CCPPA

CONCRETE PIPE & PRECAST INSTALLATION

Build on our strength

2025

POCKET GUIDE

This booklet is only a guide and is not intended to supersede the project specifications and/or local municipal standards and specifications.

Review your local provincial, municipal, or rural region specifications and standards as well as your project specific specifications and special provisions.

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INTRODUCTION

Proper installation is a critical step in a process that also includes surface and sub-surface investigations, detailed design, specification preparation, quality manufacturing, and field testing.

The design of a concrete pipeline or precast structure assumes that certain minimum conditions of installation will be met in the field. Acceptance criteria should be established by the owner to ensure that the quality of workmanship and materials provided during construction meet the design requirements.

Standard specifications for the installation of precast concrete drainage products can also be found in the local jurisdictional references or those created by larger governing agencies like the Master Municipal Construction Documents (MMCD) that provide a framework for municipal infrastructure projects in British Columbia.

Some provinces have also developed their own standards and specifications, as is the case with the Ontario Provincial Specification (OPS) used by many municipalities in the province and the Ontario Ministry of Transportation.

General installation procedures are presented in this guide, together with some of the problems that might be encountered. This is only a guide and is not intended to supersede the project specifications and/or local municipal standards and specifications.

Refer to your local or relevant requirements as appropriate.

PRECAST CONCRETE PLANT CERTIFICATION

A plant certification program provides infrastructure owners, specifiers and contractors greater peace of mind that a precast concrete producer has demonstrated its capability to manufacture precast concrete products in accordance with relevant standards to a third-party certification body.

Several plant certification programs exist for the precast concrete industry across Canada, so specifiers should contact the CCPPA or a local manufacturer to learn which program is available in your region.

Canadian Precast Concrete Quality Assurance Program (CPCQA)

As of January 1, 2018, the Canadian Concrete Pipe and Precast Association (CCPPA) and the Canadian Precast/Prestressed Concrete Institute (CPCI) established an independent third-party administered and audited certification program for both prestressed and non-prestressed precast concrete manufacturing facilities across Canada.

Both the CCPPA and CPCI recognize the mutual benefit for owners, contractors, and the precast concrete industry by combining the strengths of two well-established national plant certification programs, CPCI Certification Program for Structural, Architectural and Specialty Products and Production Processes (CPCI Certification) and the Plant

Prequalification Program for Precast Concrete Drainage Products (PPP).

Plants that are prequalified must identify all precast concrete drainage products covered by their certification, with this marking:

For a list of certified plants or more information about this plant certification program visit www.precastcertification.ca.

QCAST PLANT CERTIFICATION (QCAST)

To improve the overall quality of all concrete pipe products, the American Concrete Pipe Association offers an on-going quality assurance program to member and non-member companies. Called the "Quality Cast" Plant Certification Program, the inspection program covers the inspection of materials, finished products and handling/storage procedures, as well as performance testing and quality control documentation. Plants can be certified in storm sewer and culvert pipe, sanitary sewer, box culverts, three-sided structures, manholes and precast structures.

For a list of certified plants or more information about this plant certification program visit www.qcast.org.

BUREAU DE NORMALISATION DU QUÉBEC (BNQ)

Created in 1961, the Bureau de normalisation du Québec (BNQ) is mandated by the government to oversee standardization in Québec. It designs and applies solutions based on standards, sources of innovation and trust in every industry.

For a list of certified plants or more information about this plant certification program visit www.bnq.qc.ca.

CSA Group

Prequalification program for precast concrete manufacturers: to assess and evaluate the capabilities of precast concrete manufacturing plants to fabricate precast concrete products in the following categories:

A. Elements to the requirements of CSA A23.4 Standard. CSA prequalification program classifies precast concrete products, fabricated in a prequalified plant, under one or more of the precast concrete product group classification categories and subcategories outlined in CSA A23.4 Standard.

B. Prefabricated circular reinforced concrete manhole sections and catch basins. CSA certification covers the manufacturing and performance requirements of reinforced circular manhole sections, including base sections, riser sections, catch basins, and appurtenances such as grade rings, tops, and special sections for use in the conveyance of sewage, industrial wastes, storm water and the construction of culverts. This certification program does not include concrete pipes.

For a list of certified plants or more information about this plant certification program visit www.csagroup.org/testing-certification/product-listing/

National Precast Concrete Association (NPCA)

NPCA's Plant Certification program is dedicated to increasing the quality of precast concrete products and assisting specifiers in obtaining those products. Since 1987, NPCA experts have helped businesses like yours to continually monitor, manage and improve the quality of their products.

Plants are evaluated on product quality, documentation, production procedures, management, personnel training and equipment. NPCA certifies the processes involved in the manufacture of all precast concrete products, including product-specific requirements such as stormwater concrete pipe, sanitary concrete pipe, round manholes, box culverts, septic tanks and grease interceptors.

For a list of certified plants or more information about this plant certification program visit www.precast.org.

PRE-CONSTRUCTION

Pre-construction planning is essential for a successful project. All engineering plans, project specifications, soils reports, standard drawings, and special provisions must be reviewed prior to construction. A review of the design at the project site is helpful in identifying potential problems. Addressing these potential problems can eliminate unnecessary and costly delays.

All personnel associated with the project should become familiar with the federal, provincial and local occupational health and safety codes related to construction projects.

SITE PREPARATION

Site preparation can significantly influence progress of the project. The amount and type of work involved in site preparation varies with the location of the project, topography, surface conditions, and existing utilities.

ORDERING PRECAST CONCRETE PRODUCTS

The ordering of materials is the contractor's responsibility, however design engineer and supplier familiarity with the contractor's proposed schedule will enable better coordination to avoid delays in product deliveries and avoid unnecessary product handling.

Precast concrete manufacturers stock a wide range of standard components; however longer delivery lead times may be required when large quantities and/or custom precast concrete products are required. Information required to initiate an order should include:

- ❑ Name and location of project
- ❑ Design and manufacturing standards
- ❑ Product size, type, strength class, and quantities
- ❑ Joint materials or performance requirements
- ❑ List of special fittings
- ❑ Product or material test requirements
- ❑ Delivery date
- ❑ Invoicing instructions

In most cases, projects to be supplied with precast products have already been submitted through the precaster's material takeoff system. This helps to ensure standard inventory products have been allocated to the project, and any special design products have been scheduled, manufactured, inspected and ready for delivery. The contractor will only need to refer to the project number and list of products when ordering for delivery that day.

The contractor must provide access roads to allow delivery trucks to reach the unloading area under their own power.

HANDLING

IMPORTANT

Work procedures for material handling, worker safety, the modification of excavators for use as cranes, and all components of any lifting assembly for precast concrete products must comply with the local safety act. A competent person designated by the contractor should inspect all lifting assemblies and attachment hardware prior to each use. Any damage or defective lifting equipment must be immediately removed from service. All other safety procedures and recommended operating practices by the manufacturer of commercial lifting equipment must be followed. Failure to observe the above warnings may lead to property damage, personnel injury and death.

All precast concrete products must be handled with reasonable care. The Contractor must take all necessary precautions to ensure the method used in lifting or placing the product uniformly distributes the weight and does not induce point loading on the product.

Proprietary lifting systems are typically used for precast concrete products, including pipe, box units, and maintenance hole components. It is imperative that all lifting system components and rigging hardware be used as they are intended.

Load-Carrying Capacity of Lift Anchors

IMPORTANT

Lift anchors are sized and located specifically for each precast concrete product to be lifted individually. Contractors must not attempt to lift more than one precast concrete section at a time and must ensure that the load is applied to all lift anchors simultaneously in order to safely lift the product.

The MAXIMUM safe working load is clearly visible on the head of the lift anchor for easy recognition of the appropriate hardware and accessories to be used. However, the safe working load of any lift anchor may be significantly reduced due to several factors, such as:

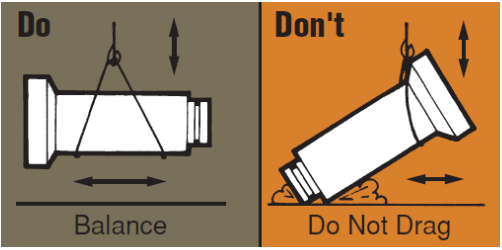
- ❑ Length of anchor, or embedment depth
- ❑ Distance to edges, corners or openings
- ❑ Concrete compressive strength
- ❑ Number of lifting points and type of rigging used
- ❑ Direction of pull (cable or sling angle)
- ❑ Impact or dynamic loads

Handling Pipe

Handling pipes consist of two parts: lifting for loading /unloading and installation

900 mm Diameter and Smaller

Lifting devices such as slings, chains or cables should be placed around the pipe or arranged so that the pipe is lifted in a horizontal position for installation at all times. If there is a chance that the lifting device could chip or damage the pipe, padding should be provided between the pipe and the lifting device. Lifting devices should be evenly balanced and choked on the exterior of the pipe along the barrel of the pipe.



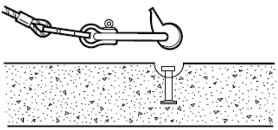
A common device used for loading/unloading pipes of all sizes is a lift fork. Lift forks are easily attached to a heavy equipment machine, such as a front-end loader. Lift forks make loading/unloading more efficient and enable the contractor to easily move pipes around the site.

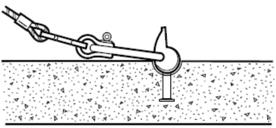
The reason for use of lift forks is that the pipes are stored and transported in horizontal position.

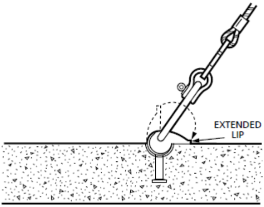
Sometimes a black mark is noticed in the interior of the pipes. This could either be from a vulcanized rubber that is placed on the lift forks; or on site from the steel lift forks of front-end loader, vulcanized rubber is not available on sites. As long as the interior of the pipe at the lift fork length is not chipped or damaged due to point loading during loading-unloading, there shall be no concern regarding the marks. That being said, care must be taken to avoid marking the pipes. If there is a chance that the lifting device could chip or damage the pipe ends, padding should be provided between the pipe and the lifting device.

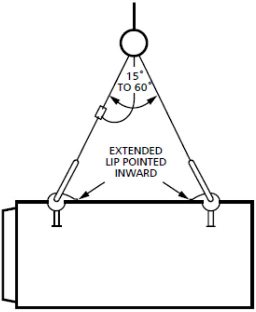
975 mm Diameter and Larger

Concrete pipes 975 mm diameter and larger are typically provided with two embedded lift anchors placed laterally along the top of the pipe. Special pipe fittings may require more than two lift anchors in various other locations on the product. Because the pipe is lifted by two or more points, stability during lifting is established.



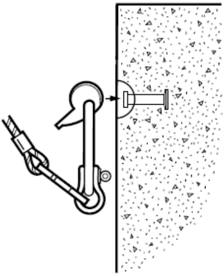


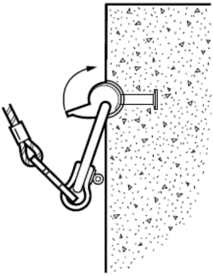


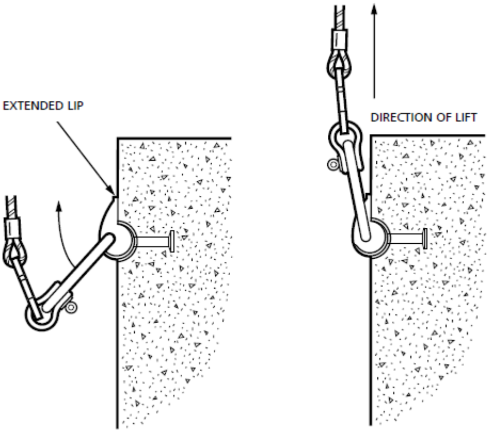


Handling MH Sections

In maintenance hole products, lift anchors are typically placed on the sides of the product. MH components have one or more lift anchors on either side of the product for stability during installation and stacking.

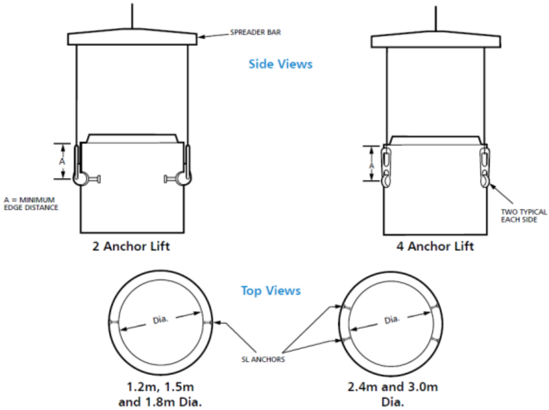






Using short lifting cables or chains that result in a sling angle greater than 60 degrees can greatly increase the possibility of damaging the top shoulders of the MH riser and potentially cause the MH riser to fail structurally.

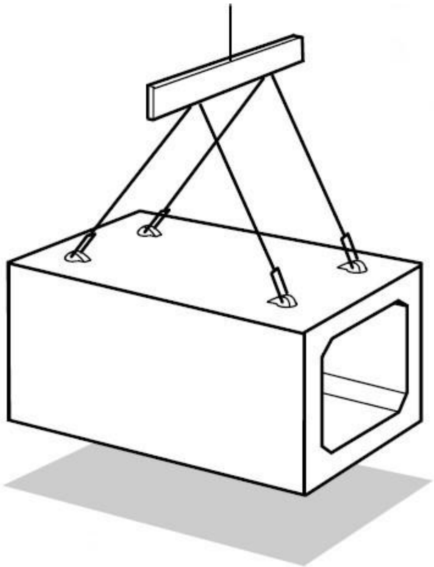
When MH risers have multiple hole openings, extra care must be taken to reduce the inward force from the rigging by means such as a spreader beam or longer cables.



Handling Box Units

Concrete box units are typically provided with four embedded lift anchors placed on the top slab. Additional lift anchors may be provided for unloading or rotating the product from its shipping position to its installed position.

Special box fittings may require lift anchors in various other locations on the product. Because the box is lifted by two or more points, stability during lifting is established.



Source: Guidelines for Handling Concrete Pipe and Utility Products by Dayton Superior.

JOB SITE PRODUCT RECEIVING

Inspection of Product Shipment

Each shipment of precast concrete product is blocked and tied down at the plant to avoid damage during transit. The product should be inspected on the truck when it first arrives at the job site before it is unloaded to ensure that damage has not occurred during transit. Damaged or missing items must be reported at this time.

It is important to check that the product is the correct size, type, and strength class, and is supplied with the proper joint material. Typically, markings on the product include:

- ❑ Manufacturing standard
- ❑ Strength designation, such as pipe class or design earth cover
- ❑ Date of manufacture
- ❑ Name or trademark of the manufacturer
- ❑ Quality assurance program certification, if applicable
- ❑ Appropriate markings to indicate the correct orientation when installed, if applicable
- ❑ Other markings as specified by the owner

Unloading

Unloading precast concrete products should be done on a level site and be controlled to avoid colliding with other products. Care should be taken to avoid damage, especially to the bells and spigots. Caution should be exercised to ensure personnel are out of the path of the product as it is moved.

If the product is damaged during delivery or unloading, the product should be set aside. Minor chips or cracks which do not pass through the wall can usually be repaired. The manufacturer can provide advice on proper repair methods.

If the product has to be moved after unloading, the sections should be lifted and should never be dragged. Transporting products over rough ground should be done in a manner that prevents excessive impact or dynamic loads on the lifting hardware. Pipe sections should not be rolled over rough ground.

Stockpiling

If the excavation is open, the pipe should be placed on the side opposite the excavated material. The pipe sections should be placed so that they are protected from traffic and construction equipment, but close enough to the trench edge to minimize handling.

If the excavation is not yet open, the pipe should be strung out on the opposite side from where the excavated material will be placed. To avoid disruption to existing natural drainage and enable construction to proceed as quickly as possible, pipe installation should follow immediately after preparation of the bedding foundation.

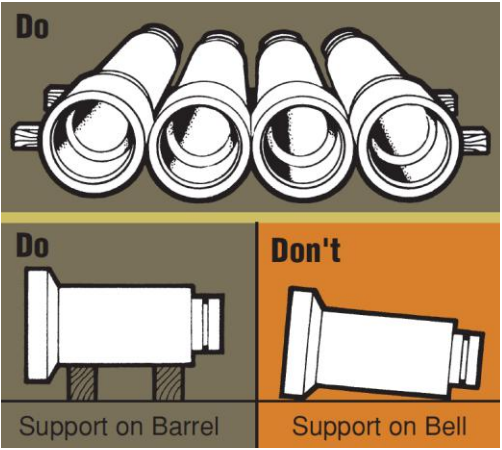
For culverts to be installed on shallow bedding at approximately the same elevation as original ground, the pipe should be strung out immediately after clearing and rough grading.

Storage

Storage of the pipe should be as close as is safely possible to where the pipe will be installed. Pipe sections generally should not be stored at the job site in a greater number of layers that would result in a total height of 2 m.

Pipe should be layered in the same manner as they were loaded on the truck. Pipe should be placed on timbers to prevent them from becoming frozen to the ground in the winter, and to permit ease of handling in summer. For small diameter pipe sizes that have protruding bells, the pipe barrel should carry the weight of the pipe keeping the bell ends free of load concentrations.

The bottom layer should be placed on a level base, on timbers supporting the barrel at either end. Each layer of bell and spigot pipe should be arranged so that bells are at the same end. The bells in the next layer should be at the opposite end, and projecting beyond the spigot of the section in the lower layer. Where only one layer is being stockpiled, the bell and spigot ends should alternate between adjacent pipe sections.



All flexible gasket materials, including joint lubricating compounds where applicable should be stored in a cool dry place in the summer, and prevented from freezing in the winter. Rubber gaskets and preformed mastics should be kept clean, away from oil, grease, excessive heat, and out of direct sunlight.

EXCAVATIONS

For sewer and culvert construction, the scope of operations involved in general includes excavating, soil stabilization, backfilling, and control of groundwater and surface drainage.

Adequate knowledge of subsurface conditions is essential for any type of excavation. This is accomplished through soil surveys and subsequent soil classification. Soil borings are usually obtained for design purposes, and the information included on the plans, or made available to the contractor in a geotechnical report. This soil boring information is useful in evaluating unsuitable subsoil conditions requiring special construction. If the subsoil information on the plans is not sufficiently extensive, it is normally the responsibility of the contractor to obtain additional test borings.

It is the contractor's responsibility to adhere to all Occupational Health and Safety Act requirements for excavations within the province where the project site is located. This includes Canadian, Provincial, Municipal, and Rural District/County codes, specifications, acts, and standards.

Excavated Material

In open-cut installations, suitable excavated material is usually used for backfill and should be placed in a manner that reduces re-handling during backfilling operations.

Stockpiling excavated material adjacent to the trench causes a surcharge load which may cave in trench walls. The ability of the trench walls to stand vertically under this additional load depends on the cohesion characteristics of the particular type of material being excavated. This surcharge load should be considered when evaluating the need to provide trench support. As a general rule, for unsupported trenches, the minimum distance from the trench to the toe of the spoil bank should not be less than one half the trench depth. For supported trenches, a minimum of 1.0 m is normally sufficient.

For deep or wide excavations, it may be necessary to haul away a portion of the excavated soil or spread the stockpile with a bulldozer or other equipment.

If the excavated soil differs significantly from the backfilled material set forth in the plans, it may be necessary to haul the unsuitable soil away and import backfill material. All material to be used as backfill should be visually inspected for frozen lumps, cinders, ashes, refuse, vegetable or organic matter, rocks and boulders over 150 mm in any dimension, and other deleterious material.

In 2020, the Ontario ministry of the environment (MECP) issued legislation pertaining to management of excavated soils, better named “Excess Soils”. Managing excavated soils regards sampling and testing the soil, and the tracking of exported excavated soils from site to a designated dumping location. The concrete pipe industry perspective is not all excavated material needs removal from the project site, and if that excavated material is deemed “select material”, it can be used as backfill around the concrete pipe. This will reduce excess soils and provide financial, logistical and material savings. Similarly, the British Columbia’s ministry of the environment is taking a similar approach.

See local requirements regarding excavated soils from infrastructure projects.

Dewatering

A continuous dewatering operation should be provided in order to keep the excavation stable and free of water. Dewatering efforts must be monitored for impacts to items such as ground settlement and ground water usage.

Water from dewatering operations must be disposed of in accordance with local regulations. Pumped water requires that it be filtered through a sediment control measure and disposed of such that it does not cause erosion or other damage to adjacent lands.

When dewatering efforts are no longer required, they must be discontinued in a manner so that disturbance of any structure or pipeline is avoided.

Review the dewatering standards/requirements of the local municipality, rural region, and province for relevant information for the location of your project.

Support Systems

Soil stabilization may require the opinion of a professional engineer to ensure that the walls of an excavation are sufficiently stable before any workers enter the excavation.

Review the support system standards/requirements of the local municipality, rural region, and province for relevant information for the location of your project.

The structural requirements of a support system depend on numerous factors such as:

- depth and width of excavation
- characteristics of the soil
- water content of the soil
- weather conditions
- proximity to other structures
- vibration from construction equipment or traffic
- soil placement or other surcharge loads
- code requirements

As the excavation is backfilled, the support system should be removed, unless it is specified to be left in place.

Improper removal of a support system can affect the backfill load on the pipe or structure, so it should be withdrawn gradually as backfilling progresses. Additional compaction of the backfill material may be necessary to fill the voids behind the support system, as it is removed. The procedure for extracting the support system and placing backfill shall ensure the backfill load is applied gradually, and disturbance of the pipeline or structure is avoided.

Trench Boxes

Trench boxes, or shields, are prefabricated support systems composed of heavily braced steel sidewalls and are capable of being moved as a unit to protect workers as pipe installation progresses. Trench boxes are commonly used for pipe or box installations and must be designed by a professional engineer.

Review the support system standards/requirements of the local municipality, rural region, and province for relevant information for the location of your project.

When a trench box is used, care should be taken when the shield is moved ahead, so as not to disturb the bedding or pull the pipe or box joints apart.

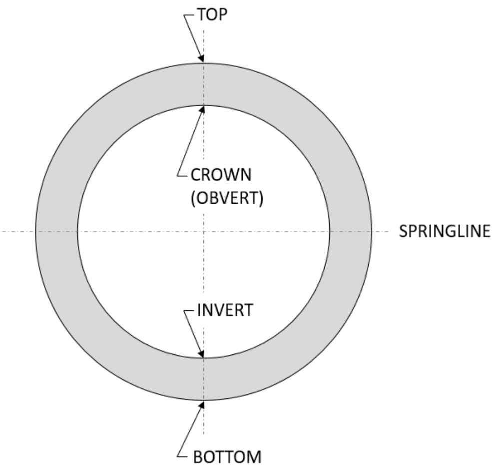
The width of trench box used is also very important. If the trench box is too narrow, proper placement of granular materials, compaction equipment or the operation will not be able to provide effecting bedding support for the pipe. If the trench box is too wide, the installation condition of the pipe might change from “Trench” condition to “Positive Projection” condition, and this will affect the design of concrete pipe. Be sure to check the engineer’s design and project drawings.

Specially designed manhole shields are also available for the installation of maintenance holes, or other vertical structures.

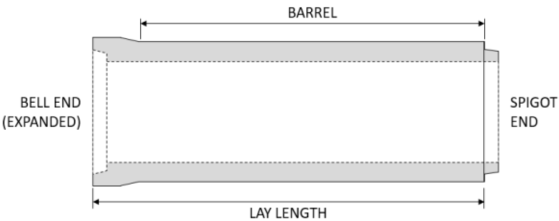
CONCRETE PIPE INSTALLATION

This section covers the requirements for the installation of concrete pipes in an open cut trench. Pipe installation using trenchless methods are discussed in Appendix A.

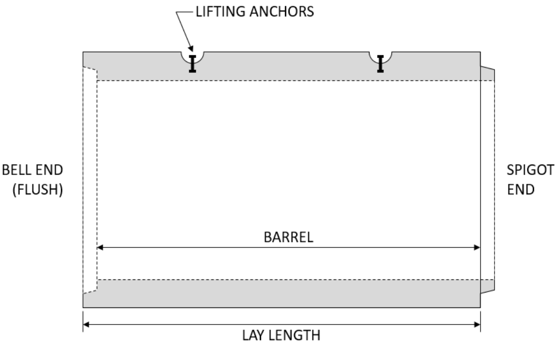
Pipe Details



Cross-section



Expanded Bell End - 975mm Dia & Smaller



Flush Bell End - 1050mm Dia & Larger

Wall Thickness

Concrete pipes are typically supplied with industry standard wall thicknesses but may vary by manufacturer. Wall thickness can be determined by the following equations:

$$\textbf{A Wall:}\quad t = \frac{ID}{12}$$

$$\textbf{B Wall:}\quad t = \frac{ID}{12} + 1$$

$$\textbf{C Wall:}\quad t = \frac{ID}{12} + 1.75$$

Where: **t** = wall thickness (inches)
ID = inside pipe diameter (inches)

Excavation Limits

The most important excavation limitations are trench width and depth. As excavation progresses, trench grades should be periodically checked against the elevations established on the sewer profile.

Improper trench depths can result in high or low spots in the line, which may adversely affect the hydraulic capacity of the sewer and require correction or additional maintenance after the line is completed. If the trench depth is excavated beyond the limits of the required excavation, granular material should be placed and compacted in the trench to reinstate the required trench limits prior to backfilling the trench.

The backfill load transmitted to the pipe is directly dependent on the trench width at the crown of the pipe. To determine the backfill load the designer assumes a certain trench width and then selects a pipe strength capable of withstanding this load. If the constructed trench width exceeds the maximum trench width specified in the design, the pipe may be overloaded and may require the use of a stronger pipe or a higher class of bedding, or both. Where maximum trench widths are not indicated in any of the construction contract documents, trench widths should be as narrow as possible, with side clearance adequate enough to ensure proper compaction of backfill material at the sides of the pipe.

When unstable soil conditions are encountered, sheathing or shoring can be used, or the banks of the trench can be sloped to the natural angle of repose of the native soil. If the trench sides are allowed to slope back, the pipe should be installed in a shallow subtrench excavated at the bottom of the wider trench. The depth of the subtrench should be at least equal to the vertical height of the pipe.

For a confined trench installation, the following trench widths at the top of the pipe are best practices:

SIDE CLEARANCE TABLE	
Pipe Inside Diameter (mm)	**Side Clearance (mm)**
900 or less	300
Over 900	500

For culverts installed under embankments, it may be possible to simulate a narrow subtrench by installing the pipe in the existing stream bed.

When culverts are installed in a negative projecting condition of construction, the same excavation limitations should be followed as for trench excavation.

Line and Grade

For sewer construction, where the pipe is installed in a trench, line and grade are usually established by one, or a combination of the following methods:

- Control points consisting of stakes and spikes set at the ground surface, and offset a certain distance from the proposed sewer centerline
- Control points established at the trench bottom, after the trench is excavated
- Trench bottom and pipe invert elevations established while excavation and pipe installation progresses
- Global Positioning System (GPS)

IMPORTANT

Line and grade should be checked as the pipe is installed, and any discrepancies between the design and actual alignment and pipe invert elevations should be corrected prior to placing the backfill or fill over the pipe.

Where control points are established at the surface and offset, lasers, transits, batter boards, tape and level, or specially designed transfer instruments, are used to transfer line and grade to the trench bottom. Regardless of the specific type of transfer apparatus used, the basic steps are:

- ❑ Stakes and spikes, as control points, are driven flush with the ground surface at 7.5 to 15m intervals for straight alignment, with shorter intervals for curved alignment.
- ❑ Offset the control points 3m, or another convenient distance, on the opposite side of the trench from which excavated material will be placed.
- ❑ Determine control point elevations by means of a level, transit or other leveling device. Drive a guard stake to the control point and mark the depth of the control point from the control point to the trench bottom or pipe invert.
- ❑ After the surface control points are set, a grade sheet is prepared listing reference points, stationing, offset distance and vertical distance from the control points to the trench bottom or pipe invert.

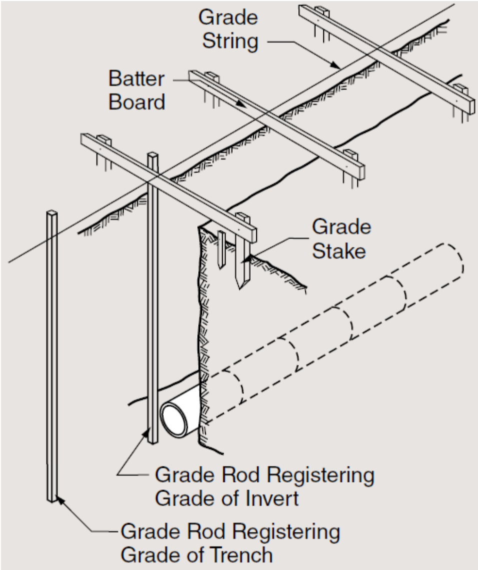
Transferring the line and grade along the trench bottom is achieved by using a laser system, or a batter board system.

The laser system, the most commonly used system, uses a transit or level to set the starting point on the trench bottom. As with any surveying instrument, the initial setting is most important. Once the starting point is established, the laser can be set for direction and grade.

Temperature can affect the trueness of the laser beam; therefore, it is helpful to keep the line well ventilated. The laser instrument can be mounted in a maintenance hole, set on a tripod or placed on a solid surface to project the light beam either inside, or outside the pipe.

There are two types of batter board systems. One type is incorporated for narrow trenches, the other for wide trenches.

For narrow trenches, a horizontal batter board is spanned across the trench and adequately supported at each end. The batter board is set level at the same elevation as the stringline, and a nail driven in the upper edge, at the centerline of the pipe. In many cases the batter board is used only as a spanning member, with a short vertical board nailed to it at the pipe centerline. A stringline is pulled tight across a minimum of three batter boards, and the line transferred to the bottom by a plumb bob cord held against the stringline. Grade is transferred to the trench bottom by means of a grade rod, or other suitable vertical measuring device.



Example Batter Board Set-up for Narrow Trench

Where wide trenches are necessary, due to large pipe sizes or sloped trench walls, the batter board may not be able to span the width of excavation. In such cases, the same transfer principle is used, except that the vertical grade rod is attached to one end of the batter board, and the other end set level against the offset stringline. The length of horizontal batter board is the same as the offset distance. The length of the vertical grade rod is the same as the distance between the pipe invert and the stringline.

Foundation Preparation

A stable and uniform foundation is necessary for satisfactory performance of any pipe. The foundation must have sufficient load bearing capacity to maintain the pipe in proper alignment and support the loads of the backfill material placed over the pipe. The foundation should be checked for hard or soft spots, due to rocks or low load-bearing soils. Where undesirable foundation materials exist, it should be stabilized by ballasting, or soil modification.

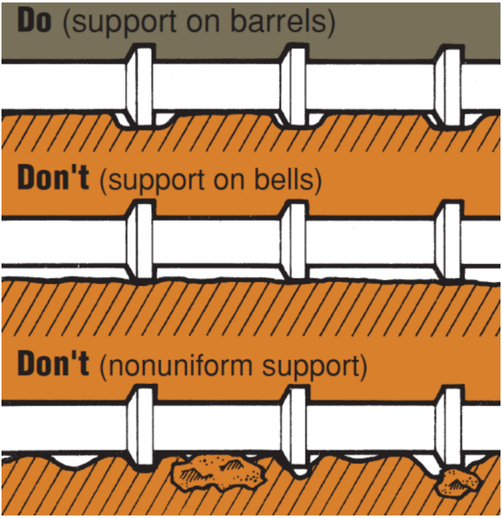
Ballasting requires removal of the undesirable foundation material and replacing it with select materials such as sand, gravel, crushed rock, slag, or suitable earth backfill. The depth, gradation, and size of the ballast depend on the specific material used and the amount of stabilization required, but usually the ballast should be well graded.

Soil modification involves the addition of select material to the native soil. Crushed rock, gravel, sand, slag, or other durable inert materials with a maximum size of 75 mm, is worked into the subsoil to the extent necessary to accomplish the required stabilization.

In rock or hard, unyielding soils, the excavation should be continued below grade, and the over-excavation replaced with select material to provide a cushion for the pipe.

Pipe Bedding

Once a stable and uniform foundation is provided, it is necessary to prepare bedding in accordance with the requirements set forth in the plans, specifications or standard drawings.

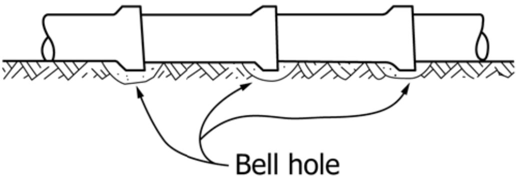


An important function of the bedding is to level out any irregularities in the foundation and ensure uniform support along the barrel of each pipe section. The bedding is also constructed to distribute the load bearing reaction, due to the mass of the backfill or fill material, around the lower periphery of the pipe. The structural capacity of the pipe is directly related to this load distribution, and several types of bedding have been established to enable the specification of pipe strengths during the design phase.

This guide describes the **Class B** and **Class C** Beddings since these are commonly used in the Ontario Provincial Standards for rigid pipe. Other bedding types, such as Standard Installation Types 1 to 4, are described in the *OCPA Concrete Pipe Design Manual* and the *Canadian Highway Bridge Design Code (CSA S6)*.

The following general requirements should be understood:

- ❑ Bedding material placed in the haunches must be compacted prior to continued placement of cover material. To ensure support in the haunches, the bedding under the middle third of the pipe should be loosely placed and uncompacted.
- ❑ Bedding material should be placed in layers not exceeding 200 mm in thickness, loose measurement, and compacted to contract specifications before a subsequent layer is placed.
- ❑ Bedding on each side of the pipe should be completed simultaneously. At no time should the levels on each side differ by more than the 200 mm uncompacted layer.
- ❑ Bell holes should be excavated to accommodate projecting joints, and to provide support along the barrel of the pipe.



Uniform Support for Pipe with Expanded Bells

Bedding Materials

Materials for bedding should be selected on the basis that uniform contact can be obtained between the bedding and the pipe. Since most granular material will shift to attain this uniform contact as the pipe settles, an ideal load distribution can be realized.

Class B Bedding

- ❑ The bedding depth below the pipe has a specified thickness of 0.15 times the outside pipe diameter, with a minimum of 150mm and maximum of 300mm.
- ❑ Class B Bedding should extend at least halfway up at the sides of the pipe (to springline).
- ❑ The bedding material is shaped to receive the bottom of the pipe. The width should be sufficient to allow 0.6 times the outside pipe diameter for circular pipe, and 0.7 times the outside span for elliptical pipe.

Class C Bedding

- ❑ The bedding depth below the pipe has a specified thickness of 0.15 times the outside pipe diameter, with a minimum of 150mm and maximum of 300mm.

- ❑ Class C Bedding should extend up the sides of the pipe for a height of at least 0.15 times the outside pipe diameter (forming a 90-degree bedding angle).
- ❑ The bedding material is shaped to receive the bottom of the pipe. The width should be sufficient to allow 0.5 times the outside pipe diameter for circular pipe, and 0.5 times the outside span for elliptical pipe.

Cover

Cover material should be placed so that damage to or movement of the pipe is avoided.

The following general requirements should be understood:

- ❑ Compacted cover material should be placed on top of the bedding to a depth of at least 300 mm above the top of the pipe.
- ❑ Cover material should be placed in layers not exceeding 200 mm in thickness, loose measurement, and compacted to contract specifications before a subsequent layer is placed.
- ❑ Cover on each side of the pipe should be completed simultaneously. At no time should the levels on each side differ by more than the 200 mm uncompacted layer.

Heavy equipment should not be used for compacting until there is a minimum depth of 900mm above the crown of the pipe.

Backfill

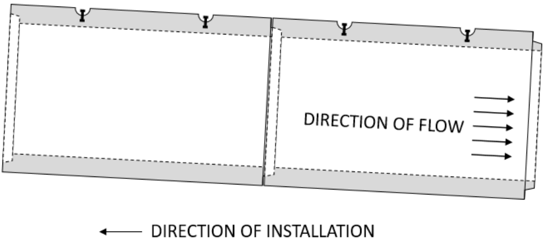
The following general requirements should be understood:

- Backfill material should be placed in uniform layers not exceeding 300 mm in thickness for the full width of the trench and each layer should be compacted to 95% of the maximum dry density before a subsequent layer is placed.
- Backfill should be placed to a minimum depth of 900mm above the crown of the pipe before power operated tractors or rolling equipment should be used for compacting. Uniform layers of backfill material exceeding 300mm in thickness may be placed with the approval of the Contract Administrator.
- If the contract specifies native backfill material, acceptable earth backfill material may be substituted with the approval of the Contract Administrator. In areas within the roadway, for a depth equal to the frost treatment, the earth backfill material should have frost susceptible characteristics similar to the adjacent material.

Jointing

Pipe should be lowered into the trench, or set in place for embankment installations, with the same care as when the pipe was unloaded from the delivery trucks.

In laying the pipe, it is general practice to face the bell end of the pipe in the upstream direction. This placing helps prevent bedding material from being forced into the bell during jointing and enables easier coupling of pipe sections.



Jointing Materials

Several types of joints and sealant materials are utilized for concrete pipes, to satisfy a wide range of performance requirements. All of the joints are designed for ease of installation. The manufacturer's recommendations regarding jointing procedures should be closely followed to assure resistance to infiltration of groundwater and/or backfill material, and exfiltration of sewage or storm water.

The most common joint sealants and joint fillers used for sewers and culverts are:

- ❑ Rubber gasket
- ❑ Mastic sealants
- ❑ Mortar

Regardless of the specific joint sealant used, each joint should be checked to be sure all pipe sections are in a homed position. For joints sealed with rubber gaskets, it is important to follow the manufacturer's installation recommendations to ensure that the gasket is properly positioned and is under compression.

Rubber Gaskets

Rubber gaskets are of three basic types:

- ❑ Pre-lubricated gasket for single offset joints. This is the type of gasket most commonly used for standard concrete gravity pipe.
- ❑ Profile gasket for single offset joints.
- ❑ O-ring gasket, which is placed in a groove on the spigot and confined by the bell after the joint is completed.

In some cases, a smooth round object, such as a screwdriver shaft, should be inserted under the gasket and run around the circumference two or three times, to equalize the stretch in the gasket, before jointing.

For all gasket types, dirt, dust, and foreign matter must be cleaned from the joint surfaces. Except for pre-lubricated type, the gasket and bell should be coated with a lubricant recommended by the manufacturer. The lubricant must be clean and be applied with a brush, cloth pad, sponge or glove.

Rubber gaskets are required to be stored in a sheltered, cool dry place. They need to be protected from prolonged exposure to sunlight, extreme heat in the summer, and extreme cold in the winter. Proper care of the gaskets prior to the installation will ensure maximum ease of installation and maximum sealing properties.

Gaskets are generally formulated for maximum sealing performance in a standard sewer installation carrying primarily storm water or sanitary sewage. Custom rubber formulations are available for special situations, where specific elements are being carried in the effluent. Some common examples of where a custom formulation would be required are where resistance is needed against hydrocarbons, acids, UV rays, ozone, and extreme heat.

Mastic

Mastic sealants consist of bitumen or butyl rubber and is usually cold applied. The joint surfaces must be thoroughly cleaned, dried and prepared in accordance with the manufacturer's recommendations.

Typically supplied in pre-formed coils, the flexible rope style sealant should be properly sized based on the dimensions of the annular joint space being sealed.

During cold weather, better workability of the mastic sealant can be obtained if the mastic and joint surfaces are warmed.

Mortar

Mortar for joints is composed of one-part normal Portland cement and two parts mortar sand, wetted with only sufficient water to make the mixture plastic.

- The joint surface is thoroughly cleaned and soaked with water immediately before the joint is made
- A layer of mortar is placed in the lower portion of the bell end of the installed pipe and on the upper portion of the spigot end of the pipe section to be installed.
- The spigot is then inserted into the bell of the installed pipe until the sealant material is squeezed out.
- The annular space within the pipe joint is filled with mortar, and the excess mortar on the inside of the pipe is wiped and finished to a smooth surface.

External Bands

External bands may be used in addition to any jointing material to serve two functions:

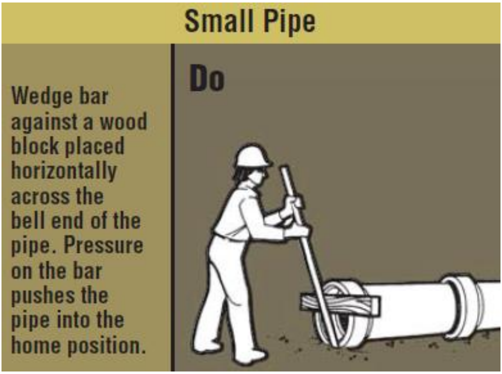
- prevent fine materials from entering the joint
- prevent infiltration of groundwater

If the prevention of bedding material from entering the conveyance system is the primary objective, filter fabric, while allowing the groundwater to infiltrate, will stop the bedding backfill material from entering.

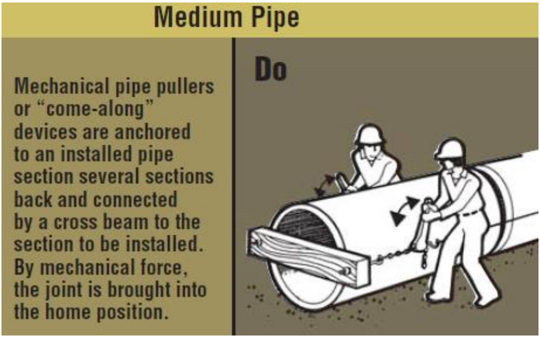
To prevent the infiltration of water, external extruded rubber gaskets are utilized. The gasket must be of sufficient width to cover the joint, and must be installed with some tension applied, according to the manufacturer's recommendations. As the joint is backfilled, pressure is applied to the gasket as it is pressed against the structure, providing a seal at the joint.

Jointing Procedures

Joints for pipe sizes up to 600 mm in diameter can usually be assembled by means of a bar and wood block. The axis of the pipe section to be installed should be aligned as closely as possible to the axis of the previously installed pipe section, and the spigot end inserted slightly into the bell, or groove. A bar is then driven into the bedding and wedged against the bottom bell end of the pipe section being installed. A wood block is placed horizontally across the end of the pipe to act as a fulcrum point, and to protect the joint end during assembly. By pushing the top of the vertical bar forward, lever action pushes the pipe into a home position.

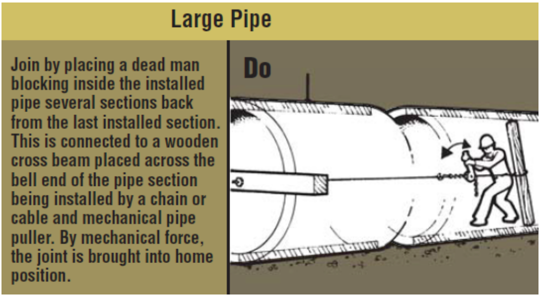


When jointing medium diameter pipe, a chain or cable is wrapped around the barrel of the pipe behind the spigot and fastened with a grab hook, or other suitable connecting device. A lever assembly is anchored to the installed pipe, several sections back from the previously installed section, and connected by means of a chain, or cable, to the grab hook on the pipe to be installed. By pulling the lever back, the spigot of the pipe being jointed is pulled into the bell of the previously installed pipe section. To maintain close control over the alignment of the pipe, a laying sling can be used to lift the pipe section slightly off the bedding foundation.



When jointing larger diameter pipes, and when granular bedding is used, mechanical pipe pullers may be required. Several types of pipe pullers, or "come along" devices, have been developed, but the basic force principles are the same.

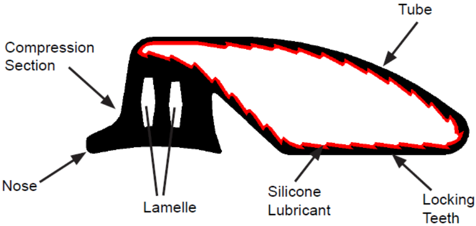
Large diameter pipe can be jointed by placing a "dead man" block inside the installed pipe, several sections back from the last installed section, which is connected by means of a chain or cable to a strong back placed across the end of the pipe section being installed. The pipe is pulled home by lever action similar to the external assembly. Mechanical details of the specific apparatus used for pipe pullers, or come along devices, may vary, but the basic lever action principle is used to develop the necessary controlled pulling force.



Note: Direct contact of the excavating equipment against the pipe surface must not be used to push pipe sections together or to adjust pipe to the final grade. The force applied by such equipment can damage pipe joints.

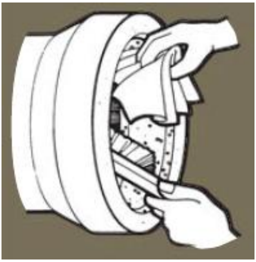
Jointing Procedures for Pre-lubricated Gasket with Single Offset Joints

The unique design of the pre-lubricated pipe gasket requires no field lubrication and no equalization after installation.

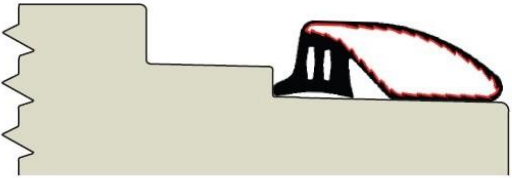


Installation:

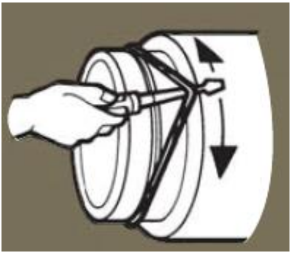
1. Clean loose dirt, debris and foreign material from the inside surface of the bell, the outside surface of the spigot and the gasket.
2. Ensure that concrete bell and spigot are free from cracks, chips, or other defects.
3. Inspect the gasket for damage.



4. Stretch gasket around the spigot, with the “Nose” against the step formed in the spigot, and the “Tube” lying flat against the spigot.

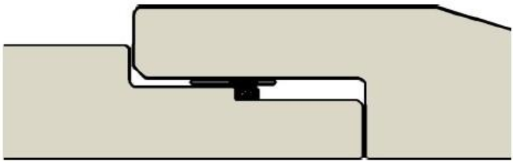


5. Pre-lubricated gaskets do not typically require equalization of the rubber gasket stretch. If equalization is required, run a smooth round object around the circumference several times.



6. Do not lubricate the gasket or joint as this could adversely affect the performance of the gasket and the joint.
7. Align the spigot with the bell and thrust the spigot home using suitable mechanical means. The homing process will cause the lubricated tube to “roll” over

itself, above the compression section, allowing the pipe to slide forward.

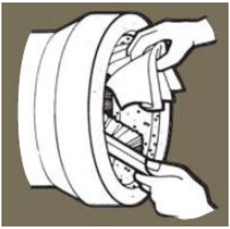
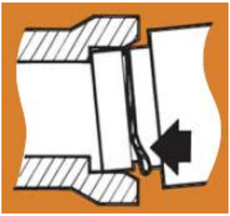


Once the pipe is fully homed,

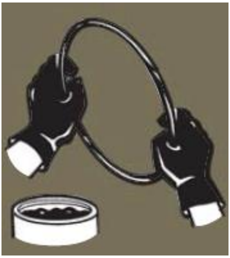
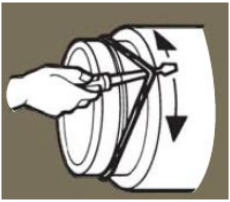
- ❑ The compression section seals the total annular space
- ❑ The rolling tube comes to rest within the small annular space – acting as a cushion against side loads
- ❑ The serrations act to resist pipe pull-out.

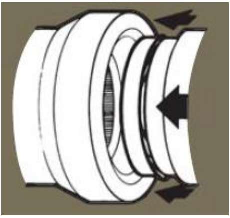
Source: Hamilton Kent.

Jointing Procedures for O-Ring Gasket

Procedure	Prevention
Clean all foreign material from the jointing surface of the bell end of the pipe. 	Foreign material on the jointing surface can prevent proper homing of the pipe. 
Carefully clean the spigot end of the pipe, including the gasket recess. 	Spigot ends that are not properly cleaned may prevent proper sealing of the gasket. 

<table>
<tr><th>Procedure</th><th>Prevention</th></tr>
<tr><td>Cover the entire jointing surface using an approved lubricant, using a brush, cloth, sponge or gloves.
</td><td rowspan="2">Bells and spigots which are not properly lubricated can cause gaskets to roll or possibly damage the joint.
</td></tr>
<tr><td>Lubricate the spigot end of pipe, especially the gasket recess.
</td></tr>
</table>

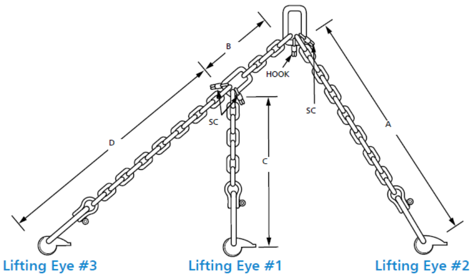
<table>
<tr><th>Procedure</th><th>Prevention</th></tr>
<tr><td>Lubricate gasket before inserting it on the spigot.
</td><td>Excessive force will be required to push the pipes together if lubricant is insufficient. This can cause extensive damage.
</td></tr>
<tr><td>When fitting the gasket, equalize the gasket stretch by running a smooth round object around the circumference several times.
</td><td>Unequal stretch can cause bunching of the gasket and can damage the bell or be the source of leaks.
</td></tr>
</table>

Procedure	Prevention
When aligning the pipes, before homing the joint, check the gasket is in contact with the entry taper around the entire circumference. 	Improper alignment can dislodge the gasket causing leaks or possibly break the bell. 

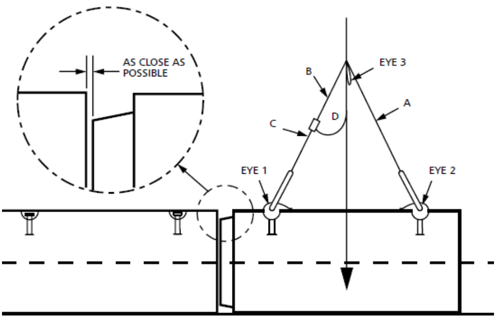
How to Use Lift Anchors for Setting Pipe

The following procedures are published in ***Guidelines for Handling Concrete Pipe and Utility Products*** by Dayton Superior, and available from the CCPPA.

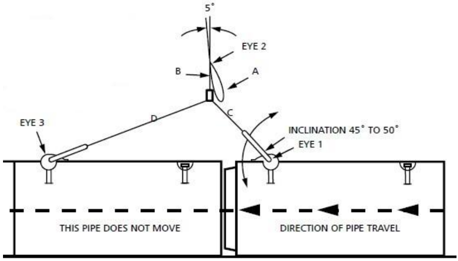
Lift anchors in concrete pipe can be used to "home" or pull the product into its final position with a three-legged chain sling, as shown below.



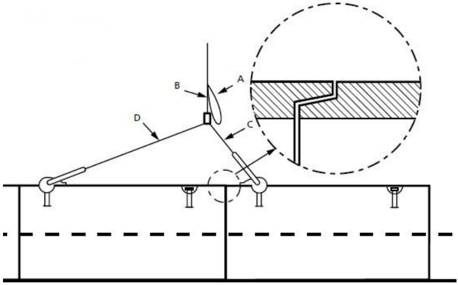
1. The pipe is first transported to the installation site with the symmetrical sling and lowered close to the already placed pipe.



2. To pull the pipe into position, the long leg of the Pipe Laying Sling is attached to the farthest anchor on the previously laid pipe. The free short leg is attached – out of the way – on the clevis link provided, eye 2.
3. Locate the center of lift over the closest anchor of the previously laid pipe. This will properly align the direction of pull.
4. The pipe is pulled into position by slowly raising the boom on the crane or backhoe without moving the boom forward or backward.



5. When the pipe has been pulled into position, the load is released and the Pipe Laying System is moved to the next pipe, and the process is repeated.



Warning: Anchors can become overloaded and fail if the crane or backhoe continues to apply load after the connection has been completed.

Service Connections

Service connections to the main pipe sewer should be made using factory made tees or wyes, strap-on-saddles, or other approved saddles.

Holes in the main pipe sewer should be cut with approved cutters and should be the minimum diameter required to accept the service connection. If mortar-on saddles are used, the inside of the pipe should be mortared at the connection.

Where existing service connections are to be connected to new pipe sewers or service connections, proper jointing procedures must be used.

Changes in Alignment

Maintenance holes should be used when there is a need to change alignment, grade or size of a pipeline. Alignment changes in concrete pipe sewers can also be incorporated into the line through the use of radius pipe or bends. *Although the joints of precast concrete pipe are tested for seal integrity in a deflected alignment, it is not recommended to deflect the joints to create an alignment change.*
Since manufacturing and installation feasibility are dependent on the particular method used to negotiate a curve, it is important to establish the method prior to excavating the trench.

- ❑ When establishing alignment for radius pipe, the first section of radius pipe should begin one half of a radius pipe length before the beginning of curve, and the last section of radius pipe should extend one half of a radius pipe length beyond the end of curve.

- When extremely sharp curves are required, radius pipe may not be suitable. In such cases, bends or elbows may be used.

Regional Variances - *Since manufacturing processes and local standards vary, local concrete pipe manufacturers should be consulted to determine the geometric configurations available.*

MH INSTALLATION

Structures must be installed on firm foundations at the locations and elevations specified and must be constructed plumb and true to alignment.

Precast base slabs or monobases must be placed level before subsequent sections complete with joint seal systems be installed. Adjustment of the structure should be carried out by lifting the affected sections free of the excavation, re-leveling the base, if necessary, and re-installing the sections. The damaged sections and gaskets must be replaced.

When specified, the inside concrete bottom of the structures should be benched and channeled to accommodate the pipe. Concrete benching should have a wood float finish, and the channel should have steel trowel finish. The channel must be smooth and flush with adjacent pipe inverts.

Obtaining maintenance hole invert levels for the preparation of as-built drawings, combined with visual inspection of the sewer, provide an additional check that settlement has not occurred.

Prebenched MH Monobases

Having the precast MH base prebenched at the factory offers advantages over benching in the field. Prebenching is done under controlled conditions, resulting in a higher quality product.

When used with flexible connectors, there is no need for workers to enter the confined space created when the maintenance hole is backfilled.

MH Connections

When the pipe connects to a rigid structure such as a maintenance hole, it may shear or crack at the connection, as a result of differential settlement. It is essential that the bedding and foundation for the connecting pipe section be highly compacted, to minimize differential settlement.

Two methods are recommended by the precast concrete pipe industry to maintain a watertight structure:

- ❑ Flexible pipe-to-MH connectors. The flexible connectors consist of a pre-formed rubber boot inserted in the MH wall opening. The pipe is inserted in the boot and the rubber connector is tightened to create a positive connection.
- ❑ Concrete grout. For many large diameter sewer applications, contractors may connect directly to MH's using grout.

The installation of pipe connectors must be according to the manufacturer's recommendations.

All pipes, except in valve chambers, must be flush with the inside walls of the structure.

Regional Variances – *For Ontario, OPSS 407 requires that one of the following connections be provided where a pipe connects to a structure:*

- ❑ A flexible pipe joint is provided within 300 mm of the outside face of the structure for flexible and rigid pipe.
- ❑ A concrete cradle to the first joint for rigid pipe.
- ❑ A resilient connector, i.e., a flexible, watertight connector, in the structure opening for flexible and rigid pipe.
- ❑ A special approved structure designed for pipe support.

Precast Concrete Adjustment Units

Precast concrete adjustment units can be used to set the frame with grate or cover at the required position and elevation.

The first adjustment unit should be laid in a full bed of mortar and aligned with the opening in the structure. Successive adjustment units are laid plumb to the first adjustment unit and should be sealed between each unit.

If the total height of adjustment units exceeds 150mm, an adjustment unit with MH rung may be required.

Frames with Grates or Covers

When precast concrete adjustment units are used, frames with grates or covers should be set in a full bed of mortar on the adjustment units.

Ditch inlet grates should be installed as specified by the precast manufacturer, or grate supplier.

BOX UNIT INSTALLATION

Box units must be installed to the alignment and grade specified in the contract documents. Installation of the box units should start at the outlet end and proceed in the upstream direction with the bell ends of the box units facing upgrade.

The gap at box unit joints must not exceed 20mm. Digging a small trench in the bedding at each box joint with a round point shovel across the full width of the box unit will ensure a proper alignment and connection. This allows for the excess bedding material to fall into the trench instead of getting trapped in the joint as the next box unit is pulled into place.

For box units placed in parallel for multiple cell installations, a 60mm ± 10mm gap filled with grout should be used to provide positive lateral bearing between adjacent cells.

For more information on precast concrete boxes, refer to the *OCPA Precast Box & Culvert Guideline*.

Foundations

Precast box units should be constructed as specified in the contract. The foundation must be firm in-situ soil or compacted backfill to provide uniform support for the full length and width of each box unit. The foundation on each side of the box unit, for a minimum distance equal to the inside width of the box unit should be at least as stable as the foundation directly below the box unit. Bedding should not be placed on frozen earth.

Bedding

The maximum particle size for bedding should not exceed 25 mm in diameter, unless the bedding layer is at least 150 mm thick, in which case the maximum particle size should not exceed 38 mm in diameter.

Bedding requiring compaction should be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer should be compacted before a subsequent layer is placed. The type of equipment used must be suited to the material to be compacted, the degree of compaction required, and space available.

Levelling

The surface prepared to support the box units should have a 75 mm minimum thickness top leveling course of uncompacted Granular A or fine aggregates.

Backfill and Cover

Backfill and Cover should be placed in layers not exceeding 200mm in thickness, loose measurement, and each layer should be compacted according to the specifications.

Backfilling on each side of the box units should be completed simultaneously. The levels on each side must not differ by more than 400mm.

Shallow Cover Box Culverts

The following optional requirements to provide shear transfer across box joints are noted in the CHBDC commentary.

Precast concrete box culverts installed with a height of fill less than 0.60m may require a reinforced distribution slab with a minimum thickness of 150mm. In lieu of a distribution slab, shear connection plates may be mechanically fastened to the culvert units across the box joints, as specified by design engineer.

Regional Variances – *Review the local standards and specifications for the requirements of the installation location.*

FIELD TESTING

The physical tests included in the material specifications, under which the pipe is purchased, assure that pipe delivered to the jobsite meets, or exceeds the requirements established for a particular project. The project specifications usually include acceptance test requirements to assure that reasonable quality control of workmanship and materials have been realized during the construction phase of the project. Tests applicable to all storm sewer, sanitary sewer and culvert projects are soil density, line and grade and visual inspection, often by video. For sanitary sewers, leakage limits are usually established for infiltration or exfiltration. Post installation inspection should be in accordance with ASTM 1840.

Soil Density

To correlate in-place soil densities with the maximum density of a particular soil, it is first necessary to determine the Optimum Moisture Content for maximum compaction and then use this as a guide to determine the actual compaction of the fill or backfill. Several test procedures have been developed for measuring in-place soil densities.

A nuclear moisture and density gauge provides a rapid, non-destructive technique for in-place determination of density suitable for control and acceptance testing of soils. It should be noted that the equipment utilizes radioactive materials, which may be hazardous to the health of users, unless proper precautions are taken.

Regional Variances – Review the soil density requirements of your local municipality, rural region, and Province.

In Ontario:
The maximum dry density can be determined by LS-706 or LS-623 for granular and by LS-706, for earth. These tests can be found in the MTO Laboratory Testing Manual:

- ***LS-623** - One Point Proctor Test (OPT)*
- ***LS-706** - Moisture - Density Relationship of Soils Using 2.5 kg Rammer and 305 mm Drop*

Elsewhere:
The maximum dry density can be determined by ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (600 kN-m/m^3)

Field density and field moisture determinations can be made in accordance with:

- **ASTM D 2922** - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth); and
- **ASTM D 3017**- Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

Visual/Video Inspection

Larger pipe sizes can be entered into and examined, while smaller sizes must be inspected by means of closed-circuit television cameras.

The following is a checklist for CCTV inspection of a pipe:

- debris and obstructions
- cracks exceeding the 0.3 mm wide design crack for reinforced concrete pipe
- joints properly sealed
- invert smooth and free of sags or high points
- stubs properly grouted and plugged
- laterals, diversions, and connections properly made
- catchbasins and inlets properly connected
- maintenance hole frames and grates properly installed
- surface restoration, and all other items pertinent to the construction, properly completed

Review the visual and video inspection requirements of your local municipality, rural region, and Province to determine the exact needs based on your site location.

Infiltration Testing

The infiltration of excessive ground water into a sanitary sewer can overload the capacity of a sewer collection system and treatment facilities. The infiltration test is intended to demonstrate the integrity of the installed materials and construction procedures as related to the infiltration of ground water. Infiltration tests should be conducted where the groundwater level at the time of testing is 600 mm or more above the crown of the pipe for the entire length of the test section. The test section is normally between adjacent maintenance holes.

- Discontinue dewatering operations at least three days before conducting the test and allow the groundwater level to stabilize.
- A watertight bulkhead is constructed at the upstream end of the test section.
- All service laterals, stubs, and fittings are plugged or capped to prevent water entering at these locations.
- A V-notch weir or other suitable measuring device is installed at the downstream end of the test section.
- Infiltrating water is allowed to build up behind the weir until the flow through the V-notch has stabilized.
- The rate of flow is then measured.

Review the infiltration testing requirements of your local municipality, rural region, and Province to determine what the allowable infiltration rate is.

Exfiltration Testing

Exfiltration tests should be conducted where the groundwater level is lower than 600 mm above the crown of the pipe or the highest point of the highest service connection included in the test section.

The test section is normally between adjacent maintenance holes. The test section of the pipe sewer shall be isolated by temporarily plugging the downstream end and all incoming pipes of the upstream maintenance hole. All service laterals, stubs, and fittings are plugged or capped to prevent water entering at these locations.

Since sanitary sewers are not designed, or expected to operate as a pressure system, care must be exercised in conducting the test and correlating the results with allowable exfiltration limits.

Review the exfiltration testing requirements of your local municipality, rural region, and Province to determine what the allowable exfiltration rate (if any) is

Testing With Water

The test section is slowly filled with water making sure that all air is removed from the line.

The test procedure outlined in ASTM C969 and OPSS 410 is as follows:

- A period of 24 hours for absorption or expansion may be allowed before starting the test, except if exfiltration requirements are met by a test carried out during the absorption period.
- Water can be added to the pipeline prior to testing until there is a head in the upstream maintenance hole of 600 mm minimum over the crown of the pipe or at least 600 mm above the existing groundwater level, whichever is greater.

- The maximum limit of the net internal head on the line is 8 m.
- In calculating net internal head, allowance for groundwater head, if any, should be made.
- The distance from the maintenance hole frame to the surface of the water should be measured.
- After allowing the water to stand for one hour, the distance from the frame to the surface of the water shall again be measured.
- The leakage should be calculated using volumes. The leakage at the end of the test period must not exceed the maximum allowable calculated for the test section.
- The allowable leakage is calculated as 0.075 litres/millimetre diameter/100 metres of pipe sewer/hour. An allowance of 3.0 litres per hour per metre of head above the invert for each maintenance hole included in the test section shall be made.
- Maintenance holes must be tested separately, if the test section fails.

Concrete Pipe for Trenchless Installation Methods

For jacked or micro-tunneled installations, concrete pipe must be capable of withstanding the longitudinal, or axial, jacking forces encountered during installation. CSA A257.2 prescribes the following minimum requirements for concrete jacking pipe which can be applied to trenchless methods:

- minimum concrete strength of 40 MPa
- only circular reinforcing cages can be used
- inner cage reinforcement must extend into the spigot
- the length of opposite sides of any section of pipe must be within 6 mm of each other
- all other requirements for reinforced concrete pipe specified in CSA A257 must be met

In all trenchless operations, the direction and jacking distance should be carefully established prior to beginning the operation. The first step of any trenchless operation is the excavation of entry pits, or construction shafts, at each end of the proposed line. The shaft from which pipe is to be jacked should be of sufficient size to provide ample working space for spoil removal, and room for the jacking head, jacks, launching frame, reaction blocks and one or two sections of pipe.

An accurate control point must be established at the bottom of the construction shaft. Provision should be made for the use of guide rails in the bottom of the shaft. For large pipes, it is desirable to set rails in a concrete slab.

Close control of horizontal and vertical alignment can be obtained by laser or transit.

The number and capacity of jacks depend on the size and length of the pipe to be jacked, and the type of soil. The size of excavation should coincide as closely as possible to the outside diameter of the pipe. The wall of the excavation is typically 25 to 50 mm larger than the pipe, and hydraulically operated jacks should have the capacity to ensure smooth and uniform advancement without over-stressing the pipe.

The excavated material is loaded into carts, or deposited onto a conveyor system, and then transported through the pipe to the launch pit. Micro-tunneling will entail the spoils be mixed with water in order to continuously pump removals to a surface area separation system. Since the rate of progress of a jacking or micro-tunneling operation is usually controlled by the rate of excavation and spoil removal, preliminary investigation and advance planning for fast and efficient removal and placement of spoil, is important in preventing delays.

Correct alignment of the pipe guide frame, jacks and backstop is necessary for uniform distribution of the axial jacking force around the periphery of the pipe. By assuring that the pipe ends are parallel, and the jacking force properly distributed through the jacking frame to the pipe and parallel with the axis of the pipe, localized stress concentrations are avoided. A jacking head is often used to transfer the pressure from the jacks or jacking frame to the pipe.

The usual procedure in jacking concrete pipe is to equip the leading edge with a jacking head, or shield, to protect the lead pipe by distributing the jacking pressure uniformly over the entire end bearing area of the pipe. In addition to protecting the end of the pipe, a jacking head helps keep the pipe in proper line by maintaining equal pressure around the circumference of the pipe.

As the succeeding lengths of pipe are added between the lead pipe and the jacks, and the pipe is jacked forward, soil is excavated and removed through the pipe. This procedure usually results in minimum disturbance of the earth adjacent to the pipe. Use of a lubricant, such as Bentonite, to coat the outside of the pipe is helpful in reducing surface friction, and soil adhesion if the jacking operation is interrupted. Because of the tendency of soil friction to increase with time, it is usually desirable to continue trenchless operations, without interruption, until completed.

The use of cushion material such as plywood or MDF between adjacent pipe sections provide uniform load distribution throughout the entire pipe length being jacked. The contact surfaces of all pipe joints that transmit the axial jacking forces must be separated by a packer of plywood with a minimum thickness of 13mm (1/2 in.) for pipe 900 mm in diameter or smaller and 19mm (3/4 in.) for pipe larger than 900 mm, or another material of equivalent or lesser stiffness that can transmit the axial jacking forces uniformly and without producing significant transverse splitting forces.

Pipe installed by jacking or micro-tunneling may require the void between the pipe and the excavation to be filled. Sand, grout, concrete, or other suitable material should be injected into the annular space. This can be accomplished by installing special fittings into the wall of the pipe to accept hoses for pressure grouting outside the pipe.

Other useful references:

American Society of Civil Engineers (ASCE)

- ❑ **ASCE 27** – Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction
- ❑ **ASCE 36** – Standard Design and Construction Guidelines for Microtunneling

Damage Assessment

The Canadian Concrete Pipe & Precast Association supports third party certification by the Canadian Precast Concrete Quality Assurance (CPCQA) certification program which was developed to ensure precast concrete drainage products leave the manufacturing facility in conformance to the program. Furthermore, the CPCQA engineer as well as the CCPPA can provide invaluable experience in the assessment of damaged pipe.

In addition to the information provided in this section, a useful reference is ASTM C1840 *Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain, and Storm Sewer Pipe*.

Repair Types

It is important to properly assess the damage on precast concrete products and determine if it requires either a structural repair, or a non-structural, cosmetic repair. The following definitions could be used as a guide to distinguish the two:

- **Structural Repair** - A defect that meets one or more of the following criteria:
    - Main reinforcement steel is exposed
    - Damage occurs in load bearing areas
    - Embedded connection hardware is exposed
    - Cracking extends from one face through the wall to the opposite face
    - Cracks in structural elements are larger than 2.5mm in width

- **Cosmetic Repair** – A defect in the appearance of the product which does not affect its performance and does not meet the criteria for a Structural Repair.

In CSA A257 - *Standards for Concrete Pipe & Manhole Sections*, precast concrete may be repaired, when necessary, because of imperfections in manufacture or damage during handling and is acceptable if:

- The repairs are sound and properly finished and cured.
- The repaired concrete conforms to all other requirements of CSA A257.

Any repair must provide the strength and durability of the original concrete.

Joint Integrity

Pipe joints are routinely checked at the plant for dimensional accuracy and to ensure that all surfaces of the joint that comes in contact with the gasket is smooth and free of imperfections that could adversely affect the performance of the joint. The rubber gaskets are designed and tested to permit easy assembly while providing a watertight flexible seal. In spite of this attention to joint leakage prevention, leaks still can occur in the field due to handling damage or adverse installation conditions.

In CSA A257.3 - *Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections, and Fittings using Rubber Gaskets*, clause 7.1 states:

Spalled areas, manufacturing imperfections, or damage (to joints) caused during handling of each pipe may be repaired and shall be considered acceptable if the repaired pipe or maintenance hole section conforms to the requirement of Clause 5.1.3 and provided that:

- The circumferential length of a single area to be repaired does not exceed 1/4 the inside diameter of the pipe; or
- The combined circumferential lengths of several areas do not exceed 1/2 the inside diameter of the pipe.

The following are a few problems typically experienced during installation and preventative measures that should be taken.

Prevention of common problems with pipe joints:

Problem	Prevention
Rebounding Joint Opening	• Proper joint lubricant, if applicable • Protect gaskets from extreme heat and cold • Use self-lubricating gaskets
Rolling or Sliding Gasket	• Clean the joint surface and lubricate both the bell and gasket surface • No lubricant required for roll-on gaskets • Proper location of gasket on the spigot

Damaged	• Maintain proper storage and handling procedures in accordance with previous sections in this guide.
Deflected Joints	• Check line and grade settings. Good alignment results in good joint performance • Follow proper installation procedures • Prepare a stable foundation
Hanging Gaskets	• Stable foundation • Proper construction of bedding under barrel of pipe • Proper compaction under maintenance holes

Cracks

An assessment of cracking in concrete pipes should be done in accordance with ASTM C1840.

Reinforced concrete pipe is designed to permit cracking. The design crack, 0.3mm in width over a length of not more than 300mm is the measure used. Not understanding this process, cracking reinforced concrete pipes can present a concern to infrastructure owners.

Cracks in reinforced concrete pipe are generally discovered through video surveys or visual assessments done as a requirement of the contract. The timing of such inspection is typically prior to the assumption of an installed system by the owner. It is very important that owners undertake these types of inspections to elevate the accountability of all those involved in the satisfaction of the contract. There can be no denying that proper installation and inspection will have a tremendous impact on the satisfaction of the expected service life of the new system. In order for owners to achieve a final project with the goals of economic and adequate serviceability, proper assessment must be stressed. Issues which may arise in the evaluation of cracks include:

- Width
- Length
- Orientation
- Location
- Severity

This section will address each of these issues.

Width

The design (service) crack used in reinforced concrete pipe is the 0.3mm crack over a length of at least 300mm. This crack will generally appear at the invert (and occasionally the obvert) of the concrete pipe since the highest tensile stress occurs at these locations. The design crack is V-shaped in nature and is widest at the surface penetrating usually no further than the first reinforcing cage in the pipe. It is very difficult to determine the magnitude or significance of a crack and the unavoidable magnification of the crack in the pipe that is inherent with video inspection technology today. As a result, it is critical that analysis of sewer videos be done by trained personnel.

Hairline cracks are extremely fine cracks, narrower than design cracks yet can be visible during video inspections. Hairline cracks are often mistaken as design cracks, yet the hairline crack is in fact the prelude to the appearance of the design crack, which will generally not occur.

Shrinkage cracks can occur during the curing process of reinforced concrete pipe. As concrete cures, moisture disappears from the concrete matrix. Depending on the rate of curing, shrinkage cracks can occur, i.e. the more rapid the curing, the greater likelihood of shrinkage cracks. Shrinkage cracks are generally hairline type cracks appearing circumferentially on the outer surface of the pipe barrel and quite often do not penetrate into the pipe wall.

The width of a crack is a critical consideration when determining the impact on the durability and or structural integrity of an installed reinforced concrete pipe.

Length

The length of a crack is rarely an indication of poor-quality material or improper installation practices. In most if not all conditions where a crack is evident in a pipe, the width and location of the crack is more critical to understand and evaluate.

Orientation

Longitudinal cracks run lengthwise along the barrel of the pipe and can be single cracks or in some instances of severe damage can become multi-directional in appearance. Circumferential cracks run around the barrel of the pipe and may or may not propagate the full inner circumference of the pipe barrel.

Location

Understanding how pipe performs in the installed condition is critical when evaluating the location of a crack.

Longitudinal cracks visible at the invert or obvert of the pipe are indications the pipe has accepted the load to which it was designed.

Longitudinal cracking at any other location along the inside barrel of the pipe can generally be attributed to poor construction practices which may include but are not limited to improper handling or weak installation and backfilling techniques. Pipe installations in certain rock formations, particularly some types of shales, exhibit a tendency to expand and may result in "rock squeeze". In parts of Southern Ontario, an overwhelming amount of evidence has been accumulated over the years on the detrimental effect of rock squeeze on underground structures.

Multi-directional longitudinal cracking, an indication the pipe has been subjected to some sort of impact load, can most certainly be attributed to the lack of care taken when installing or handling the pipe. This evidence should be considered carefully when assessing the integrity and future performance of the installed pipe.

Circumferential cracks are in no way attributed to the installation conditions to which the pipe was designed to handle. In fact, cracks propagating circumferentially on the inner surface of the pipe can be attributed in most cases to differential settlements in the pipe bedding. This condition can result from uneven placement and over-compaction of the bedding material creating point loads along the barrel of the pipe. Furthermore, failure to dig 'bell holes' to accept a protruding pipe bell, a feature of many small to mid-range diameter pipe, can lead to the development of circumferential cracking at or just beyond the pipe joint.

Severity

The key to determining if structural concerns exist is the degree or severity of the damage to the pipe. Hairline and design cracks are not a result of damage to the pipe and therefore needn't be considered for repair. Otherwise, longitudinal and circumferential cracking is an indication of damage to which severity must be assessed. As discussed later, autogenous healing is a powerful process in the repair of minor damage sustained by a concrete pipe. In most if not all cases where autogenous healing has sealed the defect, the integrity of the pipe should be considered sound. Pipe cracking or damage beyond the scope of autogenous healing must be evaluated further.

Cracks where concrete has been displaced must be considered for a structural type of repair. Also of concern would be a crack or defect that is allowing water to infiltrate into the pipe system. The infiltration can be relatively clear, or it can be a 'rust-like' colour. The latter is an indication that the steel in the pipe is being impacted by water. Regardless, both situations require remediation, the extent of which must be assessed on the amount of infiltration and structural damage.

Basis of Acceptance

The final acceptance of the rehabilitation of reinforced concrete pipe should be subject to visual or video inspection. This is the only way to ensure the ultimate owner of the system has assurance that the pipeline will be durable and achieve its intended service life. During the evaluation process of video inspection, the owner must be aware of what the video is actually showing. Distortion can occur due to the presence of water or to magnification of the video. To properly evaluate the extent of a crack, actual measurements must take place. If this is not possible due to the size of the pipe, the owner should rely on professional judgment. The practitioner should look for the visible signs of structural damage. If the crack appears wide, and the pipe is displaced on either side of the crack, or the location of the crack is not conducive to the design crack, concern is justified. If no displacement is apparent, the process of Autogenous Healing will, in all likelihood, seal the crack and ensure the longevity of the reinforced concrete pipe can be achieved.

Autogenous Healing

Autogenous healing is the ability of concrete to self-heal itself in environments where moisture and CO_2 are present. This phenomenon occurs between opposing surfaces of narrow cracks. Studies have shown cracks up to 5/16" were healed by self-healing. The self-healing ability of concrete in the presence of moisture is caused by the formation of calcium carbonate from excess calcium and hydroxide in the cement paste, and carbon from bicarbonate in the water. Cement mortar or concrete lined pipe is usually an ideal moist environment for concrete to self-heal. Calcium carbonate crystals form when bicarbonate in water reacts with the calcium hydroxide in the mortar or concrete. The calcium carbonate crystals precipitate and grow from the surface of the crack. Over time, the accumulation of calcium carbonate crystals seals the crack. The healing product may appear as white deposits on the surface known as calcium carbonate. A lack of moisture may result in delayed reactions of autogenous healing.

The strength of the healed crack has been studied under laboratory conditions. It has been suggested that full healing creates a monolithic structure, and the resulting bond at the sealed crack may be as strong or stronger than the original. Therefore, Calcium Carbonate build ups are a sign that the crack was healed by the process of Autogenous healing and the pipe can be and should be considered structurally sound and capable of performing in the manner originally intended. Furthermore, D. A. Abrams studies showed that during load testing of a concrete bridge 3 years after the initial load test that self-healed cracks from the first test did not open or they opened at a load much higher than was placed on the bridge in the earlier test. He concluded that concrete exposed to weather had healed in such a way as to form a joint even stronger than the younger, unbroken concrete.

Another concern regarding cracked pipes could be corrosion. The swelling and healing of mortar or concrete also prevents steel corrosion at the bottom of the crack. The unique corrosion inhibiting properties of cement quickly forms a passive layer preventing continuing steel corrosion at the bottom of the crack, even if some atmospheric corrosion had occurred prior to filling the pipe with water. The cement mortar or concrete will make the water in the crack highly alkaline. Alkaline environment is provided by the hydrated cement which has a PH of about 12.5. The high alkaline environment forms a protective iron oxide film on the steel surface. A partially filled pipe may show rust stains at the crack-water-air interface. Completely filling the pipe will prevent further corrosion.
Some wider cracks, when examined during acceptance, may not appear to have closed completely after soaking. Usually, the interior crack will be completely sealed with calcium carbonate, which can be verified with a thin probe. With additional soaking time the crack will typically completely fill with calcium carbonate.

Regardless of the mechanism, autogenous healing will occur in concrete pipe that has cracked. Some literature has reported cracks as wide as 1.5mm healed in a period of 5 years and cracks of 0.2mm healed completely within 7 weeks. It appears that the narrower the crack, the more rapid the healing can occur. The Ohio DOT Supplemental Specification 802 - Post Construction Inspection of Storm Sewers and Drainage Structures identifies the rehabilitation methods for installed pipe which has evidence of cracking. The specification requires the contractor to "Do Nothing" for cracks up to 1.8mm in width, with the expectation that autogenous healing will create a watertight pipe over a period of a few years. Consequently, efforts to repair interior cracks are generally not recommended. The best remedy is most often to fill the pipeline with water and allow the cement mortar or concrete lining to swell and self-heal. If there is some concern regarding the crack width, filling the crack with a neat cement paste has proven effective.

In situations where cracks have been identified, and their impact is being questioned, the engineer may opt to establish a program that monitors and assesses the behavior of the crack over a period of time to help determine remedial action, if necessary.

Rehabilitation Techniques

The National Association of Sewer Service Companies (NASSCO) maintains invaluable information on the installation and rehabilitation of pipelines and maintenance holes as provided by its members. The NASSCO Specification Guidelines are intended to properly specify sewer rehabilitation work and include the following topics:

- CCTV/Inspection
- Cleaning
- Coatings
- Cured-In-Place-Pipe (CIPP)
- Fold and Form PVC Liners
- Grouting/Joint Sealing
- Lateral/Renewal Repair
- Manhole
- Point Repair/Spot Repair
- Inspection and Testing

Open communication between the owner and the concrete pipe industry may draw on many years of experience and lead to accurate assessments of installed infrastructure and the implementation of the appropriate remedial action necessary to ensure damaged pipe satisfies project design life criteria.

Chemical Grout

Chemical grouting is used to stop infiltration of ground water and exfiltration of sewage in gravity flow sewer systems that are structurally sound. Knowledge of chemical additives can increase the performance of a chemical grout for varying conditions such as:

- Increase strength
- Reduce shrinkage
- Increase viscosity
- Assist in the filling of large voids
- Resist low temperatures

NASSCO's Infiltration Control Grouting Committee provides education and technical resources on the topic of grouting at www.sewergrouting.com.

Also, the following American Society for Testing and Materials (ASTM) specifications provide information on the rehabilitation of sewers and maintenance holes using chemical grouting:

ASTM F2304 - *Standard Practice for Sealing of Sewers Using Chemical Grouting* describes the procedures for testing and sealing individual sewer pipe joints with appropriate chemical grouts. This practice applies to sewers 150 to 1050 mm in diameter. Larger diameter pipe may be grouted with specialized packers or man entry methods. This practice should not be used for longitudinally cracked pipes, severely corroded pipes, structurally unsound pipes, flattened, or out-of-round pipes.

ASTM F2414 - *Standard Practice for Sealing Sewer Manholes Using Chemical Grouting* covers proposed selection of materials, installation techniques, and inspection required for sealing maintenance holes using chemical grout.

ASTM F2454 - *Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by the Lateral Packer Method, Using Chemical Grouting* covers the procedures for testing and sealing sewer lateral connections and lateral lines from the mainline sewer with appropriate chemical grouts using the lateral packer method. This practice applies to mainline sewer diameters of 150 to 600 mm with 100, 125 or 150-mm diameter laterals. Larger diameter pipes with lateral connections and lines can be grouted with special packers or man-entry methods. The mainline and lateral pipes must be structurally adequate to create an effective seal.

Regional Variances – Review the requirements of your local municipality, rural region, and Province.

Additional References for Ontario:

OPSS Number	Title	Date
409	Closed-Circuit Television (CCTV) Inspection of Pipelines	Nov 2023
411	Cleaning and Flushing of Culverts, Wall Drains, Pipe Sewers, Catch Basins, Maintenance Holes, Ditch Inlets and Oil-Grit Separators	Nov 2021
432	Zoom Camera Inspections	Nov

		2019
434	Laser and LiDAR Surveying of Pipelines	Nov 2023
435	Sonar Inspections of Gravity Pipe Sewers and Culverts	Nov 2023
438	Mandrel Deflection Inspections	Nov 2023
439	Direct Measurement Inspections	Nov 2019
443	Rehabilitation of Non-Pressure Pipe by Cured-In-Place-Pipe (CIPP) Liner	Nov 2023
444	Sewage Forcemain Rehabilitation by Cured-In-Place-Pipe (CIPP) Liner	Nov 2023
445	Watermain Rehabilitation by Cured-In-Place-Pipe (CIPP) Liner	Nov 2023
465	Sewer Pipeline and Culvert Rehabilitation by PVC Fold and Form Liner	Nov 2018

Trenchless Technologies

Trenchless technology includes a wide range of methods utilized for both new construction and rehabilitating existing underground utility systems with minimal surface disruption and destruction resulting from excavation.

References

1. **Canadian Concrete Pipe & Precast Association**
   www.ccppa.ca
   - Concrete Pipe Design Manual
   - Concrete Pipe Installation Guide
   - Precast Box & Culvert Guideline
2. **Ontario Provincial Standards for Roads and Public Works (OPS)**
   https://www.library.mto.gov.on.ca/SydneyPLUS/TechPubs/Portal/tp/opsViews.aspx
   - Specifications (OPSS)
   - Drawings (OPSD)
3. **Canadian Standards Association**
   www.csa.ca
   - A257 Series – Standards for Concrete Pipe and Manhole Sections
   - A23.1 – Concrete Materials and Methods of Concrete Construction
   - CAN/CSA S6 – Canadian Highway Bridge Design Code
4. **Infrastructure Health & Safety Association**
   www.ihsa.ca
   - Construction Health and Safety Manual

5. **Dayton Superior Corporation**
   www.daytonsuperior.com
   - Guidelines for Handling Precast Concrete Pipe and Utility Products
6. **American Concrete Pipe Association (ACPA)**
   www.concretepipe.org
   - Concrete Pipe Design Manual
   - Concrete Pipe Installation Guide
7. **American Society for Testing and Materials (ASTM)**
   www.astm.org
8. **National Association of Sewer Service Companies (NASSCO)**
   www.nassco.org
   - Specification Guidelines

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