

10.1. Introduction

Corrugated high-density polyethylene (HDPE) and polypropylene (PP) pipes, herein called Corrugated Plastic Pipe (CPP), are durable and can have an exceptionally long service life. Age, physical damage, changing land use, subsequent adjacent excavation, and environmental exposure can lead to CPP maintenance. To ensure the long service life for the investment in any infrastructure, it is important to have an inspection and maintenance program. Routine in-service inspections can detect minor problems, allowing for early repairs that avoid serious problems in the future. This chapter will discuss performance characteristics, in-service inspection, maintenance, and minor repairs that maximize the useful life of CPP underground infrastructure.

10.2. Performance Characteristics

CPP design includes the selection of the size and alignment required for the hydraulic capacity, as well as the installation details required for structural capacity. This section presents performance issues related to the system hydraulics, pipe shape and deflection, durability and condition assessment, and pipe joints for CPP.

10.2.1 System Hydraulics

A storm drainage system hydraulic inspection considers the hydraulic performance of the system (e.g., the ability to convey water under gravity flow through a storm sewer or beneath a highway, railroad, or other embankment) and involves the evaluation of grade and alignment. Other key items may also require maintenance such as debris accumulation at the inlet, outlet, and along the barrel, sedimentation, and protection against piping of water through the embankment around the pipe. Inadequate hydraulic performance of pipes can create blockage, flooding, overtopping, surface damage, and other safety hazards including roadway closure.

Debris accumulation is a primary maintenance concern for drainage systems, and is also an important design consideration. Types of debris that typically accumulate at the inlet and cause blockage often include wood (e.g., sticks, branches, and logs), soil, ice, and rocks. Structural controls like physical inlet barriers and nonstructural controls such as upstream maintenance can be implemented to prevent or reduce debris accumulation. The inspection of these elements should be included as part of the in-service inspection program.

10.2.2 Pipe Shape and Deflection

Plastic pipe structural performance is dependent on the competency and quality of the soil envelope, comprised of the surrounding embedment material and the native trench material, for support. Any changes in pipe shape are indicative of changes in loading or embedment support conditions, including adequacy and stability of the supporting soil envelope.

CPP are round pipe and the pipe shape is evaluated relative to its original diameter, assuming a uniform circular shape. When inspecting for pipe shape, it is important to consider diametrical deflection, bulging of the pipe wall visible on the interior, and localized flattening of the pipe wall (i.e., reduction in wall curvature). Minor pipe shape distress is not necessarily indicative of structural distress.

Diametrical deflection relates to the reduction in pipe diameter vertically, as a percent of the nominal diameter. This measurement does not assess any of the localized shape changes. A general deflection limit of 5% is most commonly-used, although larger deflections may be acceptable. The important consideration related to deflection is whether excessive strain is created in the pipe wall or whether any other limit states are exceeded. AASHTO qualifies the 5% deflection limit by stating: “The Engineer may allow alternate deflection limits for specific projects if calculations using the design method in this section show that the pipe meets all the strength-limits-state requirements” (1). Depending on the burial depth and loading conditions, the system may be capable of withstanding deflections that exceed 7.5% in some cases. If an amount of deflection greater than 7.5% of the nominal diameter is observed, the system should be evaluated by a qualified engineer familiar with CPP design. The objective of the investigation is to determine whether the combined strain exceeds the strength limit for the pipe material and to assess whether any other limit states may be exceeded, such as resistance to slow crack growth (i.e., environmental stress cracking). If the strength and material limits are not exceeded, then the deflection level will not adversely impact service life.

10.2.3 Durability and Condition Assessment

The durability inspection relates to the ability of the pipe to resist chemical degradation and mechanical abrasion. Plastic pipe degradation includes oxidative degradation, slow crack growth, photo-induced UV degradation (i.e., photodegradation), and thermal degradation. Abrasion is the gradual and progressive wearing or grinding away of the pipe barrel material by the forces of water carrying sediments or from tumbling rocks. Plastic materials produced without the necessary UV inhibitors can deteriorate due to photodegradation. This process causes embrittlement of the plastic material due to oxidation from absorption of UV radiation when in sunlight. Modern plastic pipe standards require stabilization and testing to resist photodegradation.

A condition assessment relates to identifying distress in the pipe barrel that may affect the structural stability and functional performance of the pipe. Distress may include surface wall damage such as cracks, tears, impacts and creases, which can be serious if the surface damage is extensive. Extensive surface damage can impair the structural integrity and load-carrying capacity of the pipe barrel, permit infiltration of groundwater, permit exfiltration of the conveyed fluid, or permit infiltration of structural embedment soils. In general, small localized surface damage is not critical but should be documented for use as a source of comparison in future inspections.

10.2.4 Pipe Joints

CPP joints are typically comprised of pipe ends with bells and spigots or by use of an external split coupler that wraps around the pipe ends. Joint integrity is an important requirement for the proper in-service performance of a culvert or storm drain. Culverts and storm sewer systems are typically designed to handle primarily gravity flow, but they may experience short periods of higher pressure during extreme storm events. These systems may require a joint performance standard for native soil conditions such as fine silty sands or poorly-graded fine sands.

The pipe jointing inspection process is intended to identify issues that may affect the joint integrity or connections to structures. These issues may include excessive joint separation, offset joints, sags in invert at pipe joints, infiltration, sags in invert at manholes or structures, and open joints. Joint requirements for a specific project may vary depending on the application of the pipe.

10.3. In-Service Inspection

10.3.1 Purpose

Routine in-service inspections of buried CPP are an effective way to identify and correct any problems before they become severe. Inspection of the pipe system verifies proper service functionality and the structural performance of the installed CPP. In-service inspection of CPP can occur at any point in its service life and users may refer to the AASHTO Manual for Culvert and Storm Drain System Inspection (2) for a comprehensive procedure for inspection and condition rating of buried pipe systems.

A poor design and/or materials specification, an improper installation controls, and a lack of maintenance are the primary causes of poorly-functioning pipes. Age, physical damage, changing land use, larger loads, and unusual environmental exposure can also lead to a need for system maintenance. In-service inspections offer the following benefits: optimization of service performance; mitigation of repair costs; reduction in the risk of failure; identification of maintenance needs; and, short-term and long-term planning and budgeting for repairs and rehabilitation.

The pipe owner will benefit from an inspection program that provides consistent evaluation of all types of pipes and that ensures the inspectors are trained to consistently identify deficiencies. A trained professional should be able to identify issues that adversely impact the service life of the pipe. One organization with certified trained inspectors for a standardized method of inspection is the National Association of Sewer Service Companies (NASSCO). The new AASHTO Culvert and Storm Drain System Inspection Guide provides guidance for pipe in-service inspections.

10.3.2 Inspection Techniques

Identifying the proper inspection types and categories largely depends on the criteria of the pipe's performance that is being observed. Typical CPP inspections are divided into three types: person-entry internal inspection; nonentry internal inspection (visual); and, remote-entry internal inspection. The specific type of inspection to be used for each pipe installation will depend on safety requirements, the necessary quality and accuracy of the inspection data, and available inspection resources. For example, inspectors will employ nonentry inspection methods for small-diameter pipes [less than 24 in. (60 cm), or as established per local safety regulations], pipes with significant standing water, or excessive sediment build-up. Closed systems, such as extensive pipe runs from manhole to manhole, may also be candidates for inspection by nonentry or remote-entry inspection methods.

A wide range of inspection criteria can be grouped into four categories: 1) system hydraulics; 2) pipe shape and deflection; 3) durability and condition assessment; and 4) pipe joints. Inspectors should be prepared with equipment addressing the site-specific inspection needs. Equipment categories include those which are safe for access to the pipe inlet/outlet, tools for cleaning the pipe interior, tools for measurement, tools for visual aid, methods for photographic and written documentation, and personal protective equipment (PPE).

Inspection condition is most easily tracked by the use of a standard rating scale. There are four inspection categories for CPP condition which can be used during an evaluation:

- 1 – Good: Like new, with little or no deterioration, structurally sound, and functionally adequate. No action is needed.
- 2 – Fair: Some deterioration, but structurally sound and functionally adequate. No immediate action is needed, but more frequent inspection may be warranted. Maintenance personnel should be informed.
- 3 – Poor: Significant deterioration and/or functional inadequacy, requiring maintenance or repair. Identify and note any corrective actions needed.
- 4 – Severe: Very poor conditions that indicate possible imminent failure or failure that could threaten public safety. Corrective actions are required and may be urgent. Engineering evaluation may be needed to specify appropriate repairs.

System Hydraulics

System hydraulic inspection is related to grade (i.e. slope) and alignment (vertical and horizontal) of the pipe barrel, and any special function such as design for natural soil invert for fish bearing. Grade and alignment can be evaluated visually for nonentry inspections and measured with laser systems for remote-entry inspections. The results of the inspection are compared to the construction plans.

The grade is evaluated as the average slope along the pipe length and takes into consideration the fixed elevations of end treatments or junction boxes.

Alignment evaluation includes observing the vertical alignment (i.e., level of straightness), and horizontal alignment of the pipe, horizontal or vertical rotations/bends at joints (i.e., maximum joint rotations are provided by manufacturers), offset at joints (i.e., detected by visible separation/misalignment), sag (e.g., local low spots or bird baths, often detected by the presence of standing water), or heave (e.g., local raised invert or pipe bottom) between joints that would affect water flow. These criteria are typically qualitatively evaluated with visual inspection of the interior of the pipe or measured with lasers. Vertical and horizontal alignment are typically specified on the construction plans.

Other factors affecting hydraulic performance include debris accumulation, sedimentation, seepage of groundwater into the pipe, or transport of fluid out of the pipe, and can be evaluated by visual inspection.

Pipe Shape and Deflection

Inspection for shape-related issues is best achieved by direct observations. Lamping is a simple yet effective method for inspecting shorter straight runs of pipe. Lamping is a method of inspecting the interior of the pipe with a high-intensity light source. The light source is shone into one end of the pipe and an inspector observes the shape from the other end of the pipe segment. This method works particularly well for CPP, due to the reflective properties of the plastic pipe wall.

Imperfections in the pipe wall tend to be intensified and those identified by lamping include poor grade and alignment, offset joints, excessive deflection, obstructions, and other imperfections in the installation. If imperfections are observed, a more detailed inspection may be warranted.

Mandrels are useful in identifying shape irregularities. Mandrels such as the one shown in Figure 10.1 are devices that are pulled through the pipe to determine whether the deflection observed is acceptable. They are pre-set with the minimum allowable inside diameter and if the mandrel can be pulled through the pipe, then the deflection is considered to be acceptable. An example of a mandrel in a pipe is shown in Figure 10.2.

One limitation with mandrel testing is that the mandrel is a simple go/no-go device that might not pass through the pipe for a variety of reasons, some of which are unrelated to pipe barrel diametrical deflection. A pipe with debris in the invert, a fitting that protrudes slightly into the pipe interior, or slight misalignment at the joint can all cause a failing result in mandrel test even if deflection is otherwise acceptable.

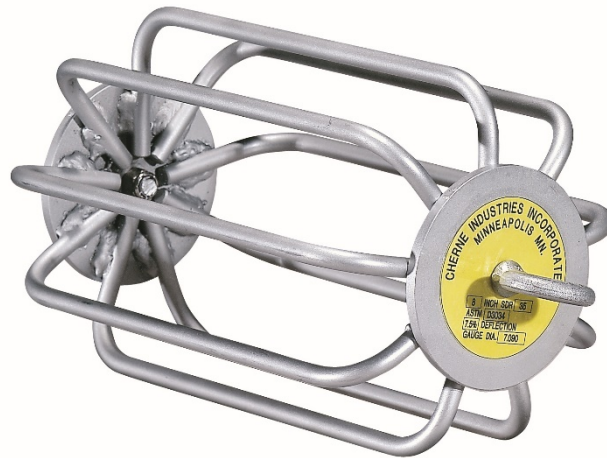


Figure 10.1 – Typical Mandrel (Courtesy of Cherne Industries, Inc.)

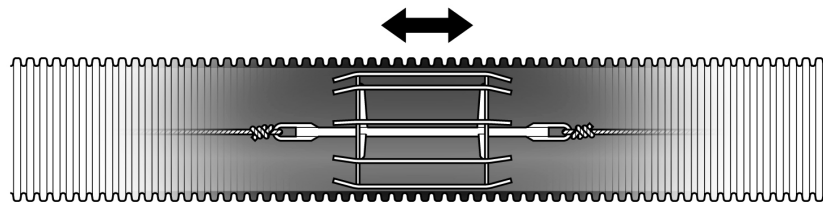


Figure 10.2 – Example Mandrel in Pipe

Entry for internal visual inspection is the most accurate method used to assess the interior of the pipe. Pipe diameters greater than 24 in. (60 cm) can generally be inspected with person-entry internal inspection or remote-entry internal inspection. Inspection of systems with pipe diameters of 24 in. (60 cm) and smaller, along with systems that otherwise prevent entry, are best conducted

using nonentry internal inspection (i.e., visual from the pipe ends) or remote-entry internal inspection.

Vertical deflection is the most commonly collected parameter to assess the overall pipe shape. Vertical diameter measurements are recorded every 10 ft (3 m) or at the pipe joint and in the middle of the pipe length. When assessing the percent deflection, it is important to determine the base diameter, which is the actual pipe diameter minus the allowable manufacturing tolerances. For pipes with diameters less than 24 in. (60 cm), one of the remote inspection techniques discussed in the next section may be used if considered necessary based on the results of lamping.

Remote inspection techniques such as closed-circuit television (CCTV) are often used in lieu of nonentry visual inspection. These remote inspection methods can be misleading regarding the condition of the interior of the pipe. It is particularly difficult to judge the size of defects in pipe using CCTV because of lens distortion and the fact that there are typically no references to scale the size of the defect. For this reason, it is recommended that an optically-corrected camera be used. Only qualified and trained personnel should be used to evaluate the images from CCTV.

Laser profilometer is a technology developed for process piping inspection and it has been used occasionally to inspect storm drainage pipe. This technology measures the interior of the pipe using a calibrated laser casting a ring of light on the inner pipe wall, a camera, and a mathematical algorithm to take measurements. Due to concerns with the reflective qualities of CPP, the presence of water, and other unique characteristics associated with CPP (e.g., slight waviness in the interior wall or pipe liner), the PPI has not endorsed the use of these devices.

Durability and Condition Assessment

The internal barrel of CPP should be visually inspected for wall distress when it is practical and safe to do so. Observations should include information on the location, severity and extent of any surface damage including wear, abrasion, impact damage, or UV degradation (i.e., material embrittlement). The barrel should also be inspected for local buckling, splits, and cracking, including the location, severity, and extent. Where cracks or splits are identified, the infiltration and presence of both water and soil should be noted. Observation of small, localized instances of wall distress is not ordinarily critical.

One example of a pipe imperfection is longitudinal cracking. These are cracks that run parallel along the length of the pipe. If found, these cracks are typically located in the invert of the pipe and are the result of placing the pipe on a hard surface with little to no placement of embedment in the haunch zone of the pipe. Any longitudinal cracking longer than 6 in. (15 cm) should be evaluated by a qualified engineer knowledgeable in CPP design to best determine the proper corrective action. Circumferential cracks at the inner liner are typically not structural in nature and are caused by differential settlement during installation.

Wall abrasion is most frequently observed in steep or mountainous areas where high flow rates carry sand and rocks are present that wear away the culvert invert. CPP is highly resistant to abrasion and is often used as liners to repair deterioration in other types of pipes that experience abrasion. Mild deterioration should be noted and more serious abrasion should be considered for repair.

Pipe Joints

CPP pipe joints should be inspected for any change in geometry including joint separation (i.e., pulling apart), vertical or horizontal joint offset, and joint rotation or pipe bends at joints. The level of change in geometry and location along the pipe should be documented. The pipe joints should also be inspected for obvious signs of infiltration, such as allowing groundwater or embedment soils to enter the pipe or exfiltration, or allowing water flowing through the pipe to leak into the surrounding soils (most commonly occurring when the groundwater level is below the bottom of the pipe).

Infiltration caused by open joints can be detected if staining is observed at the joints on the sides or top of the pipe, if deposits of soil are in the invert, or if depressions or potholes are found above the pipe. Open joints can be probed with a small rod to check for voids outside the pipe.

Exfiltration is typically not a significant issue; however, if leaking pipe joints contribute to or cause piping (i.e., migration of soil along the outside of the pipe section length), the soil envelope supporting the pipe may be disrupted and result in a structural distress. Exfiltration may be detected by visual inspection during low flow periods by inspecting culvert ends for voids resulting from piping.

10.3.3 Safety

When planning and conducting routine in-service inspections, safety of the inspection team and the public should be ensured at all times. Safety remains the responsibility of all inspection team members and each one should also receive a safety plan and safety training. The inspector should review potential site-specific hazards and select mitigating measures to reduce or eliminate hazards. Typical site hazards associated with in-service inspection of CPP include confined space, drowning, steep and/or slippery conditions, traffic, and insects or animals. All safety plans should comply with and follow procedures specified by the Occupational Safety and Health Association (OSHA) and include any agency-specific requirements.

10.4. Maintenance

Culverts, storm drains, and sanitary sewer systems may require maintenance to ensure proper performance. Typically, a municipal entity will assume the responsibility for inspection, maintenance, and repair of systems in the public right-of-way and in drainage easements.

Maintenance actions for culverts include the removal of debris from the inside of the pipe, removal of blockage from the entrance to the pipe, clearance of the waterway both upstream and downstream of the culvert, and often a quick visual evaluation for any other unusual distress indicators. The system may also require repairs or maintenance due to impacts from adjacent construction, vandalism, or other unexpected loadings.

The most prevalent maintenance items for storm drains include clearing blocked drains, removing debris from storm drain structures, and cleaning and repairing damaged drain pipes. Pipelines operating at low flow rates (i.e., 2 ft/sec (0.6 m/sec) or less) may allow solids to settle in the pipe invert. CPP have a smooth, nonwetting surface that resists the adherence of sedimentation deposits. If the system is occasionally subjected to higher flow rates, much of the sedimentation will be flushed from the system during these peak flows.

Catch basins on storm drain systems are also subjected to blockage, especially after a major storm event. Oftentimes, catch basins are designed with a sump to contain debris below the catch basin's outlet pipe elevation. Catch basins with inlet insert filtration devices such as filter bags should be inspected more frequently than those without. The frequency of inspection is largely dependent upon specific site conditions and the associated trash and debris loading.

Stormwater treatment units and retention/detention systems have their own set of maintenance-related requirements. The manufacturers of these systems will typically have a recommended frequency for the cleaning of these systems.

10.4.1 Maintenance Equipment Options

If cleaning is required for storm drains, culverts, catch basins or other appurtenances, sedimentation deposits can usually be flushed from the system using high pressure water or can be vacuumed out of the system. Some of the equipment most commonly used for clearing blockage and cleaning drainage systems include vacuum pumps, high pressure jetting, and flushing.

10.4.2 Vacuum Pump Equipment

Vacuum pump equipment is typically mounted on a truck and is designed to remove blockages from storm drain and sanitary sewer systems, (as shown in Figure 10.3). These specialized trucks typically are outfitted with a holding tank reservoir capable of storing the material that was removed from the system. Catch basins, stormwater quality units, and underground retention/detention systems are often cleaned with this type of equipment. Materials removed as a result of these cleaning operations may have unique disposal requirements, and the owners are responsible for complying with all federal, state, and local regulations.



**Figure 10.3: Typical Vacuum Pump Truck
(courtesy of Vac-Tron Equipment, Inc.)**

10.4.3 High Pressure Jetting

High-pressure sewer jetting is a method of cleaning drain and sewer pipelines using high pressure water. Water is delivered to a hose reel containing a high-pressure jetting hose with a nozzle on the end. The hose and pumps are typically mounted on a truck with its own water supply. The nozzle is designed to direct high-pressure streams of water in an umbrella spray pattern to pull the high-pressure jetting hose through a pipe, (as seen in Figure 10.4). The angles of the water stream can be adjusted to produce better cleaning results. Some nozzles have a forward point jet that can penetrate a root mass or blockage.

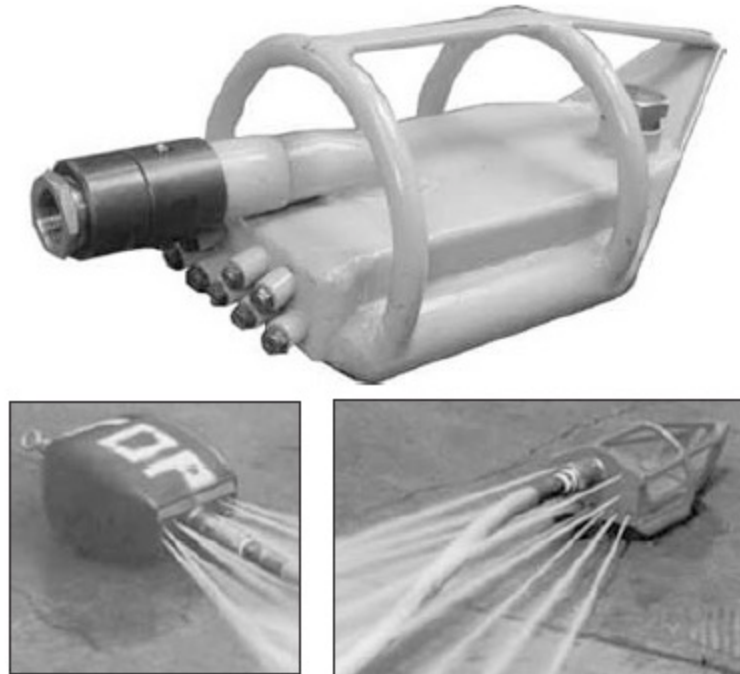


Figure 10.4: Typical Water Jetting Nozzles

10.4.4 Flushing

Flushing of lines is typically accomplished with the use of a firehose and a specialized nozzle that is able to rotate as it is dragged through the pipe. Water is usually supplied from a fire hydrant or a pump truck.

10.5. Repair Methods for Damaged Pipe and Joints

There are many repair options available for cases in which accidents and problems develop within CPP barrels or joints. The first step is to identify the nature and extent of the problem and to document any factors that might affect the repairs. Some of the initial questions to consider include:

- Is the problem leakage related or structural in nature?
- Is the damage localized or occurring over a larger area?
- Is the pipe accessible from the exterior or interior, or not at all?

- Is the installation soil-tight or watertight?
- What is the diameter of the pipe?
- What are the fill depth, live-load design, and any other special design requirements?

As the problem is better defined, the repair options can be established. A variety of repair options are presented in Table 10.1. The National Cooperative Highway Research Program (NCHRP) Project 14-19 (3) provides flowcharts to select repair methods for distressed culvert repair options. Manufacturers of the pipe and repair products should be consulted to obtain information the procedures and materials to determine the appropriate repair procedure for each case.

Table 10.1: Repair Alternatives

CPP Barrel Structural Repairs		Pipe Joint Repairs
Long-Run Repairs	Small-Length Repairs	Leakage/Joint
Structural re-line	Cap	Internal rubber seal
Mechanical re-round	Flowable fill encasement	Grout sleeve
Concrete encasement	Structural re-line	Chemical grout
Remove and replace	Mechanical re-round	
	Concrete collar	
	External mastic band	
	External slip coupling	
	Chemical seal	
	Grout sleeve	

CPP barrel structural repairs may be necessary due to improper installation, as a result of damage due to adjacent trenching, subsequent excavation operations, or other miscellaneous reasons. The scenario of improper installation typically involves longer runs of pipe needing repair, whereas trenching or excavation incidents are more often associated with localized repairs.

10.5.1 Long-Run Repairs

Typical options for repairing long run of pipe include structural re-line, mechanical re-round, concrete encasement, and remove and replace. The decision for structural repair should not be based solely on deflection (i.e., exceeding the service limits), but it should also be based on a structural analysis that clearly indicates that the design strength limits have been exceeded for the actual installed conditions of the pipeline. The pipe manufacturer and/or an engineer experienced with this unique analysis should be consulted.

Structural re-lining can be used for a pipe that has been identified as having exceeded its structure capacity or strength limit. As referred to in the AASHTO LRFD Bridge Design Specifications (1), the strength limit is defined as a limit on the plastic material strain. In cases when re-lining is required, the existing pipeline is typically over deflected, and the structural analysis indicates that the material will fail prior to its service design life. Specifically, a cured-in-place pipe may be

used to rehabilitate the line without further excavation. ASTM F1216 (4) contains procedures to properly design the liner to support hydraulic, soil, and live loads.

Re-rounding is a technique that is used to remove vertical displacement of the pipe and consolidate embedment soil at the spring line and haunch area of the pipe. Re-rounding involves the use of specialized equipment and contractors. A device is inserted into the pipe and it places a vertical and vibratory force in the interior of the pipe. The intent of the repair process is to reconsolidate the backfill around the pipe. Results vary depending upon the type of backfill, burial depth, and length of time since the pipe has been installed. Re-rounding may reduce the pipe deflection by varying amounts, depending upon the site-specific conditions. It is important to engage the services of a contractor who has experience with this type of repair method, and it is recommended to contact the manufacturer or an experienced engineer before considering this repair option.

Where possible, concrete encasement can be used to repair a distressed CPP depending on the existing surface conditions. This approach includes excavation to expose the section of pipe needing repair and then pouring the concrete load-relieving encasement. This encasement should be designed by an engineer experienced with structural analysis of CPP.

The decision that repairs are necessary, and the determination of which the specific repair method is appropriate, should involve the pipe manufacturer and a competent engineer experienced with the repair of CPP.

10.5.2 Small Length and Joint Repairs

Typical options for repairing small length and small point locations include: capping, flowable fill encasement, structural re-line, mechanical re-round, external mastic band, external slip/seal couplings, chemical seal, and grout sleeve. Internal mechanical repair products generally consist of a flexible cylindrical gasket sleeve, which is expanded to conform to the inner wall of the pipe. The feasibility of this repair method depends on the size of the damaged section or the joint, as well as the available accessibility into the pipe. Internal mechanical seals are used to slightly restrict the inside diameter of the pipe. This should be considered when assessing the risk of debris obstruction.

Coupler capping is applicable for soil-tight pipe installations in nontraffic areas and entails covering the damaged section of pipe with a split coupler. This method is used when a small hole is punched into the pipe or corrugations are damaged. For every damaged pipe situation, an assessment of the structural impact should be made. However, a general rule is that any hole or damaged corrugations that measure to be less than 15% of the pipe's inside lateral diameter may be repaired by placing a split coupler over the damaged section of pipe. The coupler should be centered over the damaged section of pipe and tightened down with the nylon straps. This repair method is not applicable for repairing a bell-and-spigot section of pipe. Special care must be taken when replacing the backfill and bedding. For installations deeper than 8 ft (2.4 m), a Class I or Class II backfill is recommended.

As a repair method, flowable fill encasement is applicable for soil-tight pipe installations in traffic areas. This method entails covering the damaged section of pipe with a split coupler and/or non-woven geotextile fabric and then backfilling the area with flowable fill. In lieu of a split coupler, a mastic style coupler may be used, as approved by the pipe manufacturer. This method is used

when a hole is punched into the pipe or corrugations are damaged. However, a general rule is that this repair method may be used for holes that measure less than 30% of the pipe diameter although an evaluation of the structural impact caused by the damaged area should be conducted. This repair method requires placing a split coupler or mastic style coupler over the damaged section of pipe. The coupler should be centered over the damaged section of pipe and tightened down with the straps. Once the coupler is in place, the flowable fill should be poured around the repair section an extended to a minimum of 6 in. (15 cm) beyond the ends of the repair coupler. This repair method should not be used to repair a bell-and-spigot section of pipe.

Concrete collars may provide an acceptable repair for soil-tight pipe, depending on the integrity of the installation. Installing a concrete collar involves building a form around the area to be repaired and encasing it in concrete as drawn in Figure 10.5. A geotextile is typically wrapped around the repair area prior to pouring the collar to keep the concrete from seeping into the pipe. Typically, an excavation of 6 in. (15 cm) beneath the pipe is done to allow for proper application of the geotextile and concrete encasement. If the pipe itself is damaged in an area that amounts to greater than 30% of the pipe diameter, then the damaged area shall be removed and a replacement pipe section will be spliced in prior to pouring the collar. In order to provide an improved level of joint performance, a gasket can be installed on the pipe in the concrete encasement.

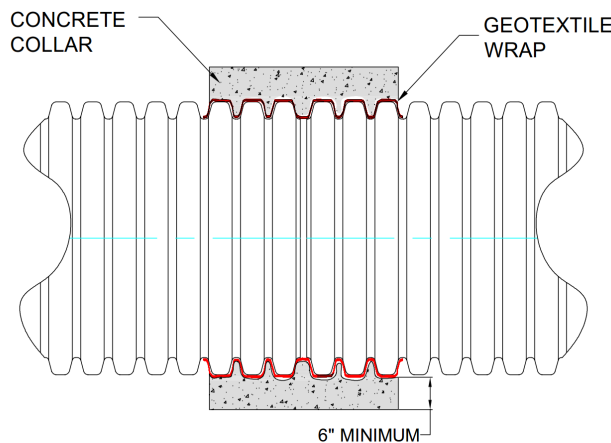


Figure 10.5: Typical Concrete Collar

Link-Pipe Grouting Sleeve™, which is a stainless steel grouting sleeve that measures between 4 to 60 in. (10 to 150 cm) and is installed with an inflatable plug. The sleeve may be used to seal a joint or repair short sections of damaged pipe. Numerous sections can be used in series to repair longer sections of pipe. These types of devices are engineered metal sections that are typically assembled in the pipeline and the annular gap, if filled with cement grout. The manufacturer should be contacted to verify that the product meets the specific application requirements including test requirements, if specified.

External mastic bands can be used to repair local small point distress or to seal joints. Mar Mac Polyseal Pipe Coupler measures 4 to 60 in. (10 to 150 cm), and consists of a mastic adhesive base layer, and a cross-laminated polyethylene middle layer with a spun-bonded geotextile polypropylene cloth outer layer. The coupler incorporates a self-adhering rubberized bonding mastic and securing bands to ensure a positive seal around the pipe. If the pipe itself is damaged in an area that measures greater than 30% of the pipe diameter, the damaged area must be removed

and a new pipe section spliced in before installing a coupler around both ends. Polyseal Pipe Couplers are typically used with soil-tight smooth interior CPP and one is presented in Figure 10.6.



Figure 10.6: Mar Mac Polyseal Pipe Coupler

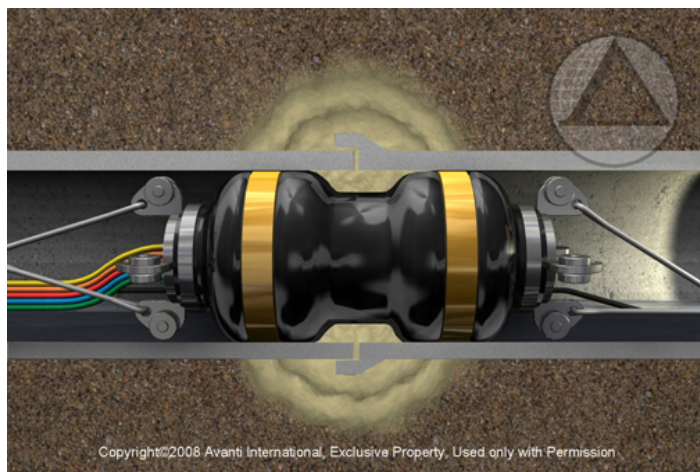
External slip repair couplings, which measure between 4 to 30 in. (10 to 76 cm), are available from some CPP manufacturers, as shown in Figure 10.7. This device involves a watertight repair that will meet most pressure testing requirements, when installed correctly. The slip coupling uses PVC bells with gaskets. The gaskets are placed in the valleys on either side of the pipe section to be repaired and slip couplings are then slid over the gaskets. PVC slip couplings are most commonly used with watertight smooth interior CPP pipe products.



Figure 10.7: Slip Repair Coupling

External seal couplings such as Springseal[®] Seal-Tite Couplers, sized 4 to 60 in. (10 to 150 cm), consist of co-extruded polypropylene and thermoplastic elastomer that form a double-ended bell. The coupler incorporates gasket material that is extruded into the external bells. The gaskets land on the crown of the corrugations and are tightened down with stainless steel fasteners that form a seal on the crown of the pipe.

Chemical sealing is a method of joint repair using chemically-activated gel or grout to minimize the amount of joint leakage. The grout is typically applied with specialized remote-controlled equipment. The remote equipment packs the grout into the pipe joint and surrounding soil. Additionally, the remote equipment can be used to air test the quality of the pipe joint repair. Larger diameter pipes sized 36 to 60 in. (91 to 150 cm) can be repaired by physically applying the chemical grout. In both methods of applying chemical grout, the grouting material is forced through the joint out into the surrounding soil where it is set up as a gel as shown in the schematic in Figure 8. The gelled mass forms a waterproof collar around the pipe and results in a significantly reduced amount of leakage. There are several types of chemical grouts available and the manufacturer should be contacted to review the specific situation and any criteria related to joint tightness or the pressure test. The work should be performed in accordance with ASTM F2304 – *Standard Practice for Rehabilitation of Sewers Using Chemical Grouting* (5). Several companies manufacture and/or install chemical grout and most pipe diameters can be chemically-grouted as long as the grouting contractor has the appropriate equipment.



**Figure 10.8: Schematic of Chemical Grout Joint Seal
(courtesy of Avanti International)**

NPC Internal Joint Seal, sized 18 to 60 in. (45 to 150 cm), consists of an ethylene propylene diene monomer (EPDM) rubber seal and stainless steel bands. The rubber seal is inserted into the pipe and positioned over the joint. A torque wrench is used to expand the bands against the inner wall of the pipe. This product is designed to seal the pipe joints, but not to repair damaged pipe sections. The damaged area of the pipe must be removed and a replacement section must be spliced in, if necessary, to use an internal joint seal such as the one shown in Figure 10.9. This system may provide a watertight joint when installed as recommended. The manufacturer should be contacted to verify that the product meets the specific application requirements, including test requirements if specified. If pressure tests are required, the vendor should be contacted to ensure that the product is suitable for the specific test criteria.



Figure 10.9: NPC Internal Joint Seal

Extrusion welding, sized for 30 to 60 in. (75 to 150 cm) diameter pipe allows for the repair of pipe joints from the interior of the pipe. Typically, a joint repair by welding is watertight. The process requires a clean and dry environment to ensure that the welding is structurally sound. The process can include either welding a flat polymer plate that spans the pipe joint or, in some cases, the joint can be welded without the plate spanning the pipe joint. This method should be performed by experts with field-welding polymers.

10.6. References

1. AASHTO LRFD Bridge Construction Specifications, 3rd Ed, 2010 with interim specifications through 2016, American Association of State Highway and Transportation Officials, Washington D.C., 2016.
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3. National Cooperative Highway Research Program (NCHRP) 14-19 Culvert Rehabilitation to maximize Service Life While Minimizing Direct Costs and Traffic Disruption, <http://onlinepubs.trb.org/onlinepubs/project14-19/index.html>, 20 September 2017.
4. ASTM F1216-16, “Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube,” ASTM International West Conshohocken, PA, 2016.
5. ASTM F2304-10 (2016) e1, “Standard Practice for Sealing of Sewers Using Chemical Grouting,” ASTM International, West Conshohocken, PA, 2016.