CHAPTER 10

INSPECTION MAINTENANCE AND REHABILITATION

INSPECTION

Drainage systems should be inspected on a routine basis to ensure that they are functioning properly. Inspections can be on an annual or semi-annual basis, but should always be conducted following major storms. Inspection of sewers, culverts and other soil-metal structures can be carried out visually and recorded with still photographs or videos. Current electronic technology enables the inspector to communicate directly with a central office using facsimile or video transmission. Inspection software has been developed by various provincial highway departments which provide a more consistent method of reporting. Inspection falls into the two general categories of environmental and structural assessment.

Environmental Assessment

Environmental assessment includes the conditions of soil side corrosion, water side corrosion, water side abrasion and clogging. Soil side corrosion can be determined by excavating a trench outside the structure or by inspecting the exposed overhang at the inlet and outlet ends of the structure. Inspection includes a visual examination for spalling, red rusting, pitting and perforating. The soil corrosivity including pH and resistivity is recorded along with moisture, soluble salts and oxygen content.

Water side corrosion is determined by a visual examination for spalling, red rusting, pitting and perforating. The water corrosivity including pH and resistivity is also recorded.

Water side abrasion is also determined visually along with an assessment of structure slope, flow velocity and upstream bed load of either rock or sand.

Clogging due to the accumulation of sediment or debris can be readily assessed visually and measured manually.

Structural Assessment

Structural assessment includes shape monitoring, joint separation, crimping of the conduit wall, bolt hole tears, bearing failure of the longitudinal seams, excessive deformation, invert lifting, pipe end lifting, and pipe end distortion.

Maintenance procedures should be developed to provide a consistent and cost effective approach for sewer and culvert assessment. Good records should be kept on all maintenance and repair operations to help plan and prioritize future work. The date of installation, a description and configuration of the product, the date of subsequent inspections and maintenance should be properly recorded.

Shape Monitoring

Traditional monitoring methods have usually consisted of a visual inspection, with actual measurements being taken only if serious signs of distress are observed. Other than the span and rise, geometric measurements are normally limited to selected

Pipe inspection.

chord lengths and offsets at specified cross sections. These dimensions can be related to the curvature of a section. The performance of the structure is judged primarily on deformation stability. Excessive flattening of a section makes it susceptible to snap-through instability. The extent of flattening that a structure can tolerate is not easily defined. Arbitrary limits on the reduction in the midordinate heights have been used to define the severity of the deformations and the remedial measures required. The changes are usually measured from the design shape, since the as-built dimensions are rarely measured. Being flexible, it is possible that the plates were deformed from the design shape during construction, with little or no subsequent deformations. As built measurements should be taken immediately after installation. Only an ongoing monitoring of the structure can confirm that the deformations have stabilized.

In photogrammetric monitoring, an object is photographed using specialized equipment following set procedures, and measurements are obtained from the photographic images. These measurements and some externally supplied information are used to determine, either analogically or analytically, the location of reference points in the three-dimensional object space. Photogrammetry is particularly useful in monitoring large or difficult-to-access structures.

Crimping of the Conduit Wall

Crimping can be regarded as a consequence of local buckling in which the metallic shell buckles into a large number of waves, each of relatively small length. It can occur in the compression zone of the wall section when the conduit wall undergoes large bending deformations. This kind of crimping usually takes place in conduit wall segments of relatively small radius of curvature. It indicates that the soil behind the segment is not dense enough to prevent excessive bending deformations.

Crimping can also occur in an entire conduit wall section subjected to excessive thrust while being supported by very well compacted backfill. Although the incidence of this kind of crimping is rare, it is known to have occurred in structures with circular conduits, which were constructed with good-quality, well-compacted backfill on relatively yielding foundation. It is assumed that the long-term foundation settlements of these structures induced negative arching, thus subjecting the conduit wall to greater and greater thrusts as time passed, until the thrust exceeded the buckling capacity of the conduit wall even though it was well supported.

Buckling of the entire conduit wall section into waves of small length has a redeeming feature. By reducing the axial rigidity and increasing axial deformations of the pipe, it induces positive arching, thus effectively reducing the axial thrust in the pipe. The result of this sequence is that, despite crimping, the pipe can be in stable condition provided, of course, that the time-dependent foundation settlements have ceased.

If the only sign of distress in a soil-steel structure is crimping limited to a few segments, then in most cases one need not be too concerned about the structural integrity.

Bolt-hole Cracks

Bolt-hole cracks or tears usually occur in longitudinal seams. Since the conduit wall is always subjected to compressive forces, the bolt-hole tears usually do not extend over the entire section of the wall. There are, however, some known cases in which the bolt-hole tears, have extended over larger segments of the conduit wall.

Bolt-hole tears are most common in pipe-arches at the longitudinal seam between the top and side segments of the conduit wall. However, they are also found, very infrequently, in other soil-steel structures. Bolt-hole tears are not always the result of excessive deformation of the conduit wall of the completed structure; they can also be formed during assembly when poorly matching plates are forced to fit at the longitudinal seams.

Reviews of this issue have been conducted and reported on by the Ontario Ministry of Transportation, Alberta Transportation and Utilities / University of Alberta, and the consulting firm of BOWSER-MORNER Associates. All reports conclude that there is a correct and incorrect way of lapping the plates at longitudinal seams.

The correct orientation for longitudinal seam plate lap results in the valley bolt being located closest to the visible plate edge. This is illustrated in Figure 10.1.

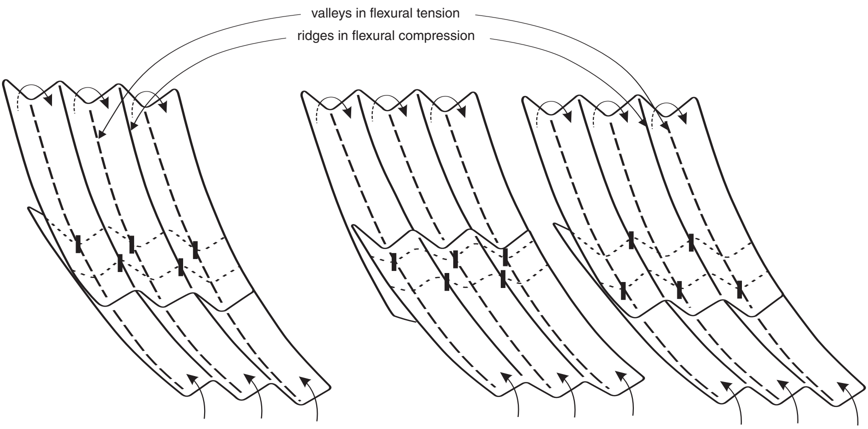

Figure 10.1 (a) Undesirable and (b) desirable arrangement of bolts. (Reproduced from Canadian Journal of Civil Engineering, Volume 15, Number 4, 1988, Pages 587 - 595: Bakht and Agarwal)

It is also suggested that the bolt orientation, in those longitudinal seams of pip-arches susceptible to the tears, had an impact. The recommended bolt orientation for the seam between the top and corner plates is illustrated in Figure 10.2

The BOWSER-MORNER report recommended a procedure for correcting the bolt hole tear phenomenon on those structures on which it has occurred. The procedure is illustrated in Figure 10.3.

Bearing Failure at Longitudinal Seams

Bearing failure at longitudinal seams can take place due to the yielding of the conduit wall directly under the bolts. This form of failure takes place under excessive conduit wall thrust and under conditions that preclude excessive bending deformations.

While the bearing failure of longitudinal seams has been observed in laboratory testing of the strength of bolted joints, it is extremely rare to find it in practice.

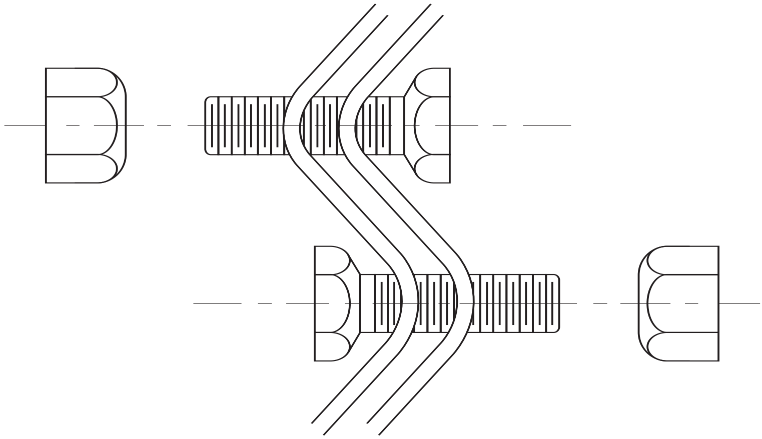

Figure 10.2 Bolt orientation.

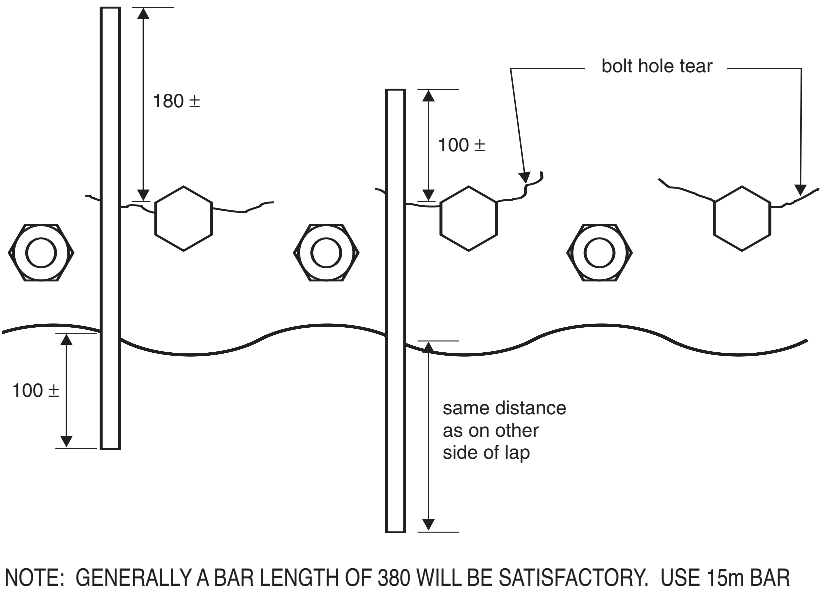

Figure 10.3 Procedure for correcting bolt hole cracking.

Excessive Deformation

Excessive deformations of the conduit wall are caused by the inability of the backfill to restrain its movement. Excessive pipe deformations do not always develop after the structure has been built. Because of its flexibility, the pipe can deform excessively during the initial stages of the backfilling operation. If such deformation is not prevented or corrected during construction, the structure is built with deformed pipe. Pipe deformations locked in during construction may not be detrimental to the structural integrity of the structure, especially if they have stabilized. Pipe deformation occurring after the completion of the structure may, on the other hand, be a warning signal for the imminent collapse of the structure.

It is very important that a record of the as-built conduit shape be kept so that it can be ascertained later whether the observed deformation occurred recently or has been there since the construction of the structure. When the records of the as-built structure are not available, it is important to record the changes in the conduit shape at regular intervals after the deformations were first noticed. If the deformations are not significant and have not undergone significant changes, then it is likely that the structure is safe.

Lifting of the Invert

In soil-metal structures with large radius or flat invert plates the pressure under the corners is much greater than under the invert plates. If the foundation has inadequate bearing capacity the structure settles more under the haunches than under the invert. This results in a loss of waterway area and also may cause the eventual collapse of the structure.

Lifting of the Pipe Ends

Another form of distress commonly found in soil-steel bridges occurs in structures in which water flows through the conduit. This kind of distress is caused by a combination of uneven settlement of the pipe foundation along its length and buoyancy effects.

Distortion of Bevelled Ends

Bevelled ends are particularly vulnerable to damage by horizontal pressures. A complete pipe, because of having a closed section, can sustain much higher intensities of the lateral pressure than an incomplete ring. Lacking a closed section, the bevelled ends of a pipe are prone to damage by heavy equipment pieces falling on them or by lateral earth pressures. These ends should be tied back into the fill.

MAINTENANCE

Various types of equipment are available commercially for maintenance of drainage structures. The mobility of such equipment varies with the particular application and the equipment versatility. The most frequently used equipment and techniques are listed below.

Vacuum Pumps

This device is normally used to remove sediment from sumps and pipes and is generally mounted on a vehicle. It usually requires a 900 to 1350 litre holding tank and a vacuum pump that has a 250 mm diameter flexible hose with a serrated metal end for breaking up caked sediment. A two man crew can clean a catch basin in 5 to 10 minutes. This system can remove stones, bricks, leaves, litter, and sediment deposits. Normal working depth is up to 6 m.

Waterjet Spray

This equipment is generally mounted on a self-contained vehicle with a high pressure pump and a 900 to 1350 litre water supply. A 75 mm flexible hose line with a metal nozzle that directs jets of water out in front is used to loosen debris in pipes or trenches. The nozzle can also emit umbrella-like jets of water at a reverse angle, which propels the nozzle forward as well as blasting debris backwards toward the catch basin. As the hose line is reeled in, the jetting action forces all debris to the catch basin where it is removed by the vacuum pump equipment. The normal length of hose is approximately 60 m. Because of the energy supplied from the waterjet, this method should not be used to clean trench walls that are subject to erosion.

Bucket Line

Bucket lines are used to remove sediment and debris from large pipes or trenches (over 1200 mm diameter or width). This equipment is the most commonly available type. The machine employs a gasoline engine driven winch drum, capable of holding 300 m of 12 mm wire cable. A clutch and transmission assembly permits the drum to revolve in a forward or reverse direction, or to run free. The bucket is elongated, with a clam shell type bottom which opens to allow the material to be dumped after removal.

Buckets of various sizes are available. The machines are trailer-mounted usually with three wheels, and are moved in tandem from site to site. When a length of pipe or trench is to be cleaned, two machines are used. The machines are set up over adjacent manholes. The bucket is secured to the cable from each machine and is pulled back and forth through the section until the system is clean. Generally, the bucket travels in the direction for the flow and every time the bucket comes to the downstream manhole, it is brought to the surface and emptied.

Fire Hose Flushing

This equipment consists of various fittings that can be placed on the end of a fire hose such as rotating nozzles, rotating cutters, etc. When this equipment is dragged through a pipe, it can be effective in removing light material from walls. Water can be supplied from either a hydrant or a truck.

Sewer Jet Flushers

The machine is typically truck-mounted and consists of a large watertank of at least 4500 litres, a triple action water pump capable of producing 6900 kPa or more pressure, a gasoline motor to run the pump, a hose reel large enough for 150 m of 25 mm inside diameter high pressure hose and a hydraulic pump to remove the loose material. In order to clean pipes properly a minimum nozzle pressure of 4100 kPa is usually required. All material is flushed ahead of the nozzle by spray action. This extremely mobile machine can be used for cleaning areas with light grease problems, sand and gravel infiltration, and for general cleaning.

REHABILITATION

Rehabilitation of the infrastructure is a major undertaking now being addressed by federal, provincial, and local governments. While the magnitude of rehabilitation may at times appear enormous, rehabilitation often is very cost effective when compared to the alternative of new construction.

Storm sewers and highway culverts represent a significant portion of the infrastructure. Methods of rehabilitating corrugated steel pipe (CSP) structures can be obtained from the CSP manufacturer. Generally, CSP structures can be rehabilitated to provide a new, complete service life at a fraction of the cost or inconvenience of replacement.

All of the methods described herein require a complete inspection and evaluation of the existing pipe to determine the best choice. With CSP, rehabilitation often requires merely providing a new wear surface in the invert. Typically, structural repair is unnecessary. However, if the pipe is structurally deficient, this does not rule out rehabilitation. Repair methods can be utilized and the structures restored to structural adequacy and then normal rehabilitation procedures performed. Even with 25% metal loss, which occurs long after first perforation, structural factors of safety are reduced by only 25%. When originally built, CSP storm sewers often provide factors of safety of 4 to 8 - far in excess of that required for prudent design.

This section deals mainly with the rehabilitation of corrugated steel pipe and/or steel structural plate or the use of CSP as a sliplining material.

Methods of Rehabilitation

In-place installation of concrete invert.
Reline existing structure.
- Slip line with slightly smaller diameter pipe or tunnel liner plate
- Inversion lining
- Shotcrete lining
- Cement mortar lining
- Patching

In-Place Installation of Concrete Invert

For larger diameters where it is possible for a person to enter the pipe, a concrete pad may be placed in the invert. Plain troweled concrete may be satisfactory for mild conditions of abrasion and flow. For more severe conditions a reinforced pavement is required.

Figure 10.4 shows one method of reinforcing the pad and typical pad thickness. The final design would be in the control of the engineer and would obviously depend upon the extent of the deterioration of the pipe.

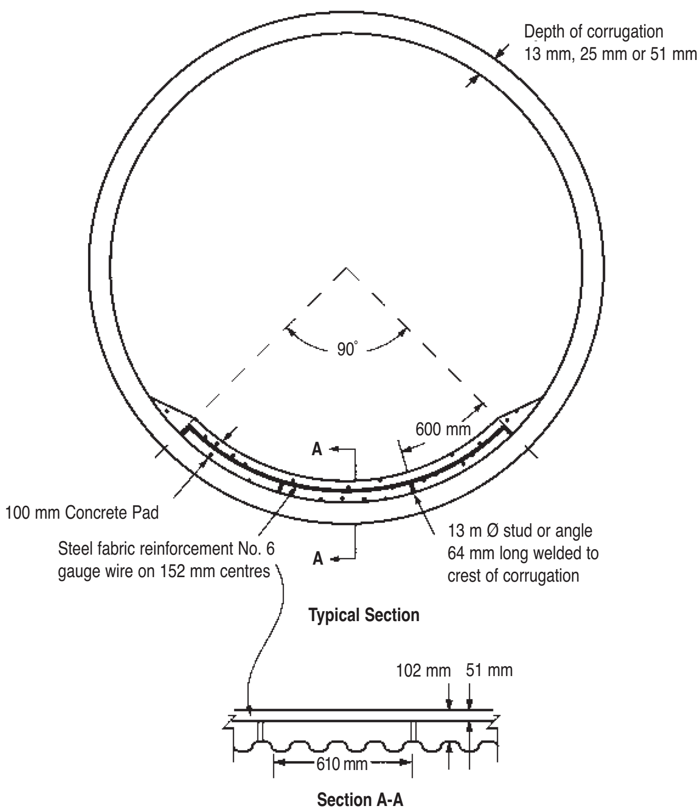

Figure 10.4 In-place installation of concrete invert.

Concrete paved invert.

Relining Materials

The selection of the reline material is dependent upon the conditions of the pipe line to be rehabilitated and the diameter and/or shape.

If the line has deteriorated to the point where it is deficient structurally, the choice would necessarily have to be a material having full barrel cross section with sufficient structural capability to withstand the imposed dead and live loads.

If there is no need to provide structural support, repair of the invert will suffice in most cases.

The following is a discussion of reline materials and methods of installing them. It is the engineer's responsibility to select the material and method of relining dependent upon rehabilitation requirements. Alternate types of materials may be found in ASTM A 849.

Sliplining

If downsizing of the existing line is not a concern, then standard corrugated steel pipe may be used and provided in lengths which would facilitate insertion. A hydraulic advantage may be gained by using helical corrugated steel pipe or spiral rib pipe if the existing pipe is annularly corrugated.

If sufficient clearance exists between the liner pipe and the existing line, the sections may be joined by the use of a threaded rod and lug type coupling band.
An alternative to the use of conventional angles or lugs and bolts is to use sheet metal screws or rivets in conjunction with an installation jig or jack.

Internal Grouting

Another effective method of repairing a conduit with excessive deformations is to place a smaller pipe within the existing one and fill the space between the two pipes with concrete grout. This method of repair, which has been successfully employed in several jurisdictions, is particularly useful when closing the structure for repairs for

Sliplining a concrete culvert with steel pipe.

extended periods is not feasible. It is also an economical solution when the depth of cover over the conduit is large, making the removal of fill for replacement of the damaged segments of the pipe an even more expensive proposition.

Repair by placing a smaller-size pipe inside the existing conduit and internal grouting is feasible for most structures. For this method, a concrete floor or a pair of rails is first installed at the bottom of the existing pipe. The new pipes, are connected outside and pulled through the existing pipe or pulled in individually and connected with internal couplers. The new pipe should be just large enough to fit through the existing pipe with a prescribed gap of 150 mm. The gap between the two pipes can be maintained through strategically located spacers.

The concrete grout is injected in the gap between the two pipes through holes in the pipe located in the shoulder areas as shown in Figure 10.5. After the grout has set, the repaired structure usually becomes much stronger than the original one, and remains virtually free of distress.

Lining a concrete box with a steel box culvert.

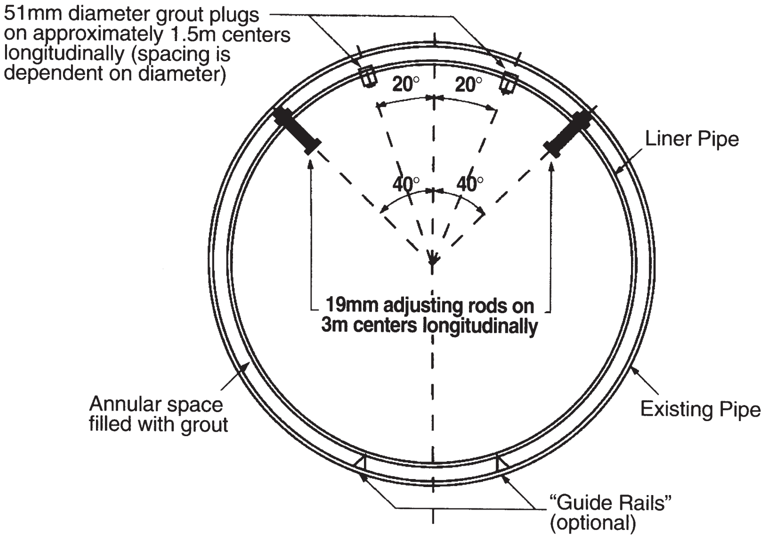

Figure 10.5 Typical section for interim grouting.

For structures having spans greater than about 6 m, the preceding procedure may not be a practical one because of the large size of the internal pipe which must be drawn through the existing one. In such a case, the internal metallic shell can be constructed from steel tunnel liners.

The bottom plates of the liner are first connected to the invert of the existing pipe by means of anchor bolts. A gap of 150 to 200 mm is maintained between the existing pipe and the liner plates through steel chairs welded to the invert.

After the gap between the bottom liner plates and existing invert is grouted, the liner plates are added symmetrically on both sides of the cross section, until the ring in completed by welding the top segments. The liners are provided with holes in the shoulder areas for injection of the grout.

Repair through liner plates permits the removal of locally deformed plates and their replacement by new ones. However, when this operation is undertaken, it is advisable to install complete rings of the liner plates on both sides of the plate to be replaced. Only after the grout between these complete liner rings and the existing pipe has set should an attempt be made to remove the damaged plate. After the damaged plate is removed, a portion of the soil will fall naturally, leaving a cavity behind the location of the removed plate. If the soil does not fall naturally, it should be removed manually to make room for the new plate to be welded in place.

Although not normally practiced, it is advisable to fill with grout the gap that may remain behind the plate that replaces the locally damaged one.

The disadvantage of repair by internal grouting, besides its excessive cost, is the reduction of the conduit size. As noted earlier, the reduction is of particular concern for culverts.

Inversion Lining

Inversion lining is accomplished by using needle felt made from polyester fiber, which serves as the "form" for the liner.

The use of this method requires that the pipe be taken out of service during the rehabilitation period. One side of the felt is coated with a polyurethane membrane and the other is impregnated with thermosetting resin.

The felt variables include denier, density, type of material, method of manufacture (straight or cross lap), and length of fiber. The physical properties of the felt and chemicals must be determined for the specific project and in cooperation with prospective contractors.

The liner expands to fit the existing pipe geometry and therefore is applicable to egg-shaped, ovoids, and arch pipe.

Inversion lining has been utilized on lines from 250 to 2800 mm in diameter. It is normally applicable for distances of less than 60 m or where ground water, soil condition, and existing structures make open excavation hazardous or extremely costly. Inversion lining with water is generally confined to pipelines with diameters less than 1500 mm and distances less than 300 m. Normally air pressure is utilized for inversion technique on larger diameter pipe. Compared with other methods, this process is highly technical. Other technical aspects include resin requirements, which vary with viscosity, felt liner, ambient temperatures, and the filler in the felt content; the effects of ultraviolet light on the resin and catalyst; and safety precautions for personnel and property.

Shotcrete Lining

Shotcrete is a term used to designate pneumatically applied cement plaster or concrete. A gun operated by compressed air is used to apply the cement mixture. The water is added to the dry materials as it passes through the nozzle of the gun. The quantity of water is controlled within certain limits by a valve at the nozzle. Low water ratios are required under ordinary conditions. The cement and aggregate are machine or hand mixed and are then passed through a sieve to remove lumps too large for the gun.

When properly made and applied, shotcrete is extremely strong, dense concrete, and resistant to weathering and chemical attack. Compared with hand placed mortar, shotcrete of equivalent aggregate-cement proportions usually is stronger because it permits placement with lower water-to-cement ratios. For relining existing structures, the shotcrete should be from 50 to 100 mm thick depending on conditions and may not need to be steel reinforced. If used, the cross-sectional area of reinforcement should be at least 0.4% of the area of the lining in each direction.

Shotcreting with a steel-fiber-reinforced concrete mix has been used successfully to line the inside of soil-steel bridges in distress. The lining, which is up to 150 mm thick, may cover the complete perimeter of the cross section of the conduit. Alternatively, it may be limited to the damaged zone of the conduit wall.

When shotcreting is used for the complete ring, shear connectors are not usually provided between the conduit wall and the shotcrete. However, their inclusion can certainly increase the strength and stiffness of the additional ring.

The partial shotcrete ring is provided to repair localized damage, such as section containing bolt-hole tears. For the partial ring, it is important to provide some sort of shear connection between the pipe and shotcrete. This shear connection may be by shear studs of the type used in composite beams, machine-welded to the pipe after the zinc coating from the galvanized plate has been ground off locally. An alternative to the usual shear stud is a U-shaped bracket which is made out of thin steel plates, and which is attached to the pipe through pins fired by a ram-setting gun. This type of shear connector has been used successfully in several repair works.

Despite the ability of the fiber-reinforced concrete to sustain fairly large tensile stresses, it is advisable to add a steel reinforcement mesh to the shotcrete ring, especially if it is partial. The location of the reinforcement mesh within the depth of the shotcrete ring depends on the sign of the moments that the repair segment of the conduit wall is subjected to. For example, the segment in the vicinity of the crown is subjected to moments causing tension towards the inside of the conduit. For this case, the reinforcement layer should be close to the exposed face of the shotcrete. On the other hand, the reinforcement mesh should be close to the conduit wall if the segment under repair is in the haunch area of the conduit. It is recalled that, for this segment, the bending moments induce tension toward the outside of the conduit.

Repair by fiber-reinforced shotcrete can prove economical and effective in many cases mainly because of the fact that it requires no formwork and little preparatory work. Because of its relatively thin layer, the shotcrete ring does not reduce the conduit size appreciably. The repair work by shotcreting can be undertaken even in cold weather, provided that the conduit wall sections to be shotcreted are adequately heated. If only the top and side segments are to be repaired, then shotcreting of culverts can be carried out without diverting the stream.

The following specifications should be considered:

1. "Specifications for Concrete Aggregates" ASTM C 33.
2. "Specifications for Materials, Proportioning and Application of Shotcrete" ACI 506.
3. "Specifications for Chemical Admixtures for Concrete" ASTM C 494.

Cement Mortar Lining

Cement mortar lining is particularly well suited to small diameter pipe which is not easily accessible.

The cement mortar lining is applied in such a manner as to obtain a one-half inch minimum thickness over the top of the corrugations. Application operations should be performed in an uninterrupted manner. The most common practice uses a centrifugal machine capable of projecting the mortar against the wall of the pipe without rebound, but with sufficient velocity to cause the mortar to be densely packed in-place. See Figure 10.6 which shows a typical setup for this process.

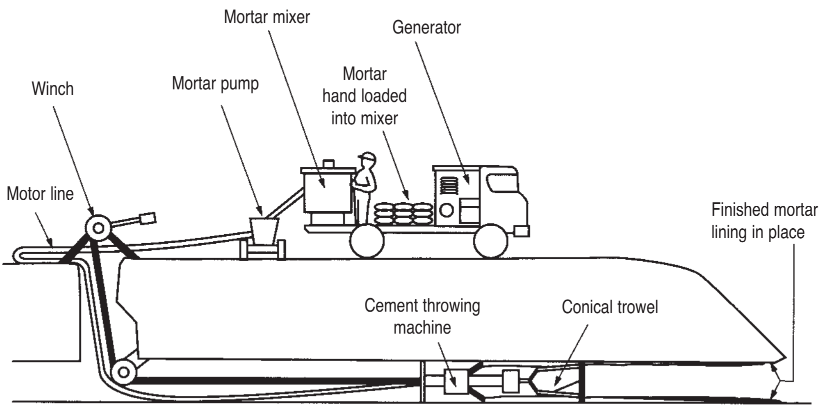

Figure 10.6 Cement mortar lining.

Patching

Numerous polymer and concrete patching compounds are commercially available for the repair of damaged materials and coatings. Patches fabricated of similar corrugated steel material can be attached mechanically or by welding over the damaged area.

Temporary props

One of the most effective and expedient measures to ensure that excessive deformations of the pipe do not degenerate into sudden collapse is the provision of temporary struts or props in the conduit. These props can be timber columns of about 200 x 200 mm cross section, or steel struts of hollow circular section of the kind used in construction formwork. The props are located in the conduit under the crown and are provided with longitudinal sills above and under them. The sills, which run along the conduit length, are of timber. When the sides of the conduit cross section are also excessively deformed, the vertical props are supplemented with horizontal supports.

The main advantage of vertical props is that they can prevent a catastrophic failure of the structure; the main disadvantage is that they constrict the conduit. This disadvantage can be particularly significant for culverts.

The props should be designed to carry, with an adequate margin of safety, the weight of that volume of soil which is statically apportioned to them by assuming the propped cross section will act as a two-span continuous beam.

The props are usually spaced at 1.0 to 1.5 meters. The butt joints of the top and bottom sills should be staggered so that they do not occur at the same location along the pipe. The sills should be long enough to contain at least two props. Screws for adjusting the lengths of these props are very effective in ensuring that the contact between the supports and the pipe is not loose.

Partial Concreting Inside Conduit

As discussed earlier, the most common form of distress in soil-steel structures, especially pipe-arches, is the occurrence of bolt-hole tears in longitudinal seams close to the invert. This form of distress indicates the presence of relatively loose fill behind the haunch areas. Accordingly, the most appropriated means of repair appears to be one which includes consolidation of the loose fill by some technique.

Unfortunately, a technique for consolidating the loose fill behind the haunches has not yet been proven by field application. In the absence of such a technique, the next best repair method appears to be one in which the conduit wall is not only reinforced to transmit shear at the section containing bolt-hole tears, but is also made flexurally very stiff at haunches. This can be achieved by partial concreting of the inside of the conduit at the haunches.

Effective contact between the conduit wall and concrete can be provided through shear studs which are machine-welded to the pipe after grinding off locally the zinc coating of the galvanized plate. As will be discussed later in the section, shear studs can also be installed on the outside of the conduit.

It can be appreciated that at the haunches the conduit wall has a tendency to bend in such a way that tension occurs towards the outside of the conduit. Except in the vicinity of the bolt-hole tears, the conduit wall itself can sustain the tensile forces. However, in the vicinity of bolt-hole tears, a reinforcing mesh should be provided close to the conduit wall. It should be noted that this reinforcing mesh should not only sustain the tensile forces resulting from subsequent excessive bending of the wall, but be capable of transmitting the shear forces acting on the wall at the location of bolt-hole tears.

The concrete can be cast in two lifts. For the first lift, it can be poured up to the horizontal construction joint. The second lift, requiring nearly vertical shuttering, can be cast later. Alternatively, and more effectively, the concrete in the haunch areas can be applied through shotcreting.

Another method of partial concreting extends the concrete at the two haunches to cover the invert as well. This form of repair is particularly useful for those pipe-arches which suffer not only from bolt-hole tears, but also from minor invert uplift. The concrete in the invert area should be provided with a reinforcement mesh close to the top surface of the concrete, to sustain tension arising from further uplift of the invert. It can be appreciated that this repair technique may not be suitable if the invert uplift is excessive.

The significant disadvantage of the foregoing repair techniques is the reduction of the conduit size; this may be particularly undesirable in the case of culverts. It is noted, however, that this reduction is much smaller if the concreting is limited to haunches.

Partial Concreting Outside Conduit

When distress in the conduit wall is limited to only the top segments of the pipe and the depth of cover is shallow, removal of the backfill from above the conduit and adding a layer of concrete to the outside of the pipe may prove to be an economically viable repair method. In this method, the concrete layer is made composite with the pipe through the usual shear studs employed in slab-on-girder-type bridges. These shear studs can be machine-welded readily to the pipe after locally scraping off the zinc layer. The shear studs are staggered for maximum efficiency.

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