floor is placed on steel stringers the tops of the stringers must be coated with an approved primer before the new floor is placed, because corrosion of a stringer almost always starts at its top flange.

It is not permissible to place raised longitudinal timber runways on top of a timber floor. If it is considered necessary to strengthen a floor by adding longitudinal planking, the entire width of the roadway must be covered. When wet or icy, narrow raised runways are a potential hazard to traffic. Also, if a heavy vehicle were to slip from the runways, there could be a severe shock to the floor system which could cause serious damage.

The floor of a steel bridge of either the truss type or the beam type may be of wood or of concrete. All timber flooring should be constructed of treated material and the timber should be properly sized. Prior to the replacement of the decks, the District Bridge Engineer should be contacted so he may check the steel stringer spacing and determine the size of lumber to be used.

Any timber less than 3" thickness should be placed laminated as shown in Figure 11-9.

Treated timber laminated flooring should receive a maximum of 60 lb/SY bituminous surface treatment to prevent wearing by traffic and weather cracking. This should be renewed every 4 to 5 years with a 10 lb./SY seal. Laminated timber flooring is very satisfactory and durable if the surface is kept sealed at all times; however, if the seal is not maintained wear and deterioration will soon destroy the floor.

Some laminated floors are placed by using every other plank of different width. This forms a saw-toothed surface which will retain a hot laid asphaltic concrete surface.

The fastening of wood floors to steel stringers is important. The most desirable method is by use of steel anchor plates as shown in Figure 11-9. The anchor plates are slotted to fit on a particular beam flange. It is very important that the plates fit tight on the flange. In order to obtain correctly fitting anchor plates, the supplier must know the type, depth and weight per foot of the beam. Before placing a timber floor, the tops of the steel stringers should be checked to insure they are in the same plane.

The top of stringers should be cleaned and painted with 2 coats of approved primer. The planks should then be placed one at a time and secured at stringers before nailing into the previously placed decking. Details of a laminated timber floor for a light steel bridge are shown in Figure 11-9.

11.01.04.02.04 ABUTMENTS AND PIERS

When scour occurs around the footing of an abutment or pier of a steel truss bridge, the methods of making repairs are the same as those described for a concrete bridge in Section 11.01.02.02.01. If an expansion plate, a rocker, or roller cannot move properly because of the presence of dirt, the dirt must be removed. If the steel part has become corroded, the rust must be removed. In the event cleaning alone is not adequate, aid must be obtained from the District bridge crew.

11.01.05 SPECIAL BRIDGE MAINTENANCE

11.01.05.01 BRIDGE DECK SURFACING

It is not permissible to place additional new surfacing on a bridge or to replace existing surfacing until approval is given by the District Bridge Engineer. The decision of the Bridge Engineer will be dependent on several factors, including the strength and structural condition of the bridge.

11.01.05.02 VERTICAL CLEARANCE

A suitable sign must be placed on every bridge crossing a highway where the clearance above the roadway is less than 15'. Periodic inspections should be made to ascertain that all signs are in place.

11.01.05.03 BRIDGE APPROACHES

The road surface at the approach to a bridge must be kept smooth and at a grade matching that of the bridge, to reduce damaging effects of impact caused by vehicles coming onto the bridge. This impact is often overlooked or ignored to the detriment of the entire structure. As soon as settlement of the road at the end of a bridge is noted, plans must be made to correct the condition by placing an overlay of hot-mix or by removing the existing pavement and base, adding more subbase, replacing and recompacting the base, and replacing the surfacing.

On an unpaved road, the development of holes or bumps at bridge approaches must be observed and repairs must be made immediately by adding surface material and reshaping, or by grading and leveling, as described in the Unpaved Surfaces Chapter of this Manual.

11.01.05.04 BRIDGE CORNERS PROTECTION

Proper guardrail protection must be installed at all four corners of every light steel bridge to protect the structure from damage by a vehicle that could otherwise collide with the bridge.

11.01.06 GENERAL INSPECTION

The Division of Highways has a great responsibility towards the safe condition of the bridges under its control. The Division also has a large investment in its bridges. This investment and the safety of the traveling public can be protected only by constant and careful inspections to find defects while they are still minor.

The Division of Highways is also bound by law to comply with the National Bridge Inspection Standards which were originated and adopted by the Federal Highway Administration. The National Standards apply to all bridges located on public roads.

The National Standards were developed upon the recommendations of AASHTO, and the AASHTO Manual for Maintenance Inspection of Bridges has been made a part of the Standards. Also, the Federal Highway Administration has developed a training manual entitled *Bridge Inspectors Training Manual 70,* which is incorporated by reference into the National Standards.

Bridge inspections must, therefore, be made in accordance with the National Bridge Inspection Standards, the FHWA Bridge Inspectors Training Manual 70, the AASHTO Manual for Maintenance Inspection of Bridges, the West Virginia Department of Highways Bridge Inspection Manual, and various special instructions from the Maintenance and Structures Divisions.

11.02 STREAM MAINTENANCE

11.02.01 ROUTINE OBJECTS REMOVAL

The channel of each stream or other natural watercourse must be kept reasonably clean within limits of the right of way of the highway and, if necessary,

beyond those limits so the water will be allowed to flow normally. Preventative measures must be taken to keep logs, trees, brush, or trash from becoming lodged against a pier or piling of a bridge. Such debris may alter the course of the stream and also may cause flooding, scouring and undermining. Where debris control becomes a problem, the use of debris barriers and deflectors may be required.

If a tree near a bridge could damage the bridge by falling on it, the tree should be removed.

11.02.02 ROUTINE EROSION OR SILTING PREVENTION

Stream banks must be checked frequently for erosion. Often, widening a stream will permit the stream to discharge the same volume of water with a lower velocity and the danger of erosion will thus be reduced.

In some parts of the State, silt or waste from coal mines collects on the beds of streams. This material reduces the clearance between the water surface in a stream and the bottom of the bridge or the roof of a box culvert. Each stream in such a locality must be watched for the presence of deposits, and deposited material must be removed from the stream bed before serious damage occurs.

Sand and gravel bars often form in a stream and divert the water from its normal channel so that it causes erosion of the bank adjacent to the highway or drainage structure. The removal of these bars not only will correct the erosion problem but will also yield material that can be used or stockpiled for future use in road maintenance. However, permits must be obtained before removing any material from the stream bed and the Department of Natural Resources strongly recommends that whenever and wherever possible, gravel and aggregates used in road construction be obtained from sources other than the actual stream beds.

11.02.03 EMERGENCY STREAM MAINTENANCE

At times of heavy rainfall, a stream may carry extra heavy burdens of trees, brush and trash, which are thrown with great force against a pier, abutment, or piling. At such times, emergency crews must clear the debris from the upstream side of the bridge. Collections of debris on the downstream side must also be broken up to prevent flood damage.

FOOTNOTE

As more fully set forth in Section 01.01.01, nothing in this manual is intended to create a legal or moral duty and has been created for internal guidance only.