
FHWA Bridge Maintenance: *Non-Structural Items*

Course No: S03-011

Credit: 3 PDH

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XIII. MISCELLANEOUS MAINTENANCE PROCEDURES

A. APPROACH MAINTENANCE

Proper maintenance of bridge approaches is often as important as proper maintenance of the bridge itself. Problems on the approach may be greater than those of the bridge and can ultimately affect the condition of the bridge. The more common maintenance procedures that may be required on the approach areas include:

- Annual patching of bituminous surfaced approaches, especially in areas where there is deep frost penetration.
- Sawing a relief joint between an approach slab and the approach pavement when the approach slab is heaved because of expansion pressure of approach pavement.
- Placing a temporary bituminous approach ramp on the bridge deck when an approach made of poor soils heaves or settles and results in a rise or drop of the approach in relation to the bridge floor.
- Grading and shaping of approaches to the level of the bridge deck.
- Adding or repairing safety items in bridge approach areas.

There are also safety maintenance activities in bridge approach areas that should be performed. These include:

- Maintaining all traffic signs.
- Prompt replacement of missing or vandalized load limit signs.
- Resetting sign posts to a vertical position.
- Removing brush, grass, and weeds that obscure signs and reduce visibility.
- Repairing deficiencies in guardrails and removing vegetation under them to improve drainage.

APPROACH SETTLEMENT

The settlement of the bridge approach pavement has been a continuing problem to most bridge maintenance engineers. See Exhibit XIII.1. Pavement settlement results in poor ride quality on the approach and may pose a safety problem in severe cases of uneven settlement. In addition, when heavy trucks travel over rough sections of pavements, impact loads may be created that can damage the structure. When concrete approach slabs are attached to the bridge, the settlement is less noticeable. The settlement usually results in cracked pavement that can become severe if it is

allowed to continue. Pavement settlement can be a recurring problem. It is often necessary to repeat the repair procedure periodically.

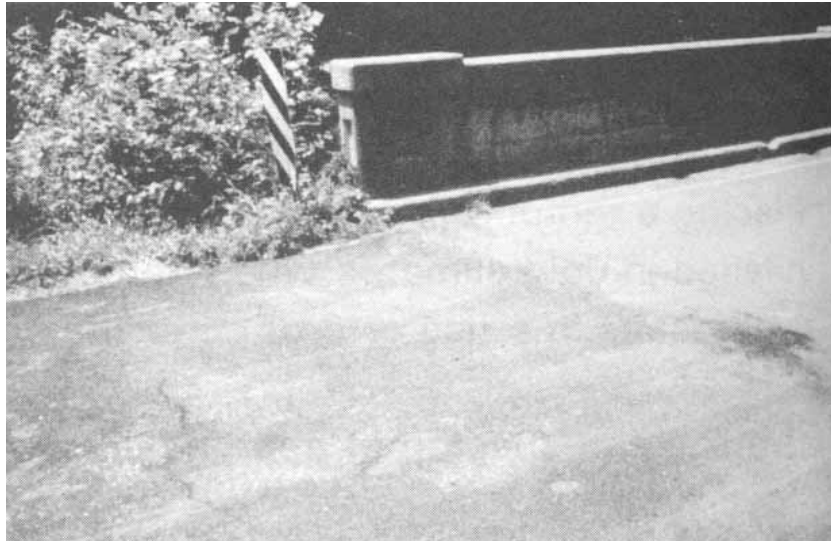


Exhibit XIII.1 Approach Settlement

CAUSES OF SETTLEMENT

The common causes of fill and approach settlement are:

- Poorly compacted fill material adjacent to the abutment that continues to consolidate over time.
- Voids behind the abutment resulting from scour caused by the waterway or erosion from surface drainage. Spill through or column abutments are particularly prone to this problem. A small rock drill can be used to locate and determine the size of voids under the pavement.
- A slight tilting of the abutment from uneven settlement or from scour caused by the waterway that creates a small void near the pavement seat. The pressure of the pavement pushing against the abutment, producing additional movement can further aggravate this situation.

If settlement is occurring, it is very important that the cause of the problem be determined. If scour is creating a void, the condition could become unsafe; additional layers of blacktop will only temporarily hide the problem and contribute to the unsafe condition because of the increased dead load over the void.

REPAIR METHODS

There are various methods of repairing the effects of bridge approach pavement settlement. Bridge approach pavement settlement repair methods include:

- A bituminous wedge overlay is applied to the approach pavement to compensate for the settlement. This is a commonly used method for temporary repair of slight settlement. It is acceptable if the problem is embankment consolidation but should not be used if a void is present.
- If the approach pavement is concrete, a polymer mortar overlay can be applied and feathered as necessary on the approach pavement. This may be done in conjunction with a bridge deck overlay project.
- Complete removal of the pavement and/or the concrete approach slab. This is followed by filling and compacting any voids in the approach fill with suitable material before replacing the pavement or adding an approach slab.
- Mudjacking to fill the voids and lift the pavement up to its original grade. Mudjacking sometimes cracks the pavement which, combined with the mudjacking holes, creates the need for a bituminous overlay to achieve a smooth ride. Following is a description of the mudjacking process.

MUDJACKING

Mudjacking is a method of raising settled portions of pavement by filling any voids and lifting the pavement by pushing it from below with “Mud”. The process requires special equipment and experienced operators. The procedure consists of drilling holes in the pavement and pressure pumping a slurry of fine soil materials and a hardening agent into the holes, causing the pavement to rise as the slurry fills any voids and flows between the pavement and the fill. See Exhibit XIII.2.

MUDJACKING MATERIAL

There are many materials that can be pumped. Some research is required on the part of the user to find the right material or combination of materials. Some of the most common materials are cement, agricultural lime, pond sand, fly ash, or combinations of these materials. Sufficient water is added to make slurry workable. The characteristics that the material should have are that it is inexpensive, readily available, and is a material that will pump under pressure without having the carrier water separate from the material. Coarser materials or sand allow this to happen and can cause many problems. Usually when this separation occurs, it is easily corrected by adding a lubricating material to the mix. The proportion of cement can vary from 1 percent to 20 percent depending on the application or the base material being used. The following mixes have proved satisfactory for mudjacking operations:

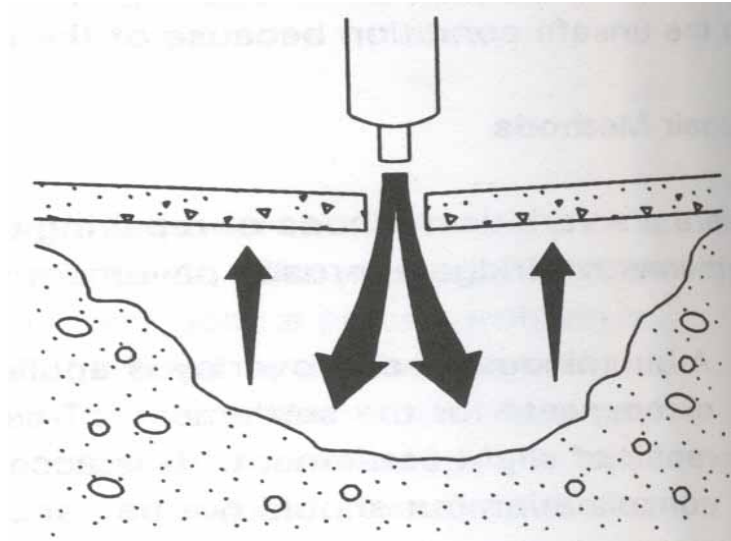


Exhibit XIII.2 Mudjacking

Mix No.1

6 parts sand
 2 parts commercial (hydrated) lime
 1 part Portland Cement

Mix No. 2

4 parts sand
 8 parts sugarbeet lime (or 12 parts marl)
 1 part Portland Cement
 Cut-back asphalt RC-1, or asphalt emulsion AE-2, or AE-1 M at a rate of 6.2 liters/cubic meter (1.5 gallons per cubic yard) of slurry

Mix No.3

2 parts sand
 4 parts commercial (hydrated) lime
 1 part Portland Cement
 Cut-back asphalt RC-1 , or asphalt emulsion AE-2, or AE-1 M at a rate of 6.2 liters/cubic meter (1.5 gallons per cubic yard) of slurry

The fine sand used may be any type having well-rounded particles. Sufficient water must be added to each of the above mixes to make the slurry workable. Mix No.2 may be used without the asphalt materials.

MUDJACKING PROCEDURE

Holes are drilled through the pavement. The diameter of the hole should fit the nozzle on the mudpump. Spacing of the holes depends on the condition of the concrete pavement and the amount of lifting to be accomplished. A typical pattern consists of two rows of holes, each 1 m (3 feet) from the edge of a 4m (12-foot) traffic lane with the holes 2 m (6 feet) apart along the

lane and equally staggered from the holes in the other row. When adjacent lanes are drilled the holes are staggered from those in the nearest row of the other lane.

The holes should be flushed with water under pressure to create a space for the slurry to start lifting the slab. All except two holes are sealed with wooden plugs or with wooden stakes. The slurry is pumped into the void through one hole until it is visible in the second hole. One of the two open holes is then plugged. The mud is then pumped into a third hole that has been opened. The operation is continued until slurry has been pumped into each hole and the entire area is raised to the desired level. Care should be taken to guard against overcharging at any location since this may cause additional cracking. A number of small charges will produce better results with less cracking. When pumping is completed all drill holes should be refilled with rapid-set cement concrete.

If slurry should blowout on the shoulder, an old grader blade can be wedged along and below the pavement edge. Shoulder material can then be added and compacted to seal off the blowout. A wide plank, with the dual wheels of the mudjacking equipment placed upon it, is also effective in keeping the shoulder material from blowing out.

Where the settled pavement areas to be raised are adjacent to structures, extreme caution should be exercised to prevent the concrete pavement approach slab from rising above the bridge deck. The following two methods have proven effective in preventing over-raising the slab:

Drill 22-mm (7/8-inch) holes diagonally through the approach slab and into the bridge deck slab. 19-mm (3/4-inch) "L" shaped pins are inserted into the holes to pin down the approach slab and prevent over-raising of the bridge deck joint. Usually only two or three pins are needed on an 8m (24-foot) pavement. After raising the approach slab, the "L" shaped pin should be removed and the holes refilled with mortar.

Mudjacking is also used to fill voids under the approach pavement where settlement has not taken place. The procedures followed are basically the same except that the pressure on the slurry should be held to a minimum because lifting of the slab is not required and the probability of blowout is reduced.

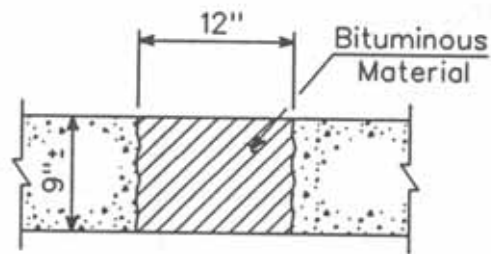
GUARDRAIL ATTACHMENT

When replacing or repairing railing, there should be a smooth, uninterrupted transition between the approach guardrail and the bridge rail. The objective is to safely transition an errant vehicle back into the roadway without impacting a blunt end on the bridge. The approach rail and posts should be reinforced adjacent to the bridge and attached structurally so as not to give under impact and permit the vehicle to be directed into the end of the rigid bridge rail or parapet. State DOT's have standard details for providing this attachment for different roadway classifications and rail types. The boltholes that attach the rail should be slotted at expansion ends of the bridge to prevent damage due to thermal movement.

INSTALLING RELIEF JOINTS IN APPROACH PAVEMENT

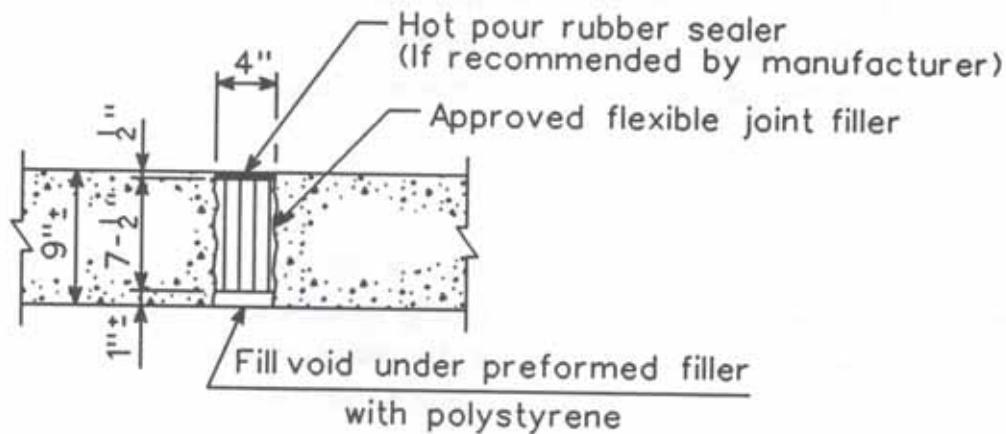
Relief joints are installed to prevent or stop expansion pressure on abutments resulting from expansion of concrete roadways. Considerable damage to bridges has been caused by pressure from encroaching pavements. Damage has been caused to abutment backwalls, parapets, rail posts, deck joints and bearings. Relief joints should be made in the approach pavement as soon as it is apparent that pavement progression is occurring.

Relief joints should be located at cracks or joints in the existing pavement. To construct relief joints a section of the concrete pavement is removed across the width of the roadway. The sides should be saw cut. The opening is normally 300 mm (12 inches) wide and filled with bituminous material. See Exhibit XIII.3.



1" = 25.4mm

Exhibit XIII.3 Relief Joint



1" = 25.4mm

Exhibit XIII.4 Narrow Relief Joint

Narrower relief joints, say 100 mm (4 inches), can be filled with bridge deck joint filler/sealers. See Exhibit XIII.4. The system must be checked and additional joints constructed as the pavement continues to grow.

B. DEBRIS REMOVAL FROM CHANNEL

The words drift and debris can be used interchangeably to describe any floating or submerged materials that are transported by flowing water. Vegetation, sediment, trash, man-made materials, rocks and ice are all considered to be debris or drift. Vegetative debris and sediment will be considered primarily, as ice is a more specialized debris problem.

BRIDGE DAMAGE CAUSED BY DEBRIS

Many bridges have been damaged or have failed as a result of problems caused by debris. The types of damage caused by debris can be divided into the following general categories: scour, impact, drag, and miscellaneous damage.

SCOUR

Floating debris caught either on bridge members or obstructions in the stream channel will tend to catch and accumulate additional debris. These accumulations divert the flow of water, increase velocity, and create turbulence which increase the likelihood that scour damage will occur. See Exhibit XIII .5.

IMPACT

During peak flows a waterway can carry massive size debris such as automobiles, trees, superstructure elements from other bridges, etc. Debris striking a bridge may cause damage to timber piles in fast moving streams. If the water level reaches the superstructure, damage may result to beams, and bottom chords or trusses. Impact damage to solid piers and other structural members is rare but not impossible if barges, floats or heavy watercrafts are swept into them by fast water.

DRAG FORCES

Debris caught on substructure or superstructure members will trap additional debris. Depending upon the size of the debris accumulation and the water velocity, tremendous forces can be applied to the bridge. In 1972, the floodwaters of Hurricane Agnes, which created a tremendous drag force, pushed several bridge spans off their piers when debris accumulated on their superstructures.

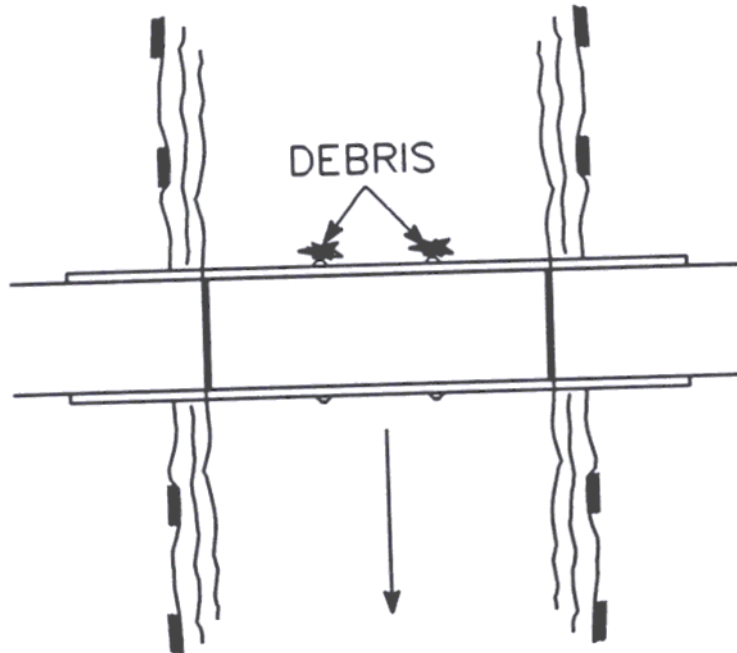


Exhibit XIII .5 Scour Caused by Debris

MISCELLANEOUS DAMAGE

Less common or serious types of damage include:

- *Fire* -vegetative debris caught on or beneath the bridge can be a fire hazard during dry seasons.
- *Abrasion* – sand, gravel, and other suspended particles can cause damage due to abrasion in streams with fast moving water.
- *Scarring* – debris can scratch and mark substructure and superstructure units.

DEBRIS REMOVAL

Structures should be routinely checked after heavy storms to determine the need for debris removal. All structures should be checked at least once a year. Structures that have a history of debris accumulation should be checked more frequently. Factors that affect the likelihood of debris problems include:

- *Type of Substructure* --open web piers and pile bents are more likely to catch debris than piers with solid webs.
- *Length of Structure* --long spans are less likely to be damaged by debris than short spans.
- *Height of Structure* --bridges with low clearance will usually collect debris more readily than high bridges.

- *Unstable Banks* --bridges on streams with easily eroded banks are more likely to accumulate debris than bridges on streams with stable banks.
- *Land Use* --heavily forested areas will usually generate more floating debris than non-forested areas. Logging and mining operations will increase the chance of debris problems, as will some land development and farming activities.

EMERGENCY DEBRIS REMOVAL

During peak flows it may be necessary to have maintenance personnel available for emergency debris removal. This work involves removing floating debris that has lodged against the piers and abutments. This type of work can be hazardous, and workers should be required to wear safety belts, buoyant work vests, hard hats, and other safety gear where appropriate. A flashlight that will operate when submerged is an excellent safety item for nighttime work. Having the necessary resources available to close a bridge when it is in jeopardy during peak flow can prevent loss of life.

ROUTINE DEBRIS REMOVAL

Routine debris removal should include the removal of all floating debris such as logs, brush, tree limbs, and fallen trees that have lodged against the bridge or have been deposited in the immediate vicinity of the bridge. It is important that the necessary EPA and Coast Guard permits or approvals be obtained before performing this work. Bars and other deposits of debris should be removed on a high priority basis when it appears that the deposit will:

- Cause turbulence near the piers or abutments
- Direct flow into the piers or abutments
- Direct flow into the embankments behind the abutments

Trees that have been undercut should be removed or protected with riprap to prevent them from falling into the stream. Obstructions in the streambed, such as trees, bars or boulders that can trap or catch debris should be removed. All debris that is removed should be hauled away from the bridge or disposed of in a manner that will not allow the debris to contribute to debris accumulations at downstream bridges.

PREPARATION

The methods used for debris removal may depend on environmental regulations. Prior to performing routine debris removal tasks, maintenance workers should contact appropriate environmental and water resources agencies. The worker should determine the types of work that can be performed in a stream channel without a permit, with a blanket permit that applies to many sites, or with a permit for a specific site.

Environmental restrictions generally apply to those activities that involve major disturbances of a natural streambed. Although maintenance personnel have a different objective, protecting the structure rather than the stream, alternative courses should be evaluated when extensive work

must be performed to remove bars or to reshape or regrade a stream channel. The use of light cranes, saws, or other such equipment may be necessary. Schedule variations such as scheduling for fall rather than summer accomplishment may also be needed. Locations requiring extensive work should be referred to both engineering and conservation personnel for evaluation.

Maintenance workers should also obtain permission from property owners when it is necessary to remove debris from private property. Some agencies handle this through formal or informal agreements between maintenance personnel and property owners. Other agencies require that a right-of-way office make arrangements.

METHODS

A winch or crane is often the most effective type of equipment for removal of vegetative debris such as logs and fallen trees that have accumulated near a bridge. A crane with a clam shell bucket can remove trees, stumps and other debris. At bridges that span a flood plain area a bulldozer or front end-loader can be used during dry periods to push debris on the flood plain into piles that can be reached by a crane.

When work in the stream channel is required, a crane with a dragline can be used for reshaping and regrading. During low flow it may be possible to reshape and regrade the channel with a bulldozer. The need for regrading and reshaping or other extensive work in the stream channel must be in conformance with environmental regulations and should be evaluated by an engineer and conservation personnel. A proper solution may require a great deal of coordination, planning, and review before approval is received, but if this is not accomplished, the cause of the problem cannot be corrected.

DEBRIS COUNTERMEASURES

The effectiveness of debris countermeasures has not been adequately proved. However, many states believe that the implementation or installation of various types of countermeasures can occasionally reduce debris problems. Types of countermeasures include:

- Structure modifications
- Debris deflectors
- Flood relief
- Debris and sediment traps
- Land-use regulations

STRUCTURE MODIFICATIONS

Piers that have rounded edges and solid webs reduce debris accumulation. Solid webs can be constructed in multiple column piers to prevent debris from lodging between the columns. Timber or metal cribs have been installed by some states on bridges with open pile bents. Care must be taken in selecting the cribbing to ensure that it does not worsen the problem. Cribbing with a large mesh may actually help to catch debris rather than prevent the accumulation of debris.

DEBRIS DEFLECTORS

Debris deflectors may consist of piles immediately upstream from a pier or fins attached to the upstream end of a pier. The piles and fins are intended to divert and guide debris through the waterway opening of the bridge. The effectiveness of deflectors depends upon the direction of flow. In situations where the flow is not parallel to the pier, deflectors may cause hydraulic problems. In such cases the use of flow control devices such as spur dikes, see Exhibit XIII.10, may be necessary to allow the deflectors to function properly.

FLOOD RELIEF

When the approach roadway geometry permits, flood relief sections can be constructed. Flood relief sections allow water to top the approach roadway when the bridge waterway opening is blocked by debris. Although relief sections often require extensive repair after flooding, they are usually less costly than replacement of the bridge.

DEBRIS AND SEDIMENT TRAPS

Debris and sediment traps have been found to be effective in forest management projects but are not generally used on bridge approaches. The use of sediment traps and erosion control measures are finding widespread use in many types of construction projects including highway construction. They are primarily used to reduce the amount of sediment washed into streams during the construction process and generally are not considered as permanent installations. Siltation fences and screens (hay bails) are examples of this type of device.

LAND-USE REGULATIONS

Sediment control and land development regulations can be effective means of reducing the amount of vegetative debris and sediment that is washed into streams. In many areas strict sediment control regulations have been enacted that apply to various types of land use, land development, and construction activities. For example, some agencies limit the square footage of disturbed area and the amount of time that can elapse before re-establishing ground covers. In some areas logging operations are required to leave undisturbed buffer strips along streams to catch debris.

C. SCOUR PROTECTION AND REPAIR

A wide variety of methods have been developed for scour control and slope protection. Methods in common use range from routine maintenance activities such as filling and stabilizing washed out areas to major construction of extensive slope protection and flow control systems. In extreme cases modifications to bridges such as additional spans may be necessary to provide a larger flow channel.

ROLE OF MAINTENANCE FORCES

Maintenance crews are primarily involved with bank erosion problems that can be corrected by minor or routine types of maintenance. Engineering personnel generally handle the selection, design, and construction of scour control and slope protection measures for major or chronic problems. Once these protective measures are constructed, however, they become the responsibility of maintenance forces. Maintenance workers should, therefore, have a basic understanding of the types of devices available, how they function, the most likely types of failure, and how the devices should be maintained. The role of maintenance worker can be divided into four important areas:

- Response to emergency situations
- Maintenance of the protective devices
- Assistance in identifying the need for protective devices
- Provision of input on the selection of alternatives

Area maintenance personnel should know the bridges that are susceptible to problems from a major storm. They are generally the first on the scene and the first to know when bank erosion is occurring, or when slope protection and flow control measures have been damaged. They should also look for damage to the bridge or bridge foundation. Often during major storms bridges are damaged and fail later under traffic. It is important that the need for repairs be recognized as early as possible. Minor repairs made in a timely manner are likely to reduce the need for major repairs that may result if the problem is left untreated.

In severe conditions, many slope protection and erosion-control devices take the brunt of the hydraulic forces in order to prevent more costly damage to the bridge or highway facility they were designed to protect. It is important that maintenance technicians be aware of these situations so repairs can be scheduled on a routine basis.

IDENTIFYING THE NEED FOR SCOUR COUNTERMEASURES

Slope protection and scour control devices are usually provided at the time the highway or bridge facility is constructed. Natural or man-made changes in the stream channel or drainage basin can change run-off characteristics, the type and amount of sediment carried by the stream, stream alignment, and other characteristics of the stream. The early identification of potentially severe problems can provide the lead-time necessary for analysis, design, and construction of appropriate erosion control and slope protection measures. Sites, where problems recur frequently, worsen in spite of frequent maintenance, or shift to another unprotected location when eroded areas are repaired, should be reported to engineering personnel for evaluation.

SELECTION OF ALTERNATIVES

The selection and design of appropriate slope erosion control and bank protection measures usually involve the analysis of complex stream characteristics that can best be accomplished by experienced hydraulic engineers. There are several practical matters that require input from maintenance personnel including:

Cause --Maintenance personnel are usually the best source of historical data, such as shifts in channel alignment that might help to determine the cause of the problem. Repairs are more likely to be successful when the cause of the damage can be determined.

Past Practice --An important consideration is how successful or unsuccessful different treatments have been under similar conditions in the past.

Materials --The use of locally available materials will usually reduce construction and maintenance costs.

Maintenance Requirements --The ease of maintenance should be an important consideration. Access and frequency of maintenance are key elements.

The many different methods currently used to control erosion and protect slopes from stream flow, tidal flow and wave action can be classified into three general categories: revetments (slope protection), flow control (stream training), and structure or channel modification.

REVETMENTS

The dictionary defines a revetment as a facing, such as stone or concrete, used to support an embankment. In engineering the term applies to a wide variety of longitudinal structures, coverings, or linings used to protect the banks of stream channels. All of the revetments discussed in this section can also be used to protect the channel bottom. Other terms frequently used instead of revetment are slope protection, bank protection, bed armor, and bank armor. Revetments can be divided into two general categories: flexible and rigid. Flexible revetments are able to conform to minor changes in the underlying bank with very little damage to the covering material. Rigid revetments do not conform to minor changes in the underlying material.

FLEXIBLE REVETMENTS:

Examples of Flexible Revetments Include:

- Rock riprap
- Wire enclosed rock riprap
- Planted vegetation
- Precast concrete shapes
- Grout filled bags

Dumped Riprap

Dumped riprap revetments consist of graded stone (or broken concrete) placed on a prepared surface, usually with some type of filter layer between the stone and the supporting bank. Although hand and mechanical placement is used to achieve an even distribution of the various sizes of stone, the stone is placed primarily by dumping.

Dumped riprap is flexible, easy to repair and the most widely used type of revetment in the United States. It is used primarily to protect banks that are roughly parallel to the direction of flow. When properly sized and properly installed dumped rock riprap has been highly effective.

Primary reasons for the failure of dumped rock riprap include:

Inadequate Cut-Off Walls and Toe Walls --Failures due to inadequate protection of revetment ends is common. Sandy and silty soils require that the toe walls and cut-off walls extend five feet below the streambed. Riprap walls should be deeper on the outside of curves and in other scour-prone locations than on straight sections .

Inadequate Coverage of the Bank --Failure to extend the revetment far enough causes problems similar to inadequate toe walls. Revetments must be extended far enough upstream and downstream from curves and constrictions so that they do not end in an area susceptible to scour. Revetments should also extend far enough up the bank to protect against high water.

Inadequate Size of Stone --Failures due to the use of stone that is too small are less common than the two types of failures listed above. Larger stone and thicker layers of stone should be used in areas where the flow is not parallel to the revetment. When broken concrete is used, flat shaped pieces are usually not satisfactory.

Erosion of the Supporting Soil --A filter layer must be used in sandy and silty soils to prevent loss of the material supporting the riprap. Aggregate layers or filter cloth may be used. Filter cloth is usually selected since it is easier to install.

Slope Failure --Prior to installing riprap the slope must be shaped to a stable grade. Slopes should not be steeper than 1.5 to 1.

Maintenance of dumped riprap primarily involves replacing riprap that is displaced or damaged by storms.

Hand-Placed Riprap

Hand-placed, ungrouted riprap is similar to dumped riprap except that stones are carefully placed by hand to produce a tightly fitted, fairly smooth surface. Hand-placed riprap lacks the flexibility of dumped riprap and does not have the strength of a rigid revetment. Studies have shown that hand-placed riprap is much more likely to fail than an equal thickness of dumped riprap.

Wire Enclosed Rock Riprap

Wire enclosed rock riprap is installed in two ways: in wire mattresses usually less than one foot thick, and in rectangular wire baskets called gabions. The uses of this type of revetment are similar to dumped riprap, yet it has the advantage of not being so easily displaced, it is appropriate for use on steeper or unstable slopes, and when large riprap is not available. The primary disadvantage to this type revetment is potential failure of the wire mesh due to corrosion or abrasion. New PVC wire coatings may improve the resistance to corrosion. See Exhibit XIII.6.



Exhibit XIII .6 Wire Enclosed Rock Riprap

Vegetation

Planted vegetation is generally not suitable for bank protection at locations with high water velocities. Plantings of sod, grass seed, or willow stakes have been used successfully for smaller streams and in combination with other types of bank protection. A number of products are available to assist in the establishment of seeding and planting. These products often include biodegradable materials such as paper and mats made of jute that last only long enough to permit the vegetation to become established. Synthetic materials such as nylon fabric, which reinforce the root system on a long-term basis, are also used.

Concrete Block Matting

Precast concrete blocks are available from several manufacturers to form flexible bank protection mats. Most concrete block mats (CBM) utilize interlocking blocks with spaces for vegetation to grow between and through the blocks. The vegetation helps to anchor the blocks in place. Some CBM's use blocks that are interconnected with cables or synthetic fiber ropes.

Grout Filled Bags

Grout bags are individual nylon or acrylic bags fabricated from panels of material to create a rectangular block form. Every bag is large enough to resist movement from flows. The bags are positioned like tiles around the pier to form an erosion-resistant floor. The bags are pumped full of grout after they have been located on the channel bed. Because the bags are formed in position, they fit snugly against each other. See Exhibit XIII.7.

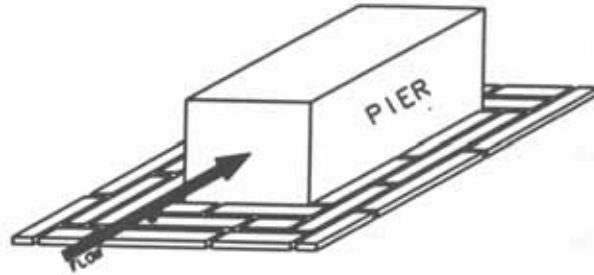


Exhibit XIII.7 Grout Filled Bags

Tetrapods

Tetrapods are pre-cast concrete shapes with extending legs that are randomly placed like riprap for channel protection. The tetrapods shown in Exhibit XIII-8 are presented in the U.S. Army Corps of Engineers Shore Protection Manual.

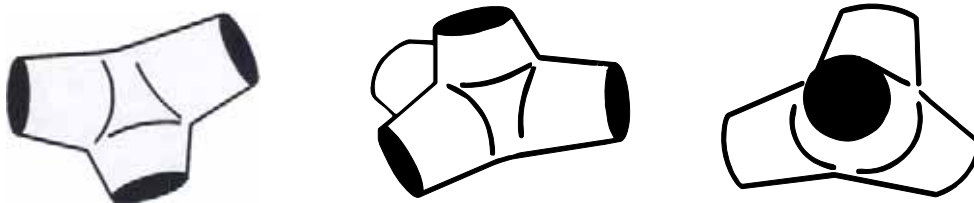


Exhibit XIII.8 Tetrapods

RIGID REVETMENTS:

Examples of Rigid Revetments Include:

- Concrete pavement
- Concrete grouted riprap
- Sacked concrete
- Concrete-filled fabric mats
- Bulkheads

Concrete Pavement

Plain and reinforced concrete pavement is used by many states for stream channel lining and slope protection. The concrete is cast-in-place on a prepared subgrade. It is also used in areas where riprap is not readily available. This procedure is typically performed at the downstream end of a culvert. The sides and bed of the stream are paved for up to 20 meters (60 ft) to dissipate the stream turbulence as the water exits the culvert. Thicknesses range up to 300 mm(12in).

The primary disadvantage of concrete slope protection is that it is very susceptible to failure by undercutting, scour and undermining at toe and ends of the pavement slabs. Once a failure begins it is generally progressive in nature and leads to a complete failure. It is extremely important that the toe and ends of a concrete revetment be well protected. Extending the pavement beyond points that are likely to scour will help to protect the ends. The toe of the slope protection must be extended vertically below the level of any possible scour. Concrete slope protection should be inspected regularly, particularly after storms. Sealing cracks and joints will help to prevent infiltration of water and erosion of the subgrade.

In cases where scour has occurred around the concrete slope protection but has not yet caused undermining, dumped riprap can be used to prevent further erosion. When undermining has occurred, pressure grouting or underpinning with cast-in-place concrete can be attempted. These measures are often not practical unless accompanied by other work due to the fact that voids may be difficult to plug or may be very large before they are detected. Prior to filling voids it is usually necessary to backfill the exposed scoured areas and then extend the concrete slope protection to solid foundation material. The voids beneath the slope protection may then be filled through holes drilled or punched through the existing concrete. Some agencies install anchors at the tops of slabs in areas likely to be undermined to prevent slippage when undermining occurs.

Concrete-lined channels may also fail due to hydrostatic pressure that is water pressure behind the lining. The installation of weepholes during construction is commonly required to relieve hydrostatic pressure. In areas where hydrostatic pressure is a problem, maintenance forces should periodically check weepholes to make sure they are functioning. Holes drilled through the slabs may reduce hydrostatic pressure in cases where weep holes were not installed. Underdrains to intercept seepage may also help.

Grouted Rock Riprap

Grouted rock riprap is a rigid type of revetment. The grouting prevents the rock from being displaced and provides an impervious surface. Like concrete slope protection, it is subject to undercutting and should be inspected after major storms.

Sacked Concrete

This type of revetment is constructed by stacking burlap, or other porous fabric, sacks filled with concrete. The concrete oozes through the burlap and cements the sacks together forming a rigid type of revetment. In some applications the sacks are connected together with dowels driven through the sacks. Sacked concrete slope protection can be placed on fairly steep slopes when the

soils are stable. However, the slope grade should not exceed 1 to 1. Advantages of sacked concrete are that it is easy to construct and easy to maintain. Sacked concrete slope protection, because it forms a rigid revetment, should be inspected for undercutting after major storms. Large cracks should be repaired to prevent loss of embankment material.

Concrete-Filled Fabric Mats

This type of revetment utilizes synthetic fabric mats that are filled by pumping concrete or grout into the mat in the field. Concrete-filled mats are similar to concrete slope paving. Advantages are the reduced construction time required for the forming and the ease of slope preparation. See Exhibit XIII.9.

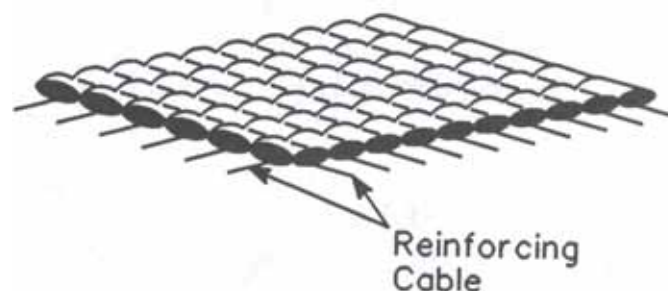


Exhibit XIII.9. Grout Filled Mat

Bulkheads

Bulkheads are vertical walls constructed from plain or reinforced concrete sheet piles, timber piles or cribbing. Bulkheads act as retaining walls and as slope protection. Bulkheads are primarily used to protect the embankments at abutments and approach roadways where fill slopes are likely to erode or have failed by slumping. Bulkheads may be used when there is no room to grade the banks to a stable slope. Failure of bulkheads is generally due to undermining. Erosion of the fill material behind the bulkhead and lack of foundation support are other causes of failure. Maintenance involves repair of erosion at the base of the bulkhead, keeping weep holes open, and repairing cracks or other types of damage that might occur.

FLOW CONTROL MEASURES

Flow control measures control one or more of the following characteristics: direction of flow, velocity of flow, and depth of flow. Commonly used flow control structures include: spurs, retards, dikes, spur dikes, jack fields, and check dams. See Exhibit XIII.10.

SPURS

A spur is a linear structure that projects into a channel from the stream bank or embankment. Spurs change the direction of flow and reduce flow velocity along the bank or embankment thereby protecting the bank from erosion. Other names for a spur are jetty, groin, deflector, and

wing dam. Common materials for constructing spurs are rock and earth embankments, timber piles, steel piles and sheet piles.

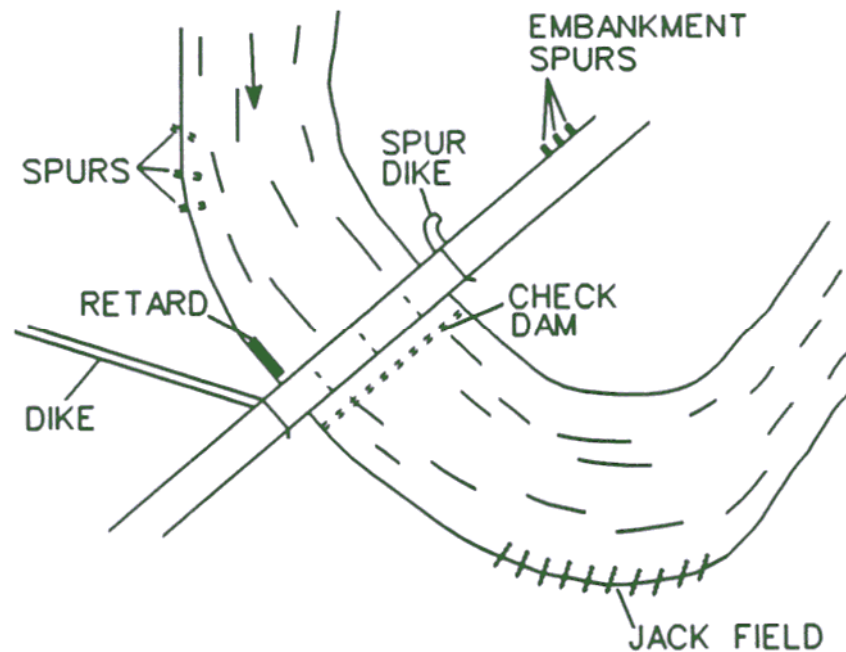


Exhibit XIII.10 Hydraulic Training Structures

Spurs can be divided into two groups: those that allow water to pass through the spur (permeable) and those that do not (impermeable). Permeable spurs are generally fence-type structures and are best for flows that carry a lot of silt or sediment. Maintenance of permeable spurs consists mainly of replacing pile bracing and fencing material. Removal of drift that could be a fire hazard should also be performed.

RETARDS

A retard is a linear flow control structure that may use the same types of structures as spurs, revetments, and other flow control devices. The main difference between retards and spurs is that retards are parallel to the bank rather than projecting from the bank into the stream. They are also not supported by the bank, are usually at the toe of the bank, and may be permeable or impermeable. The construction methods, materials, and maintenance needs are similar to spurs. Retards are used to correct alignment problems and to reduce flow velocity along the stream bank. Retards may be used at curves to keep flow from striking a bank directly.

DIKES

Dikes are usually used on flood plains to control the flow of water that overflows the banks. For example, dikes may be used on the upstream side of a bridge to prevent high water from bypassing the waterway opening of the bridge. Maintenance is similar to that required for corresponding revetment types.

SPUR DIKES

A spur dike is a projecting dike usually located on the upstream side of a bridge. Spur dikes project out from the approach roadway embankment to reduce the erosion caused by water flowing along the upstream side of the embankment. Spur dikes also direct the flow of water in the channel into the waterway opening of the bridge. Spur dikes are generally used when the waterway opening of the bridge is narrower than the channel, as when approach roadways are on embankments, and scour is occurring at the upstream ends of the abutments. Scour may still occur with spur dikes but will be moved upstream and away from the abutments. Spur dikes are usually earth or rock embankments protected with some type of revetment. Maintenance is similar to the maintenance of revetments.

JACK FIELDS

Jacks, or tetrahedrons, are devices used to reduce flow velocity along stream banks. Each jack consists of several struts that are bolted or fastened together to form six perpendicular arms. Jacks may be made from concrete or steel struts. They are usually arranged in fields consisting of several rows of jacks that are fastened together with cables. Jacks may also be arranged to serve as retards and spurs. Jack fields work best in streams that carry a lot of floating debris, and, if debris does not collect on the jacks, they will have very little adverse effect on bank erosion.

CHECK DAMS

A check dam is a low dam or weir built across a channel to control the velocity of flow and prevent erosion of the streambed. Check dams are usually built downstream from the structure that they are to protect. Check dams may be built from rock riprap, gabions, concrete, sheet piles, or concrete-filled mats.

Maintenance may require replacement or repair of displaced or damaged portions and removal of debris, such as trees, that may affect the flow.

STRUCTURE OR CHANNEL MODIFICATIONS

Changes to the stream channel or the bridge structure may sometimes be necessary to control erosion. Structure modifications include increasing the height of the structure and the adding of spans. Channel changes include modifications to the horizontal or vertical alignment, cross section, and roughness. Structure and channel modification projects are beyond the scope of responsibility for maintenance workers. However, maintenance personnel should be aware of these options since poor channel alignment or a restricted waterway opening may be the cause of continuing maintenance problems.

The practice of relocating streams for better alignment is no longer permitted in many areas and if it were permitted it would require involvement of other agencies such as the Corp of Engineers. Most changes to horizontal alignment, such as straightening a channel, will also involve a change in slope. Change in slope can result in increased erosion when the slope is steeper, or an increased accumulation of sediment when the slope is flatter.

Local channel modifications in the immediate vicinity of the structure do not always have the intended effect. For example, if the water level is controlled by downstream conditions, modifying the channel cross section at the bridge will not lower the depth of flow. Minor channel modifications in the immediate vicinity of a bridge may be effective but should not be made without a careful engineering analysis.

REPAIR OF SCOUR AND SUBSTRUCTURE UNDERMINING BY REPLACEMENT OF MATERIAL

Most repairs for scour around bridge piers and abutments will involve the placement of the eroded material. In many cases both riprap and concrete will be used. There are several special considerations that apply to the placement of these materials around bridge substructure units.

RIPRAP

The following factors should be considered when placing riprap around piers or abutments:

- Care must be exercised when dumping riprap around existing structural units. The large stones required can easily chip or break the concrete elements. Placement of riprap around piers must often be done from a barge.
- Placement should be made in even lifts to avoid unbalanced loads on footings.
- An analysis should be made to ensure that footings or pile supports would not be overloaded.
- The stone must be of suitable size for the anticipated flow conditions.
- Riprap should not extend above the original streambed. Riprap that does not extend above the original streambed will act as an obstruction. The turbulence resulting from riprap improperly placed around a pier can cause localized scour at other piers or at the abutments.

CONCRETE

Placement of concrete to repair scour or undermining of substructure units usually requires either dewatering or underwater placement of concrete. In either case proper placement, good forms, and skilled personnel are essential. Dewatering may be accomplished by constructing cofferdams, or if environmental regulations permit, diversion of the flow away from the repair area. The primary disadvantage of dewatering with cofferdams is the clearance required for driving sheet piling. General precautions for concrete placement under wet or dry conditions include:

- An analysis should be performed to ensure that pile support would not be overloaded.
- Forms should be prevented from moving and should not be removed prematurely. Prebagged concrete or concrete pumped into fabric forms are often used in place of conventional forms.

- Concrete should not be placed in running water or be allowed to drop through water as this could wash the cement out of the concrete.

Underwater placement can be accomplished by underwater tremie, pumping, bagged concrete, and prepacked concrete. Descriptions and special considerations for each of these methods are briefly discussed in the following paragraphs:

Tremie- A tremie is a tube with a hopper at one end and a discharge gate at the other. It is used to place concrete under water by gravity flow. The discharge gate end is closed until the tremie is filled with concrete and lowered to the point where the concrete is to be placed. Once the pour begins, the discharge end must be kept submerged in the newly placed concrete and the tremie hopper must be kept filled with concrete. If this is not done, the pipe will fill with water. Multiple tremies are needed to reduce lateral travel and when reinforcing steel restricts the movement of the tube.

Pumped Concrete- Placement of concrete by pumping is similar to tremie placement. Since, however, the concrete is pumped rather than gravity fed it is somewhat easier to control the discharge. A manifold can connect multiple hoses.

Bagged Concrete- Concrete can be placed underwater in bags made of a porous material such as burlap. The bags are partially filled with concrete and then placed by workmen in shallow water or divers in deeper water. Bags may be filled with dry concrete and wetted during placement. Concrete may also be pumped into fabric forms specially sized to fill a void under the footing.

Prepacked Concrete- Prepacked concrete involves filling the forms with coarse aggregate and pumping in a grout. The grout displaces the water and fills the voids in the aggregate. Special equipment and techniques are required for this method.

EXAMPLES OF SUBSTRUCTURE REPAIR

Following are two examples of repairs to correct scour damage to bridge substructure units. While one is a pier and the other is an abutment, most of the procedures could be used for either.

EXAMPLE 1. REPAIR OF SCOUR AT PIER FOUNDATIONS

Undermining of footings that are not on piles can result in reduction of load capacity, settlement, tipping, or failure of the structure. Undermining of footings that are supported by piles can also be a serious problem. Exposure of the piling increases the load on the piling and exposes the piling to increased corrosion and abrasion. The load-carrying capacity of the bridge is also reduced because the footing has less support. Repair of undermined pier foundations is accomplished by the use of a tremie concrete encasement to fill the void and installation of riprap to prevent future undermining. See Exhibit XIII.11.

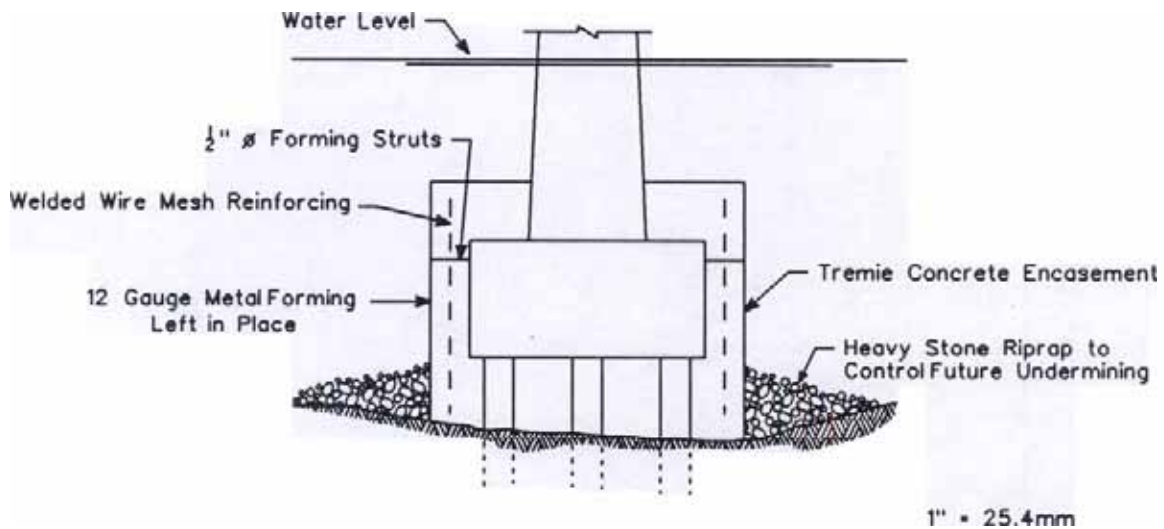


Exhibit XIII.11 Tremie Concrete Scour Repair

Preliminary Planning

Planning should include the following:

- Analyze the flow characteristics to determine the cause of the problem.
- Consider of the additional weight of the concrete encasement on the piling and soil foundation.
- Fabricate metal forming and reinforcement.

Resource Requirements

The following will be needed:

- Pile driving equipment if cofferdams are used
- Pumping or tremie concreting equipment
- Crane or other lifting equipment

Construction Procedures

The following repair steps are required:

1. Clean all exposed concrete surfaces of marine growth and loose or deteriorated concrete to ensure a good bond.
2. Place welded wire mesh around the footing. Rebars may sometimes be used to withstand shear load if the encasement significantly spreads the footing.
3. Set forms and pour tremie concrete.
4. Leave metal forms in place.
5. An alternate to the preceding procedure is to substitute dry-mixed concrete riprap in bags for the steel forms. See Exhibit XIII.12.

6. For small voids under the footings, a technique using fabric forms filled with mortar and grout injection pipes is an alternative that can prove to be cost effective. See Exhibit XIII.13.

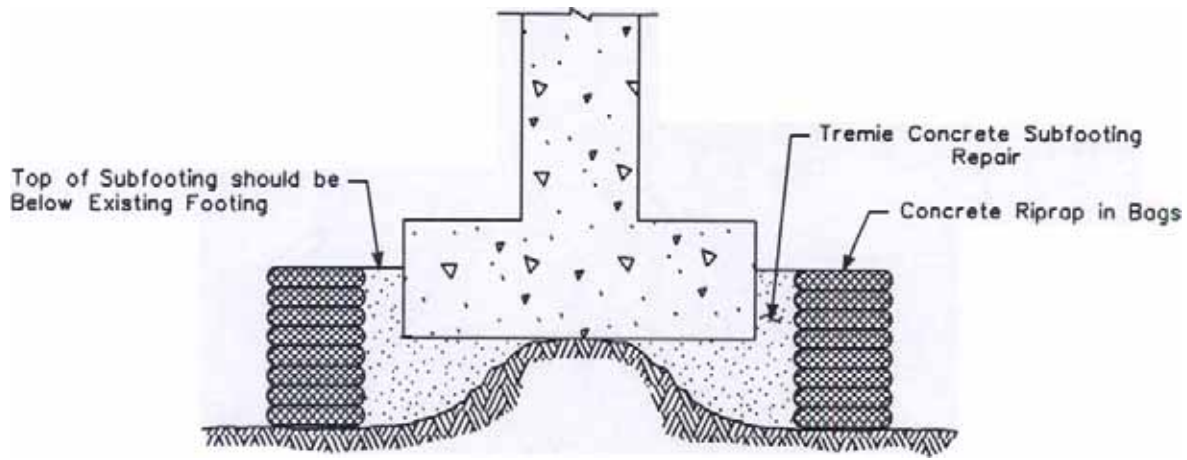


Exhibit XIII.12 Bagged Riprap Scour Repair

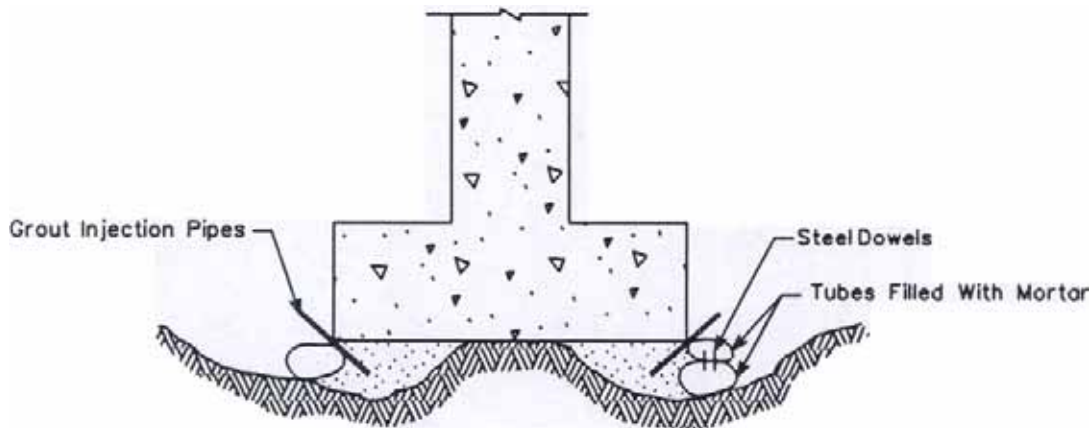


Exhibit XIII.13 Mortar Filled Tube Scour Repair

EXAMPLE 2. REPAIR OF ERODED ABUTMENT FOOTINGS

The undermining of abutment footings results from causes similar to the undermining of pier footings. The consequences are also similar with the additional hazard that the abutment is likely to be asymmetrically, not evenly, loaded due to the approach fill pushing against it. These forces may tend to tip the abutment toward the streambed. The magnitude of asymmetric loads, as well as deadmen that may have been provided to resist them, should be ascertained in evaluating safe conditions during repair. See Exhibit XIII.14.

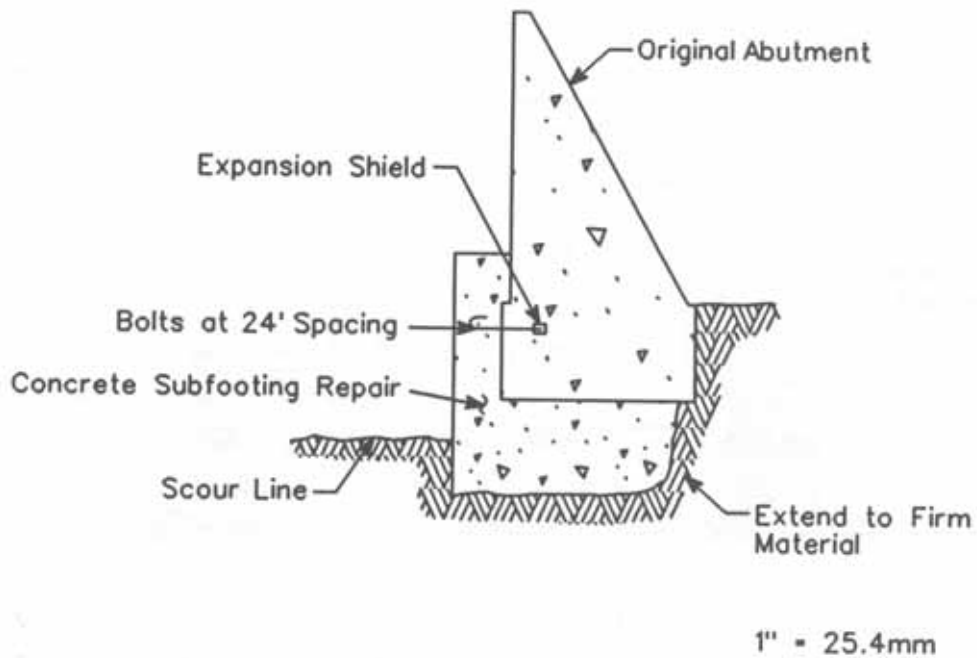


Exhibit XIII.14 Eroded Scour Repair

Preliminary Planning

Planning must include the following:

- Analyze the flow characteristics to determine the cause of the problem.
- Evaluate safety problems during repair due to potential instability of the abutment.
- Analyze the hydraulic effect of stone riprap on the flow through the opening under the bridge.

Resource Requirements

The following equipment is usually needed:

- Equipment for placing riprap
- Pile driving equipment
- Crane or other lifting equipment
- Concrete drilling equipment
- Concrete pump and tremie equipment

Construction Procedures

The sequence of repairs is as follows:

1. Remove loose material and silt from the foundation area.
2. Clean exposed concrete surfaces that will interface with subfooting.
3. Drill holes on 600 mm (2-foot) centers in existing concrete and install anchors.
4. Erect forms for the face of the subfooting.
5. Place concrete for subfooting using mix that is sufficiently plastic to fill all voids.
6. After the concrete has reached design strength, remove the forms and add stone riprap.

REBUILDING SCOURED STREAMBED

The effectiveness of rebuilding a streambed depends on whether the scour problem is isolated in an area around the bridge or whether the streambed has been generally lowered. When the streambed has been generally lowered, it is best to extend the concrete footings below the scour line. This takes advantage of the deeper channel to reduce flow velocities. This procedure also aids in minimizing the construction of the channel by placement of riprap. Maintaining the maximum possible depth and width of a channel aids in reducing flow velocities which in turn reduces the scour action and the probability that any riprap used will be undermined or dislodged. See Exhibit XIII.15.

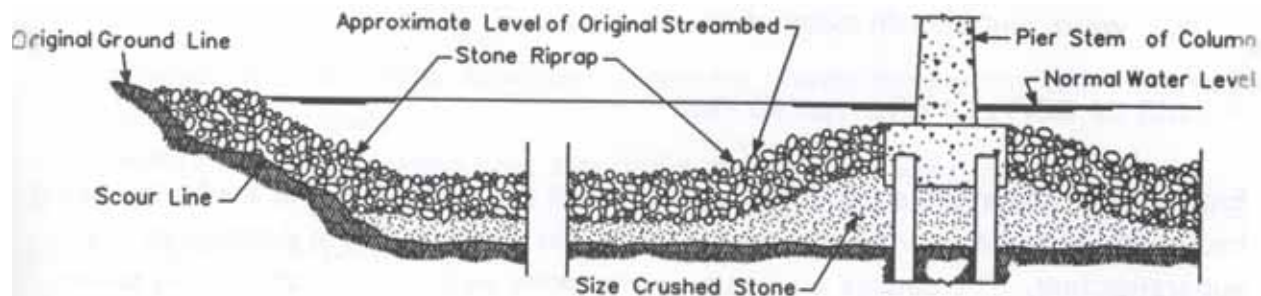


Exhibit XIII.15 Stream Bed Paving Repair

PRELIMINARY PLANNING

The planning should include the following:

- Determine whether the streambed is generally lowered.
- Determine whether the extension of concrete footings below the scour line is feasible.
- Determine the velocity of flow and the size of riprap and crushed stone necessary to resist the scour.

RESOURCE REQUIREMENTS

The following material and equipment are required:

- Riprap, stone, or crushed stone
- Equipment such as front end loaders or cranes to place the material

CONSTRUCTION PROCEDURES

The required construction procedures include:

1. Place crushed stone in the channel to an elevation approximately 600 mm (2 feet) below the proposed top of the stream bed taking care to fill voids below the footings.
2. Add a 600 mm (2-foot) layer of large stone riprap in the 70 to 225 kg (150 to 500 pound) range over the crushed stone. The riprap should extend above the high water line at both sides of the channel.

REPAIR OF SETTLED AND TILTED PIER

Erosion that undermines a footing, particularly if no supporting and anchoring piling has been used, may permit the pier to settle and tilt, resulting in damage to the superstructure. The causes are basically the same as in other undermining cases. The stabilizing of the footing is also similar to other undermining cases. The repair is complicated by the need to repair the damaged superstructure. See Exhibit XIII.16.

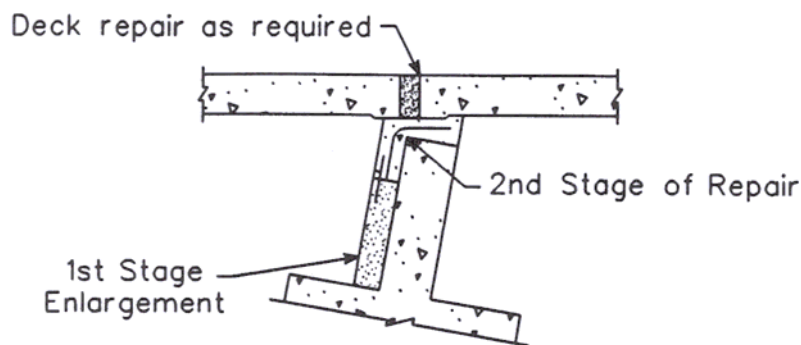


Exhibit XIII.16. Repair of Settled or Tilted Pier

PRELIMINARY PLANNING

Planning must include the following:

- Evaluate the condition of the structure and the foundation to determine whether it is repairable and whether the pier can be stabilized in its present location.
- Evaluate the need for temporary supports until repairs are complete when traffic must continue to use the bridge.
- Design the stem enlargement and fabricated reinforcement.

RESOURCE REQUIREMENTS

The following equipment and materials are required:

- Equipment for light lifting, dewatering, jacking, tremie concreting, and installing a cofferdam if required
- Concrete for riprap, tremie seal, pier and superstructure repair

CONSTRUCTION PROCEDURES

The sequential steps in making the repair are:

1. Follow instructions provided under "Repair of Eroded Areas at Pier Foundations".
2. Construct first stage of pier enlargement to above water level.
3. After the new concrete has attained design strength, it can be used as a seat to jack the superstructure back to its original grade.
4. A sufficient amount of the second stage portion of the pier is placed to permit removal of temporary supports.
5. After concrete has attained sufficient strength to support the superstructure, the remaining concrete is placed in the pier and the deck and the superstructure is repaired.

XIV. WINTER MAINTENANCE PROCEDURES

A. WINTER MAINTENANCE PROCEDURES

INTRODUCTION

Bridges and bridge approaches cause special problems in winter maintenance. There are bridges at interchanges and this compounds the problem since an interchange can represent the most difficult portion of a winter maintenance operator's route. This chapter focuses on the specific winter maintenance problems associated with bridges and their appurtenances.

This training program cannot provide detailed information about correct winter maintenance since that is a special field. It is assumed that states that employ bridge maintenance employees on a regular or standing basis to operate winter maintenance equipment provide suitable and far more detailed training in winter maintenance activities than would be possible or appropriate in this program.

TRAINING

The improper operation of winter maintenance units can cause great damage to structures; conversely, structures can cause great damage to winter maintenance units when the proper operating procedures are not followed. Equipment operators, who constitute the backbone of winter operations, must have special knowledge and skills in snow plowing and ice control methods.

New operators must be trained to operate the snow, ice control and communications equipment. Each requires a special knowledge of techniques and safety precautions for snow and ice control with emphasis on bridges, underpasses, and interchanges. Exhibit XVI.1 shows a winter maintenance problem unique to bridges.



Exhibit XVI.1 Snow Removal

RESPONSE TO ICE AND SNOW ON THE DECK

Ice usually forms and snow accumulates on bridges and overpasses before it does on adjacent road surfaces. Consequently plowing and ice treatment are required on bridges or overpasses before they are required on roadways.

Standby maintenance crews to treat bridges at the first indication of a potentially critical situation should be considered. Temperature-sensing devices that warn of icing on bridges and indicate that treatment should be initiated may be advisable in some locations.

In some states motorists are notified that bridge surfaces may freeze before the adjacent roadway by signs. A typical sign used for this purpose is "Bridge Ices Before Road Surface". When such signing is the policy, care should be taken to ensure that the signs are properly placed.

Ponding of water on bridge decks, especially if deicing chemicals have been applied, creates a dual hazard. First, the water is a traffic hazard whether it stays liquid or becomes ice. Second, the water and chemicals may penetrate the deck and cause deterioration through freeze-thaw cycling and corrosion. Bridge deck drainage systems should be kept open to rid the bridge of these hazards. When weather conditions make it impossible to keep the drains open, it may be advisable to load and haul away the ice and snow as soon as possible.

Bridges located on north south highways are susceptible to icing under certain circumstances when snow or ice is allowed to remain in windrows at the curb. When daytime temperatures rise to freezing or slightly above and the sun melts the ice and snow on the west side of the bridge, the resulting water can run off into the traffic lanes. This situation can be made worse when the bridge has a super elevation. As the sun moves to the west, the runoff in the traffic lanes will freeze. This can occur in the mid-afternoon in midwinter and may cause the only icy conditions in miles of bare pavement. A further complication is that this situation often occurs after winter maintenance personnel have completed work for the day.

ICE AND SNOW REMOVAL FROM THE BRIDGE

Bridges generally have narrow roadways so that snow and ice control measures must ensure that the entire roadway is kept serviceable for traffic flow and safety.

Snow markers are also advisable in regions of heavy snowfall as an aid in avoiding damage to the structure, railings, curbing or lane dividers.

Snow and ice should be removed from the roadway surfaces on bridges at frequent intervals. When it is allowed to build up, it can become very hard through freeze-thaw cycles and is then nearly impossible to remove.

Snow removal at bridges, interchanges and ramps may require loading, hauling and dumping if the deck or roadway becomes restricted. Snow or ice left on bridges can create water and salt damage to the structure, frozen drains, traffic hazards, and bridge deterioration problems from freeze-thaw cycles.

Icicles may form on overpasses, particularly where drains become frozen, and these icicles present a hazard to traffic passing underneath. They may have to be removed and proper warning and traffic control procedures should be followed during this process.

SNOW PLOW DAMAGE TO THE BRIDGE

The deck expansion joints of bridges are seldom perfectly matched in height and there is often a gap between the sections. Proper adjustment of the plow shoes is not always effective when the joint is in poor condition and the shoes are not long enough. The plow must ride over this discontinuity without hanging up and damaging the plow or the joint.

An extremely hazardous condition is created when the angle of the plow matches the skew of the bridge so that the entire blade edge suddenly contacts the uneven joint or drops into the joint because the plow shoes are inadequate. The resultant damage to the joint, the plow unit, and the operator may be severe. Auxiliary, extended shoes, positioned near the end of the plow blade, are effective in preventing this mishap. Adjustable angle plows and straps welded across the joint for the plow to ride on are other solutions.

CHEMICALS AND ABRASIVES

The use of chemicals and abrasives is an established technique of snow and ice control. Spreading equipment should be adjusted to permit the additional application of deicing chemicals and abrasives on bridge decks as well as other critical locations to counteract severe, localized icing conditions. The resulting accumulation of these materials should be completely removed from every part of the bridge as early as possible following the winter season. This can be done by sweeping, flushing, scraping or a combination of these methods; but flushing should always be a part of this procedure.

WINTER MAINTENANCE ACTIVITIES

As mentioned previously in this chapter, keeping bridge decks clear of snow and ice is very important to insure a safe condition for the motoring public. In addition it is important to keep the bridge clear of contaminants that can affect the life and integrity of the bridge. The following are some of the more important preventive maintenance activities that can be performed to insure that the bridges are kept safe and the life of the bridges are not shortened.

REMOVAL OF SNOW AND ICE- CHEMICAL

The steps in this activity are normally accomplished in the following order.

1. Monitor air temperature at bridges that have snow or other moisture on decks.
2. If air temperature approaches freezing (0°C or 32°F) apply chemical materials to bridge decks.
3. Repeat chemical applications as required until bridges dry out or temperature rises above freezing.

REMOVAL OF SNOW AND ICE- MECHANICAL

The steps in this activity are normally accomplished in the following order.

1. Establish traffic control as required.
2. Using loading equipment, remove the snow and ice from the bridge deck and place it off of the bridge or place in dump trucks for removal away from the bridge.
3. If necessary, place chemical materials on any remaining snow and ice material to keep from freezing on the deck.
4. Remove traffic control.

CLEANING THE BRIDGE DECK

As mentioned previously the use of chemicals and abrasives is an established technique of snow and ice control. The resulting accumulation of these materials should be completely removed from the bridge deck as early as possible following a storm for after the winter season. This can be done by sweeping, flushing, scraping or a combination of these methods; but flushing should always be a part of this procedure.

The steps in this activity are normally accomplished in the following order.

1. Establish traffic control as required.
2. Sweep and remove any larger quantities of materials from the deck.
3. Flush the deck with water to remove the remaining materials from the deck.
4. Clean and flush the deck drains of any material that might be lodged in the pipes.
5. Remove the traffic control.

CLEANING THE UNDERSIDE OF THE BRIDGE DECK

This activity is for removing the salt and abrasives that have accumulated or adhered to the under side of the bridge deck. Areas include the sides of beams and diaphragms where water has come off of the deck and bridge seats where horizontal surfaces collect material coming through deck joints. Areas might include:

- beam ends and diaphragms at deck joints that leak or allow water to pass through
- sides of beams where deck drains extend below the beam
- bearings and bridge seats at joints where material is allowed to come through

The steps in this activity are normally accomplished in the following order.

1. Establish traffic control as required.
2. Flush the beams and bridge seats with water to remove materials from the element.
3. Remove the traffic control.