Arizona
Department of Transportation

WORKBOOK

for

PIPE PLACEMENT INSPECTION (Course Number 103)

a training course developed
for the

ARIZONA DEPARTMENT OF TRANSPORTATION
Phoenix, Arizona

by

ROY JORGENSEN ASSOCIATES, INC.
Gaithersburg, Maryland

Revised by ADOT – October 20, 2006

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Directions To Workbook Users

Pipe Placement Inspection (Course Number 103) is one in a series of training courses on inspection and quality control for earthwork construction. Other courses in the series include:

- Field Sampling and Testing for Earthwork (Course 101),
- Excavation and Embankment Inspection (Course 102),
- Subgrade and Base Course Inspection (Course 104), and
- Incidentals Inspection (Course 105).

This course is designed primarily for highway construction inspection personnel, but it can also be used in training other personnel.

This workbook is to be used in conjunction with discussion sessions with the trainee's instructor or supervisor, and other materials that make up the course. As sections of this workbook are assigned, each trainee should:

1. read and study the material to review previously presented information and gain additional details,
2. complete the exercises and quizzes as they are provided,
3. check his answers against those provided following the exercise or quiz,
4. review the material as needed to correct and clarify any incorrect answers, and
5. discuss any areas that are still not clearly understood with his instructor or supervisor.

Each trainee should be provided with his own copy of this workbook so that he can write in it and keep it for future reference and review.

This course is based primarily on the following sections in ADOT's *Standard Specifications for Road and Bridge Construction*:

501 – Pipe,
502 – Structural Plate Pipe, Pipe Arches, and Arches,
1006 – Portland Cement Concrete, and
1010 – Concrete and Metal Pipe.

The following sections of the Arizona Department of Transportation's *Construction Manual* also provided information for this course:

501 – Pipe,
502 – Structural Plate Pipe, Pipe Arches, and Arches,
1010 – Concrete and Metal Pipe, and
1 108(a) – Staking Pipe Culverts.

Section One: Introduction

Wherever pipe is to be installed, the project plans will specify:

- the size,
- the location,
- the approximate length, and
- each approved option for such variations as coatings, linings, class, and strength.

At each such specified location, the contractor shall use pipe of one kind and material from the options shown on project pipe summary plans. All contiguous pipe and all metal pipe in close proximity shall be of the same kind and material. Special sections, fittings, elbows, branch connections, tapered inlets, end sections, connectors, couplings and other such items shall be of the same material and coating as the pipe to which they are attached unless otherwise stated in the specifications or Special Provisions.

When trenching in excess of five feet is required prior to construction, the contractor shall submit in writing to the Engineer a detailed description of his proposed trenching operations, including shoring methods.

Types of Pipe

There are two basic types of pipe, cast-in-place (non-reinforced) concrete and prefabricated. Cast-in-place concrete pipe includes monolithic pipe, that is pipe which is cast without joints, as well as pipe which is cast with joints by using special equipment and interior forms. Prefabricated pipe can be broken down into two major categories: metal pipe and precast concrete pipe. Another minor category of prefabricated pipe is the thermoplastic pipe which has limited use. Let's look more closely at each of these basic types of pipe.

All cast-in-place concrete pipe must be constructed according to the Department specifications and the project plans. The equipment used to cast this pipe must be approved by the Engineer. When designing the mix, the proposed slump must be the minimum required to ensure proper placement of the concrete without having any segregation, bleeding or incomplete consolidation. If the pipe is to be forty-eight inches in diameter or smaller, the maximum course aggregate size is one inch in diameter. If the pipe is larger, this aggregate should be no more than 1-½ inches in diameter.

When working with prefabricated pipe, you are concerned with these types of metal pipe: corrugated metal pipe (CMP), spiral ribsteel pipe, concrete lined corrugated metal pipe, slotted pipe, structural plate pipe and nestable steel pipe. Also, for our purposes, precast concrete pipe includes reinforced concrete pipe (RCP) and non-reinforced concrete pipe. At this time, the only thermoplastic pipe included in the specifications is the corrugated polyethylene pipe designed for light use, with a maximum diameter of 48 inches (see approved list).

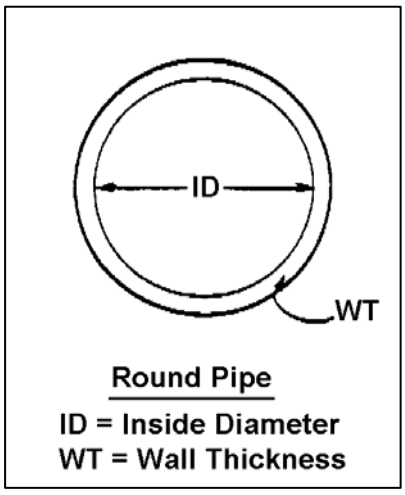
Certificates of compliance, which state that the pipe to be used meets State specifications, must be issued for each lot. As part of the ADOT specifications, all prefabricated pipe also must meet applicable American Association of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM) requirements. It would be impractical to include in this workbook the AASHTO and ASTM regulations as they apply to each type of prefabricated pipe. If you need more information on them, use this reference guide to ADOT's *Standard Specifications for Road and Bridge Construction*:

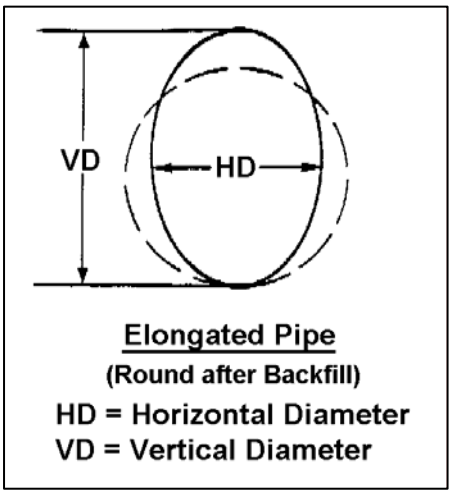
Types of Pipe	**Section**
Corrugated Metal Pipe	1010-2.01
Spiral Ribsteel Plate	1010-2.02
Concrete Lined Corrugated Metal Pipe	1010-2.03
Slotted Pipe	1010-3
Structural Plate Pipe	1010-4
Nestable Steel Pipe	1010-5
Reinforced Concrete Pipe	1010-6
Non-Reinforced Concrete Pipe	1010-7
Corrugated Polyethylene Pipe	1010-8

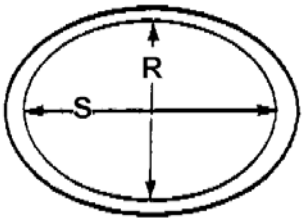
Pipe Shapes and Dimensions

As we all know, pipe comes in various shapes. However, for the sake of standardization, let's look at each of the shapes and the proper way to measure them.

Keep in mind that except for corrugated pipe, these are end views:

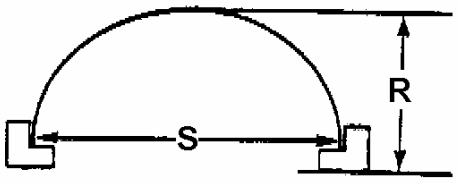






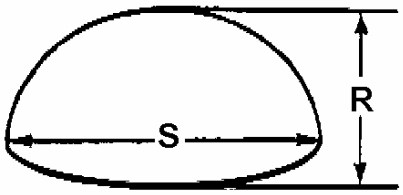
Eliptical Pipe

S = Span
R = Rise



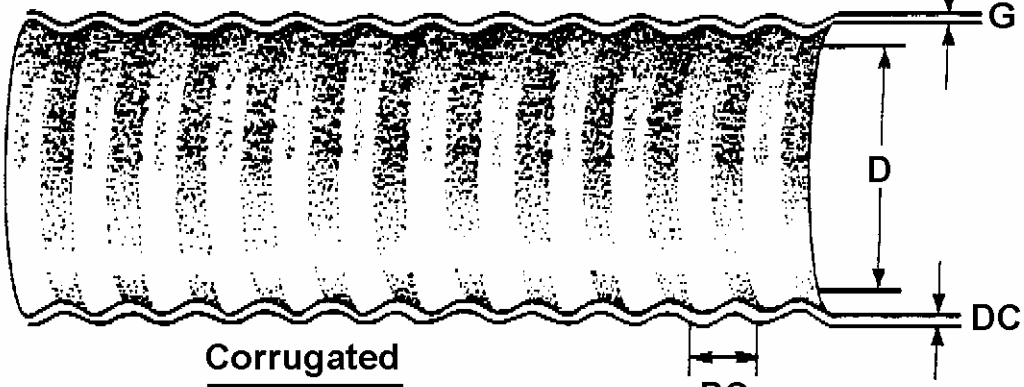
Arch

S = Span
R = Rise



Pipe Arch

S =Span
R = Rise



Corrugated

D = Diameter
G = Gauge (Thickness of Metal)
DC = Depth of Corrugation
PC = Pitch of Corrugation

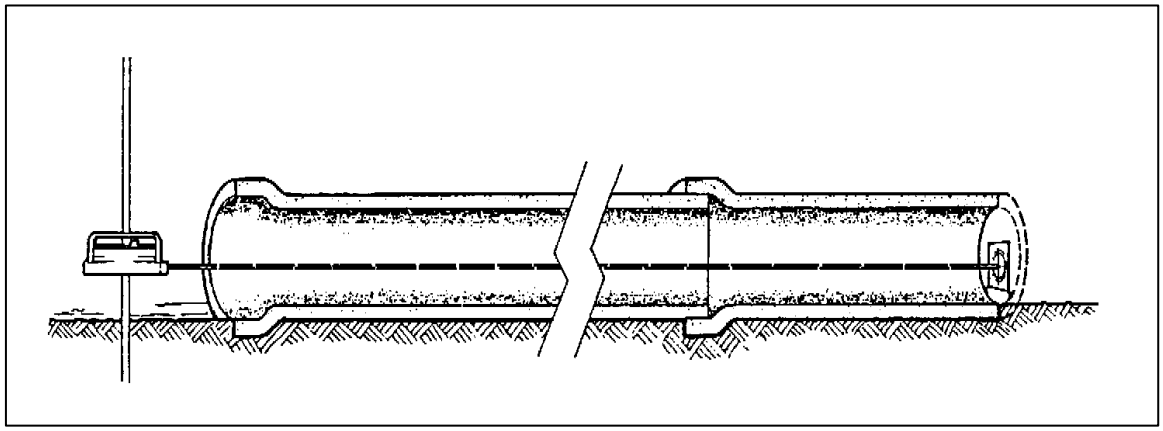
Alignment Controls

A study of the normal drainage flow should be made before any pipe alignment measures are taken. The object is to improve or maintain good drainage flow after the pipe is placed. The desired alignment and grade for pipe placement is shown on the project plans, however, on-site changes can be made at the Engineer's discretion.

Whether checking the pipe alignment with centerline or offset stringlines, all measurements must be true and accurate to assure proper drainage flow. When using a laser system to check pipe alignment:

- the control box must be positioned at the centerline of the pipe,
- the control box should be set at the desired slope, and
- the target must be placed directly above the flow line.

When the beam of light hits the center of the target, the pipe has the proper grade.



Grade Controls

Maintaining the proper grade for pipe placement is very important. If the desired grade is compromised at any point for the sake of making an easy fit at a pipe joint, the problem will worsen because it will become harder to maintain a workable grade and proper fit as additional pipe is placed. When checking the grade with offset references, be sure to measure to the flow line of the pipe. The measured value must remain constant at every location it is checked.

Section One Quiz

1. A detailed explanation of trenching operations is required if ... (Circle one)

   a. cast-in-place concrete pipe is being installed.
   b. more than 5 feet of material must he excavated.
   c. prefabricated pipe only is being installed in trenches deeper than 5 feet.
   d. the area to be excavated contains a lot of hardpan.

2. Concrete pipe does **not** include ... (Circle one)

   a. monolithic pipe.
   b. cast-in-place pipe.
   c. slotted pipe.
   d. RCP.

3. Which pipe measurements are common to elliptical, pipe arches, and arches? (Circle one or more)

   a. horizontal diameter
   b. span
   c. vertical diameter rise

4. Which of these measurements apply to round corrugated pipe? (Circle one or more)

   a. gauge
   b. pitch of corrugation
   c. span
   d. diameter

5. To check the grade with offset references, measure to … (Circle one)

   a. the exterior bottom of the pipe.
   b. the top of the pipe.
   c. the flow line of the pipe.

Section One Quiz Answers

1. b. more than 5 feet of material must be removed.

2. c slotted pipe.

3. b. span
   d. rise

4. a. gauge
   b. pitch of corrugation
   d. diameter

5. c. the flow line.

Section Two: Cast-In-Place Concrete Pipe (CG)

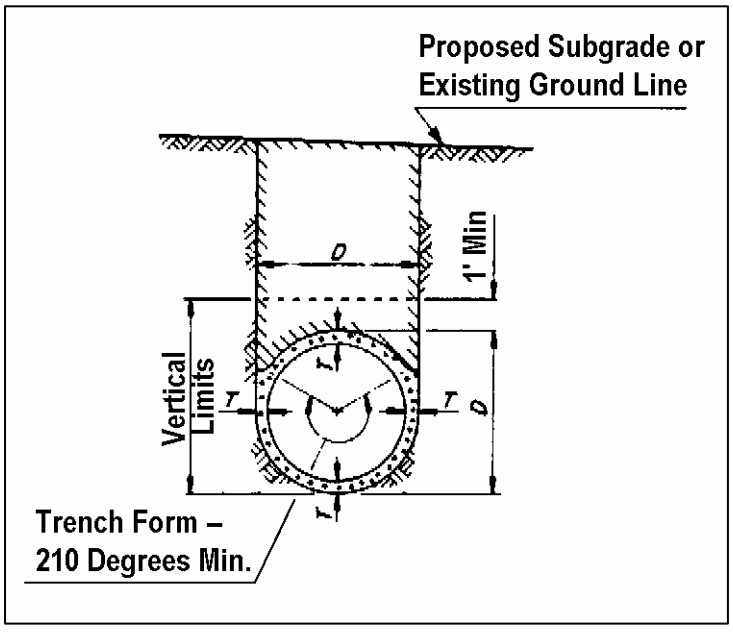
Excavation

When installing cast-in-place concrete pipe, the trenches must be excavated to the lines and grades specified in the project plans. Limit the length of open trenches to 1,600 feet unless otherwise specified by the Engineer.

Soft, spongy, and other unacceptable material must be removed from the bottom of the trenches. Replace the unacceptable material with suitable material and compact it to 95 percent of its maximum density.

Remove all boulder and rock ledge material which is within six inches of the pipe surface. Replace it with approved material, compact it to 95 percent of its maximum density and shape it as necessary.

The trench walls from one foot above the pipe to the top of the trench should be sloped, benched, or shored as necessary to provide stability for the purposes of safety. If approved shoring is used under these conditions, the sides may be steeper as long as the same degree of stability is maintained. Refer to OSHA Standards on excavation.



Placement

Prior to installing the cast-in-place concrete pipe, moisten the surfaces of the trench to prevent moisture from being drawn from the fresh concrete. This concrete must be vibrated, rammed, tamped, or worked to consolidate it and to entirely fill the formed space.

If the placed concrete will set before additional concrete is poured, slope the end approximately 45 degrees. Place 24-inch, No.4 dowels one foot into the center of the pipe's wall at eighteen-inch intervals to secure the new concrete when it is poured. Cast-in-place concrete collars may be used instead of dowels. These collars must be 1-¼ times as thick as the pipe wall and they must overlap the entire joint two times the thickness of the pipe's walls. Immediately before resuming concrete placement, the joint shall be cleaned of all laitance, loose or defective concrete, coatings and other deleterious materials, thoroughly wetted and coated with a layer of bonding mortar approximately ¼-inch thick.

After the concrete forms are removed, inspect pipe interiors for pockets, voids, cracks, and form lap indentations. These defects must be promptly repaired.

The flow line of the finished cast-in-place pipe must not vary more than 0.10 foot from the grade line established by the Engineer when tested with a 10-foot straight edge.

Curing and Finishing

To cure the exposed top portion of the pipe, spray it with a membrane-forming compound or cover it with approved polyethylene film held in place by loose soil not more than six inches (*15 cm*.) deep. Humidity must be maintained inside the pipe by keeping all openings covered for at least seven days.

After the concrete has cured, the interior of the pipe should be free of fractures, cracks and roughness. Also, the interior should be as smooth as a wood float finish.

Crack Repair and Checking Wall Thickness

Refer to Section 501-3.07(G) and (H) of the 1996 *Standard Specifications* for information on these topics.

Backfilling

Backfilling shall not start until the concrete has developed a compressive strength of at least 2,500 pounds per square inch.

The type of backfill material, the placement of pipe and trench backfill material and compaction shall conform to the backfill requirements.

Section Two Quiz

1. Which material within 6 inches of the pipe's surface must be removed? (Circle one or more)

   a. spongy material
   b. vegetation
   c. rock ledge
   d. boulder

2. Why must the sides of a trench be moistened before casting concrete pipe? (Circle one)

   a. to prevent moisture from being drawn from the concrete
   b. to provide the proper moisture for compaction
   c. to keep the dust level down
   d. to provide a good bond

3. What can be used to secure a newly cast concrete pipe with concrete pipe that was previously cast? (Circle one or more)

   a. metal sleeves
   b. concrete collars
   c. dowels
   d. structural plates

4. Which of these methods can be used to cure cast-in-place concrete pipe? (Circle one or more)

   a. cover it with polyethylene film
   b. place building paper over it
   c. leave it exposed
   d. spray it with a membrane-forming compound

5. Under which conditions can cured cast-in-place concrete pipe be rejected? (Circle one)

   a. if any transverse cracks are found
   b. if any longitudinal cracks are found
   c. if any longitudinal cracks more than .01 inch wide and shorter than 12 inches are found
   d. if any longitudinal or transverse cracks more than .01 inch wide and longer than 12 inches are found

Section Two Quiz Answers

1. c. rock ledge
   d. boulder

2. a. to prevent moisture from being drawn from the concrete

3. b. concrete collars
   c. dowels

4. a. cover it with polyethylene film
   d. spray it with a membrane-forming compound

5. d. if any longitudinal or transverse cracks more than .01 inch wide and longer than 12 inches are found

Section Three: Prefabricated Pipe (CG)

Compliance

When inspecting metal pipe for compliance, check each lot for scrapes and dents. If the pipe is unacceptable, reject it for use. Also, be sure to verify the heat or lot numbers for the required corresponding Certificate of Compliance.

When inspecting concrete-lined corrugated metal pipe, check the lining to make sure it is of the required thickness, that it is of uniform thickness with a consistent troweled finish, and the inside diameter requirements of the pipe are maintained.

When inspecting precast concrete pipe, check each lot for lip breakage, hairline cracks in the barrel and exposed reinforcement. Reject any precast concrete pipe that is unacceptable. If the pipe is acceptable, verify the date for each lot with the Central Materials Division.

When inspecting corrugated polyethylene pipe, check each lot for damage such as cracking or brittleness using a hammer and striking it moderately hard. Make sure the pipe is properly stored in a shaded area out of direct sunlight and verify the lot number with the required Certificate of Compliance.

Foundation Preparation

When preparing foundations, there are two basic conditions: a non-trench condition and a trench condition. Let's look at each of these in detail.

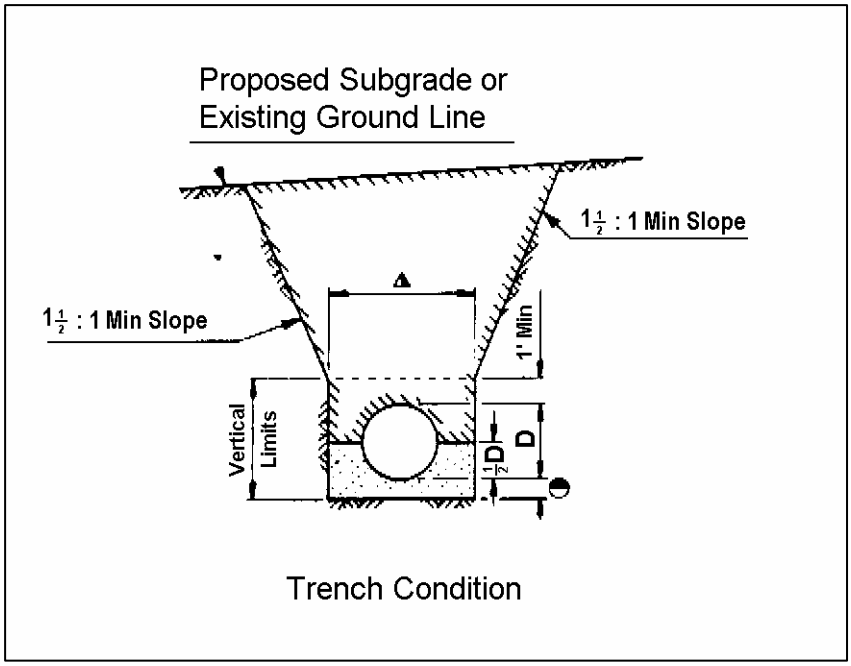
In situations where the vertical sides of the excavation will not extend more than one foot above the top of the pipe to be installed, and where the width of the excavation is greater than the diameter of the pipe plus 2 feet, for pipe less than 4 feet in diameter, or greater than the diameter of the pipe plus 3 feet for a pipe 4 foot or more in diameter, a **non-trench condition** exists.[1]

When working in a non-trench condition where the pipe is less than four feet in diameter, all rock, hardpan or other unyielding material must be removed for the same width of the pipe plus two feet and to a depth of at least one foot unless otherwise specified by the Engineer. When working with pipe four feet or more in diameter in a non-trench condition, remove all unsuitable material for the width of the pipe plus three feet. After removing all unsuitable material, backfill the excavation with approved material in six-inch layers and compact it to 95 percent of its maximum density.

[1] ADOT has adopted the policy of treating all excavations as “trench condition.” All excavations are unique to variable conditions such as, but not limited to: size, depth, soil conditions, weather, and proximity to traffic. Each situation must be handled on an individual basis from a safety point of view.

A **trench condition** exists where the vertical sides of an excavation will extend at least one foot beyond the top of the pipe (as shown below), and where the maximum width of the excavation is the diameter of the pipe, plus 2 feet for pipe up to 4 feet in diameter or the diameter of the pipe plus 3 feet for pipe 4 feet or greater in diameter. In a trench condition, remove all rock, hardpan or other unyielding material at least one foot beyond the side of the pipe to be placed and to the same depth specified for non-trench conditions.

If any soft, spongy or other unsuitable material is found at the bottom of the excavation, remove it for at least three times the width of the pipe and to the depth specified by the Engineer. Backfill this excavation with approved material placed and compacted in six-inch layers compacted to 95 percent of its maximum density.



Trench Condition

Bedding Materials

There are two types of bedding materials: standard aggregate bedding material and cement-treated slurry bedding material. All bedding material must conform to established gradation requirements. The plasticity index of the bedding material for all pipe shall not exceed 8.

Bedding material for all pipe shall have a value of resistivity not less than 2000 ohm-cm or the value shown on the project plans, whichever is less. When resistivity is not shown on the plans, the bedding material shall have a value of resistivity not less than that of the existing in-place material or 2000 ohm-cm, whichever is less. Bedding material shall have a pH value between 6.0 and 10.0, inclusive, for all metal pipe installations except aluminum. Bedding material for aluminum pipe installations shall have a pH value between 6.0 and 9.0 inclusive. See Section 501-3.02(A)(1) of 1996 *Standard*

Specifications. Bedding material shall have a pH value between 6.0 and 12.0, inclusive, for all concrete or plastic pipe installations.

Bedding materials are placed to spring line of the pipe which is normally the elevation at the maximum horizontal width of the pipe. When placing bedding materials, all trash, forms, sheeting, bracing, loose rock, and loose earth must be removed from the area where these materials will be placed.

Generally, place the aggregate bedding materials in uniform layers not more than eight inches thick. However, if aggregate slurry is used or if compaction is to be done by jetting, the layers should be no more than four feet thick. Bedding material must be compacted to 95 percent of its maximum density. Compaction is most important under the haunches of the pipe so that a joint load does not occur along thc bottom centerline of the pipe.

If compaction is done by jetting, the bedding material must conform to specifications. Jetting cannot be undertaken more than one foot above the pipe. The material below the springline of the pipe must be compacted before additional material is placed.

When aggregate slurry is being compacted, no more than thirty-five gallons of water should be used per ton of bedding material. Slurry must be compacted by using internal vibrators. No ponding will be allowed in jetting or slurry.

To check the density of compacted slurry or jetted materials, excavate holes for density samples, conduct the tests, then refill the excavated holes and compact the material.

Cement-treated slurry bedding materials shall be required when pipe culverts or storm drains 36 inches in diameter or larger are placed in a trench condition, but may be used in other applications as well. Cement-treated slurry shall be placed in a uniform manner to prevent voids in, or segregation of the bedding, without moving or shifting the pipe. No backfilling above the cement-treated slurry will be allowed for a minimum of 24 hours after placement. The Engineer may require the use of vibrators to consolidate the cement-treated slurry and fill voids. No density tests will be required for cement-treated slurry bedding material.

Installation

Several general guidelines must be followed when installing prefabricated pipe. Handle all pipe carefully. If any pipe is damaged for any reason, it must be repaired or replaced. When any pipe sags or is improperly aligned, it must be removed, the bedding must be repaired, then the pipe must be replaced. Be sure to keep the pipe interiors clean during installation operations. Let’s look at installation procedures for specific types of prefabricated pipe.

Corrugated Metal Pipe (CMP)

Field joints for each type of corrugated steel pipe shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of the pipe, prevent infiltration of side fill material and prevent leakage of water into the surrounding soil.

Corrugations in the coupling bands shall have the same dimension as the corrugations in the pipe being connected. The use of bands with projections shall be limited to end sections, pipe with dissimilar ends, and pipe laid on grades under 10 percent. Refer to Coaching Notes dated July 31, 1995.

Pipe fabricated with helical corrugations shall have the end re-rolled to circumferential corrugations to facilitate coupling to other corrugated pipe, except for the end of an existing in-place helical pipe which is to be extended.

Where bands with projections are used to join pipe, the projections shall conform substantially to the shape and depth of the pipe corrugations and shall be in circumferential rows with one projection for each corrugation of helically corrugated pipe. Bands with projections for pipe diameters to 72 inches, inclusive, shall be at least 10-½ inches wide and shall have two circumferential rows of projections. Rows of projections shall be spaced to provide equal contact on each side of the pipe being joined.

When bands with projections are used, the joints shall be sealed with a continuous sponge rubber strip. When bands without projections are used, the joints shall be sealed with a resilient sealant material, a continuous sponge rubber strip or a rubber “0”- ring gasket. The rubber “0”-ring gaskets shall be installed one on each side of the joint.

Slotted Pipe

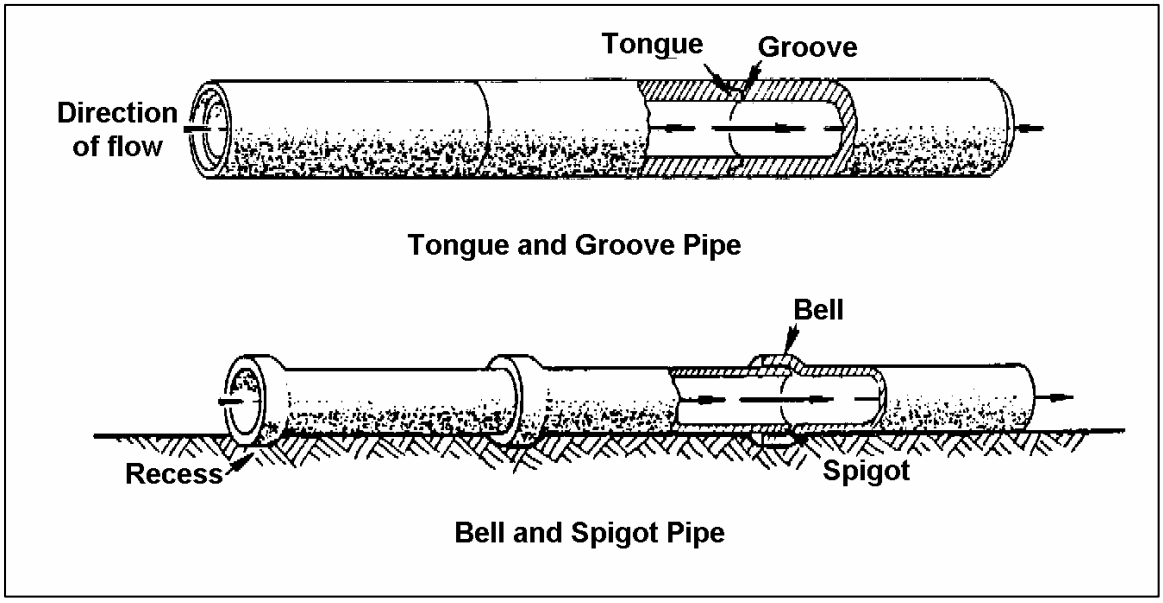
Use coupling bands to join slotted pipe. All connections must be made watertight. After slotted pipe is installed and before any subsequent backfilling or paving operations, cover the slotted portion with heavy tape, roofing paper or timber to prevent infiltration of material or debris into the pipe. These coverings must be removed after paving operations are completed. Slotted pipe should be backfilled with grout in accordance with project plans.

Structural Plate Pipe, Pipe-Arches, and Arches

When installing structural plate pipe, the upstream plates must overlap the downstream plates. When working with steel plate pipe, punch the bolt holes to form double longitudinal seams two inches apart, with the bolt holes being staggered. When working with aluminum plate pipe, the punch bolt holes must form double longitudinal seams, with the bolt holes having a center-to-center dimension of 1-¾ inches.

Precast Concrete Pipe

Both the tongue-and-groove and bell-and-spigot pipe sections should be properly placed in relation to the direction of flow, as shown below.



The inner surfaces of installed sections of precast concrete pipe should be flush and even. Portland cement mortar, portland cement grout, rubber gaskets, plastic sealant compound or other approved types of sealants may be used for making joints. When making self-centering tongue-and-groove mortar joints, their interiors should be smooth. When Portland cement is used to make the joints in precast concrete pipe, protect the joints from rapid drying.

Spiral Rib Corrugated Metal Pipe

Spiral rib pipe shall he installed in the same manner as conventional corrugated metal pipe except that special care shall be taken during placement of the pipe and backfilling to avoid damage to the pipe. Each pipe end shall be fabricated with a minimum of two rolled corrugations to allow use of conventional CMP band couplers, rubber gaskets, or “O”-rings. Coupling bands shall be a minimum of 10-½ inches wide.

Concrete-Lined Corrugated Metal Pipe

Concrete-lined corrugated metal pipe shall be installed in the same manner as conventional CMP except coupling bands shall be a minimum of 10-½ inches wide, formed with two corrugations to nest in the second corrugation from each pipe end. Pipe connections shall be made using rubber gaskets or “0” rings and tightening the coupling bands in accordance with the manufacturer’s recommendations.

Corrugated Polyethylene Pipe

Corrugated polyethylene pipe shall be assembled and installed in accordance with the manufacturer's instructions. Each coupling band must be a minimum of four corrugations in width to allow nesting in the first two corrugations of each pipe end. Magnetic tape shall be placed in the trench at the crown of the pipe to aid in future location of the pipe. Special care shall be taken in the handling and installation of the pipe to prevent damage. Make sure the pipe is firmly positioned in place during backfill operations.

Filter Materials

Filter materials must be placed around perforated pipe according to the project p]ans. These materials must meet specified gradation requirements.

Encasements

Prefabricated pipe should be encased in Class B concrete when specified in the project plans.

Backfill

Pipe backfill material shall be selected from excavation or from a source selected by the contractor, It shall not contain frozen lumps, stones larger than three inches in diameter, chunks of clay or other objectionable material. Backfill material to be used for pipes, pipe-arches or arches made of metal shall have a value of resistivity not less than 2,000 ohm-cm or the value shown on the project plans.

When resistivity is not shown on the plans, the backfill material shall have a value of resistivity not less than that of the existing in-place material or 2,000 ohm-cm, whichever is less. Backfill material shall have a pH value between 6.0 and 9.0, inclusive, for all metal pipe installations. Backfill material shall have a pH value between 6.0 and 12.0 for all concrete or plastic pipe installations.

Before placing backfill material, be sure all debris has been removed from the area to be backfilled. Generally, the backfill material must be placed in uniform layers no thicker than eight inches. However, backfill mixed as an aggregate slurry must be placed in layers no thicker than four feet. The maximum water content for aggregate slurry is thirty-five gallons per ton of material. Aggregate slurry backfill must be compacted with internal vibrators. No ponding is allowed. Cement slurry may also be placed as backfill and may require vibration if required by the Engineer.

It is very important that pipe backfill and bedding material are brought up evenly on both sides of the pipe to one foot above the top of the pipe. Place trench backfill or embankment material from this point up to where the base or surfacing materials will be placed.

After normal aggregate backfill material is placed, it must be compacted to 95 percent of its maximum density. Jetting cannot be used to compact material that is more than one foot above the top of the pipe. If slurry was used as backfill, excavate holes to check the density then refill them. See Section 501-3.04(C).

Section Three Quiz

1. If you are verifying the date and lot number with Central Materials Division, you are checking what kind of pipe? (Circle one)

   a. prefabricated concrete pipe
   b. cast-in-place concrete pipe
   c. corrugated pipe

2. A non-trench condition is … (Circle one or more)

   a. when unyielding material is found where pipe is to be placed.
   b. when the pipe to be installed is less than four feet in diameter.
   c. when unsuitable material must be removed for the same width as the pipe.
   d. when the sides of the excavation extend less than one foot above the top of the pipe.
   e. when the width of the excavation is greater than the diameter of the pipe plus 3 feet for pipes 4 foot or more in diameter.

3. Which of these specifications apply to bedding materials? (Circle one or more)

   a. free of debris larger than 8 inches in any dimension
   b. plasticity index less than 8
   c. pH value between 6.0 and 9.0
   d. resistivity value of 2,000 ohm-cm or more

4. If pipe which has been placed sags for any reason, it first must be ... (Circle one)

   a. replaced with new pipe
   b. repaired before the backfill is placed
   c. removed so the bedding can be repaired

5. What type of material should be used to backfill slotted pipe? (Circle one)

   a. clean borrow
   b. grout
   c. small aggregate
   d. large aggregate

6. Which of the following are commonly used for sealing joints in precast concrete pipe? (Circle one or more)

   a. Portland cement grout
   b. concrete collars
   c. dowels
   d. plastic sealant
   e. rubber gaskets
   f. coupling bands

7. Jetting can be used to compact material which is … (Circle one)

   a. less than one foot above the top of the pipe
   b. more than one foot above the top of the pipe

Section Three Quiz Answers

1. a. prefabricated concrete pipe

2. d. when the sides of the excavation extend less than one foot above the top of the pipe.
   e. when the width of the excavation is greater than the diameter of the pipe plus 3 feet for pipe feet or more in diameter.

3. b. plasticity index less than 8
   c. pH value between 6.0 and 9.0
   d. resistivity value of 2,000 ohm-cm or more

4. c. removed so the bedding can be repaired.

5. b. grout

6. a. Portland cement grout
   d. plastic sealant
   e. rubber gaskets

7. a. less than one foot above the top of the pipe

Section Four: Documentation

This section summarizes the documentation involved in inspecting pipe placement in terms of:

- measurements as the basis for payment,
- key information and events to be documented, and
- the records and reports used.

Measurements for Payment

The basis of payment for pipe placement operations is usually on a line-item basis. Although the Special Provisions section identifies specific items, let's look at some typical line items as they apply to these operations:

- **pipe** – cast-in-place pipe is measured by the linear foot parallel to the central axis for the length of placed pipe. Prefabricated pipe is measured by length of pipe used at a predetermined contract unit price; and
- **filter material, fittings, collars, bands, and materials used to join pipe** – no separate unit of measurement. Their cost is included in the cost of the pipe for which they are intended.

If unyielding or unstable material is encountered below the vertical limits shown on the plans, its removal and replacement with suitable backfill are paid for as Extra and Force Account Work.

Key Information and Events

Some of the key information and events that need to be documented for incidental concrete structures is similar to that of any construction work including:

- **routing information** – such as the type of work being done, the project, the location, the time of the work and the weather; and
- **special events or problems** – including any unusual conditions, instructions to the Contractor, rejected work or materials, and corrective actions taken by the Contractor.

Other key items of information and events that need to be documented specifically for pipe placement operations include:

- number of lifts for backfill
  - borrow
  - excavated material to be reused in construction, and
  - excavated material to be discarded;
- pipe placed
  - cast-in-place, and
  - prefabricated;

- results of moisture and density tests;
- which personnel worked on these operations and for what length of time:
  - backfilling,
  - compacting,
  - excavation,
  - placing prefabricated pipe, and
  - pouring cast-in-place pipe; and
- which types of equipment were used for these operations and for what length of time:
  - backfilling,
  - compacting,
  - excavation,
  - placing prefabricated pipe, and
  - pouring cast-in-place pipe.

Records and Reports

The principal records and reports used in documenting pipe placement operations are the:

- Daily Diary,
- field notes,
- sampling and testing documents,
- delivery tickets,
- Certificates of Compliance, and
- Daily Cast-in-Place Observation Report.

Your instructor should be able to provide copies of examples of most of these records and reports.

Daily Diary

The Daily Diary serves as both a record and a report of all key events that occur during the day. All Daily Diaries are the property of the Department and serve as the foundation of all construction project records, so they must be maintained neatly and legibly in ink. They are generally a summary of key events and information, but they must provide sufficient detail so that other personnel can get an accurate picture of what happened each day. The items recorded in the Daily Diary include:

- such routine information as:
  - identification of the project, the type of work being done,
  - the location of the work,
  - the times work is started and stopped,
  - weather conditions,
  - any important phone calls or other communications sent or received, and
  - an inventory of the contractor's equipment and personnel resources being used on the work;

- information on any special events or problems encountered such as:
  - any official visitors to the project,
  - unusual conditions that may affect the work,
  - the times and causes of any delays,
  - important discussions with the contractor and any specific instructions or orders given,
  - the rejection of any materials or work including the reasons for the rejection,
  - any changes, adjustments or corrective actions by the contractor, and
  - any other information that may be relevant to any potential disputes or claims; and
- summaries of the pipe placement work under way or completed during the day, including the type and location of any:
  - backfilling,
  - compacting,
  - excavation, and
  - placement of pipe.

Additional Information for Daily Diaries

Field notes are used to record detailed technical information of the work. Because it is also a key part of the Department's permanent record of the work, all entries must be made neatly, clearly and accurately.

For pipe placement operations, the technical information recorded in the field notes should include calculations and diagrams used in such inspection activities as:

- checking layout and grade controls;
- determining structural excavation quantities:
- checking compressive strength of poured concrete;
- calculating backfill quantities; and
- measuring structural pay quantities.

In pipe placement work, the field notes should also include:

- the number of lifts for a given task;
- identification of the delivery tickets for dust palliatives;
- results of moisture and density tests;
- amount of pipe placed; and
- dates for completion of each task.

Certification, Sampling and Testing

The inspector must control all materials used in pipe placement operations through these documents including:

- Certificates of Compliance, and
- results of samples sent to the lab for proctor, gradation and plasticity tests.