

Recommended Installation Procedures Reinforced Concrete Pipe

Storm Drain | Sanitary Sewer | Culvert

NOTE: This guide presents recommended practices for the preconstruction planning, delivery, handling, excavation, bedding, installation, jointing, backfill, and acceptance testing of precast reinforced concrete pipe (RCP) produced by NPCA certified manufacturers. It is intended as a guide and does not supersede project specifications. Always consult the engineer of record for project-specific design and specification requirements.

1. Pre-Construction

1.1 Safety

All installation work must comply with applicable federal, state, and local safety regulations. Key federal standards include:

- OSHA 29 CFR Part 1926, Subpart P — Excavations: requires a competent person to classify soil, determine required protective systems (sloping, shoring, or trench box), and inspect the excavation at the start of each shift, after rain or other disturbance, and whenever conditions change.
- All rigging equipment (slings, shackles, hooks, spreader bars) must be rated and inspected before each lift.
- Personnel must never enter an unprotected trench that meets OSHA depth thresholds.
- Contractors should review their installation practices against the project engineer's design assumptions, particularly regarding trench box use and compaction requirements, before beginning work.

1.2 Ordering

Pipe manufacturers frequently adapt production to meet project-specific requirements, particularly for large quantities or special pipe types. To ensure accuracy, orders should be placed in writing and include all of the following information:

Required Order Information	Required Order Information (continued)
Project information, including name, location and project owner or authority having jurisdiction (AHJ).	ASTM, AASHTO or other governing agency specification designation
Pipe internal diameter(s) and laying length for each	Pipe class or strength designation (D-load or wall class)
Total quantity of each diameter (linear feet)	Joint type (tongue and groove, confined O-ring, single offset gasket, other)
Pipe shape (round, arch, elliptical)	Gasket or joint material quantity (or "to be determined by supplier")
Elliptical/arch reinforcement orientation (E or Q, "top" marked)	Fittings and specials (tees, wyes, radius pipe — size and quantity)
Manhole sections, bases, cones, grade rings	Material test documentation requirements
Required delivery sequence / schedule	Invoicing and delivery instructions

NOTE: Pipe sections must be clearly marked with: specification designation, pipe class or strength, diameter and laying length, date of manufacture, and manufacturer name or trademark. Elliptical and arch pipe must also be marked with reinforcement orientation ("E" or "Q") and "top."

1.3 Applicable Standards

Unless otherwise specified in the contract documents, RCP is manufactured in accordance with ASTM or AASHTO product standards for the intended application. The project engineer specifies the required standard and strength class.

Manufacturing Standard	Application
ASTM C76 / AASHTO M 170	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Wall Thickness Classes I–V)
ASTM C361	Reinforced Concrete Low-Head Pressure Pipe
ASTM C506 / AASHTO M 206	Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C507 / AASHTO M 207	Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C655	Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe (Direct Design)
ASTM C1417	Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design
ASTM C1765	Steel Fiber Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C1818	Synthetic Fiber Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C1846	Performance Based Manufacture of Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
Design and Installation Standard	Application
ASTM C1479 / C1479M	Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
ASCE 15	Standard Practice for Direct Design of Buried Precast Reinforced Concrete Pipe (SIDD)

2. Delivery, Handling, and Storage

2.1 Receiving Inspection

Conduct a thorough inspection of each shipment before pipe is unloaded. Record any discrepancies on the delivery document before the carrier leaves.

- Check total quantities of each item against the delivery slip.
- Confirm that certification and required test documentation accompany the shipment.
- Verify pipe markings (specification, class, diameter, date of manufacture, plant ID) against approved submittals.
- Inspect each pipe section for cracks, spalling, damaged bells or spigots, and missing or damaged gaskets.
- Any pipe damaged in transit that exhibits through-wall cracks or joint surface damage affecting watertightness should be set aside and the manufacturer notified promptly. Surface chips or minor damage not affecting structural integrity may be repairable — consult the manufacturer.

NOTE: For standardized criteria on what constitutes acceptable, repairable, and rejectable conditions in precast concrete drainage products — including cracks, chips, honeycombing, spalls, and damaged ends — refer to AASHTO R 73, Standard Practice for Evaluation of Precast Concrete Drainage Products. AASHTO R 73 applies to RCP produced under AASHTO M 170, M 206, and M 207, and is applicable after curing and prior to installation.

2.2 Unloading

Unloading operations should be coordinated with the construction schedule to minimize rehandling. The contractor must provide site access adequate for the pipe manufacturer's delivery vehicles to operate under their own power.

- Perform an overall visual inspection of each shipment before unloading begins.
- Pipe sections must not be rolled over rocky or irregular ground, dropped, or allowed to collide with other sections. Special care is required to avoid chipping or spalling of spigot and bell surfaces.
- For small-diameter circular pipe, sections may be rolled with care on smooth, prepared surfaces. Larger diameters, arch, and elliptical pipe require mechanical equipment for all unloading operations.
- When using slings, chains, or cables: arrange them to lift the pipe horizontally; do not pass rigging through the pipe barrel; keep hardware away from joint surfaces. Use padding where contact with the pipe wall could cause damage.
- When lifting holes are provided, a manufacturer-supplied threaded eye bar/bearing plate device or an equivalent approved lifting insert may be used.
- Automatic unloading equipment (fork-type rear unloaders on flatbed trucks) may be used for circular pipe — ensure personnel are clear of the pipe path during lowering.

CRITICAL: Personnel must remain clear of suspended loads and the swing radius of lifting equipment at all times.

2.3 Stockpiling

- Store pipe as close as practical to the point of installation to minimize rehandling.
- Place the bottom layer on a flat, level base with adequate blocking to prevent rolling or shifting as additional layers are added.
- For bell-and-spigot pipe: arrange each layer so all bells face the same direction. In the next layer, reverse the bell direction so bells overhang spigots of the lower layer rather than bearing on them. In single-layer stockpiles, alternate bell and spigot ends between adjacent sections.
- Support all pipe sections along the length of the barrel — joint ends must be free of load concentrations.
- Maximum stack height should not exceed manufacturer recommendations based on diameter and wall class. As a general guide:
 - 12–24 in. diameter: up to 5 layers
 - 27–36 in. diameter: up to 4 layers
 - 39–60 in. diameter: up to 3 layers
 - Over 60 in. diameter: 1–2 layers maximum, or per manufacturer recommendation
- Protect rubber gaskets or other joint sealing materials from direct sunlight, ozone, petroleum products, and freezing temperatures. Keep in original packaging until immediately before use.
- Do not stockpile pipe in standing water or on saturated, muddy ground. Use timber dunnage to elevate pipe above wet conditions.

2.4 On-Site Handling

- Use only approved lifting devices rated for the unit weight of the pipe, complying with OSHA requirements (29 CFR Part 1926).
- Maintain sling angles of not less than 60 degrees from horizontal. Where adequate angles cannot be achieved, use appropriately rated spreader bars.
- Backhoes and front-end loaders may be used only if of sufficient rated capacity and equipped with proper attachments. Excessive travel speed on rough terrain must be avoided to prevent bouncing damage.
- Do not push, drag, or roll pipe on-site using machinery.

3. Excavation and Trench Preparation

3.1 Line and Grade

Establishing accurate line and grade before excavation prevents costly grade corrections after pipe placement. The following practices are recommended:

- Set offset stakes or batter boards at intervals sufficient to maintain continuous control of horizontal alignment and vertical grade throughout the installation.
- Check and verify control benchmarks before beginning work. Do not rely on a single benchmark.
- Grade control devices (laser levels, grade rods, string lines) should be checked for accuracy at the start of each work shift.
- Pipe should be installed starting at the downstream (outlet) end and laid upgrading (toward the upstream end), with the bell end facing upstream. This orients the joint to minimize flow disturbance at the joint annulus.

3.2 Trench Width

- Minimum trench width must allow for adequate pipe placement and proper compaction of bedding and haunch materials on both sides of the pipe. Keep in mind that rammer and plate compactors can be 18 to 24 inches wide.
- Per ASTM C1479, the minimum clearance between the pipe outside wall and the trench wall shall not be less than Do/6 on each side.
- For larger-diameter pipe or where compaction equipment requires more room, increase trench width accordingly.
- Excessive trench width in embankment conditions can increase the earth load on the pipe (wide trench effect). Consult the project engineer when specified trench widths must be exceeded.

3.3 Excavation Limits and Material

- Excavate to the depth and width shown on project plans, plus the required bedding thickness below the pipe invert.
- Remove all rock, boulders, roots, and frozen material from the trench bottom to the limits required for the designated installation type.
- Where rock or other unyielding material is encountered, over-excavate to the minimum depths specified and backfill with approved compacted granular material.
- Excavated material suitable for use as bedding or backfill should be segregated and stockpiled separately from unsuitable material. Material containing large stones (greater than 1½ in. in backfill zones near the pipe, or greater than half the lift thickness elsewhere), frozen lumps, or organic matter should not be used in the pipe zone.

3.4 Dewatering

- Where surface water or groundwater conditions exist, dewater the site and trench prior to pipe installation.
- Maintain dewatering throughout the installation process — do not allow the trench bottom to become saturated or softened after preparation.
- Dewatering methods (pumping, well-pointing) that create significant groundwater flow through the trench may cause migration of soil fines into the coarser pipe zone embedment materials. Where this risk exists, use appropriate filter fabrics or graded stone filters at the boundary between incompatible materials (see Section 4.5).
- Do not backfill over water. Remove water from the trench before proceeding with each lift of bedding, haunch, or backfill material.

4. Foundation and Bedding

RCP performs as a composite pipe/soil system — the pipe and the surrounding soil envelope work together to carry applied loads. Bedding and embedment quality directly determines the pipe's effective load-carrying capacity. The project engineer specifies the required installation type and it must be properly constructed and verified in the field (see Section 11).

4.1 Foundation

- The foundation (subgrade) shall consist of moderately firm to hard in situ soil, stabilized soil, or compacted fill.
- Unsuitable or unstable foundation material (soft clay, peat, organics, saturated soil) must be removed and replaced with approved compacted fill before proceeding.
- Where rock, concrete, or other unyielding material cannot be removed, cushion the pipe with a minimum 6 in. (150 mm) layer of granular bedding material to prevent point loading on the pipe barrel.
- Pipe installed where future blasting is anticipated shall be cushioned to prevent blasting shock transfer.

4.2 Standard Installation Types (ASTM C1479)

ASTM C1479/C1479M defines four Standard Installation types (Types 1–4) relating bedding and embedment compaction requirements to the pipe's design load capacity. Type 1 provides the highest load capacity and requires the most control; Type 4 requires the least but demands a stronger pipe. Compaction values reference Standard Proctor density (ASTM D698 / AASHTO T 99).

Type	Bedding Thickness	Haunch & Outer Bedding	Lower Side
Type 1	Do/24 min, ≥ 3 in. (75 mm) Rock: Do/12 min, ≥ 6 in. (150 mm)	95% Category I	90% Category I or 95% Category II
Type 2	Do/24 min, ≥ 3 in. (75 mm) Rock: Do/12 min, ≥ 6 in. (150 mm)	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	Do/24 min, ≥ 3 in. (75 mm) Rock: Do/12 min, ≥ 6 in. (150 mm)	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	None required Rock: Do/12 min, ≥ 6 in. (150 mm)	No compaction required (Category III: 85% min)	No compaction required (Category III: 85% min)

NOTE: Soil Categories: Category I = clean coarse-grained soils (SW, SP, GW, GP, or soils beginning with these symbols with $\leq 12\%$ passing #200 sieve, AASHTO A-1, A-3). Category II = coarse-grained soils with fines (GM, GC, SM, SC) or sandy/gravelly fine-grained soils (CL, ML with $\geq 30\%$ retained on #200, AASHTO A-2-4, A-2-5, A-2-6; A-4 or A-6 with $\geq 30\%$ retained on #200). Category III = fine-grained soils (CL, ML with $< 30\%$ retained on #200, AASHTO A-2-7; A-6 with $< 30\%$ retained on #200). Category IV soils (MH, CH, OL, OH, PT, AASHTO A-5, A-7) are NOT permitted in haunch or bedding zones. See ASTM D2487 and AASHTO M 145 for full classification.

4.3 Bedding Classes (Indirect Design — Legacy Specifications)

Some project specifications and older designs reference traditional ACPA/AASHTO Bedding Classes (A through D) rather than the Standard Installation Types. These classes are based on a bedding factor given to a specific level of soil support. The table below summarizes the four classes for reference when legacy specifications are encountered:

Class	Description	Soil Support / Compaction	Bedding Factor
Class A	Concrete cradle or concrete arch over pipe	Continuous concrete support; reinforced or plain per design	2.8 – 4.8+
Class B	Granular material to centerline; compacted sides and haunches	Compacted granular material to springline; select backfill above	1.9
Class C	Granular material to $\frac{1}{4}$ pipe diameter; minimal haunch support	Lightly compacted or hand-placed material to $\frac{1}{4}$ OD	1.5
Class D	Flat-bottom trench; no shaped bedding	Ordinary trench backfill; no special compaction	1.1

NOTE: When a project specification references both a bedding class and a pipe strength class (e.g., "Class III pipe, Class B bedding"), the combination determines the required D-load capacity. Consult the project engineer if the specification system is unclear.

4.4 Bedding Placement

- Construct bedding uniformly along the full pipe barrel length to distribute load-bearing reaction evenly.
- For Standard Installation Types 1, 2, and 3, leave the bedding under the middle third of the pipe ($D_o/3$ at the invert) loose and uncompacted before setting the pipe. This allows the pipe to settle into the bedding and achieve uniform, full-length barrel support. Compact the soil in the outer bedding, haunch, and lower side zones to at least the same compaction level as the overfill.
- Type 4 installations: no minimum bedding is required on soil foundations, but rock foundations require $D_o/12$ minimum (not less than 6 in. / 150 mm) of granular material.
- Maximum aggregate size in bedding: 1 in. (25 mm) for bedding thickness less than 6 in. (150 mm); $1\frac{1}{2}$ in. (38 mm) for 6 in. (150 mm) or greater. Aggregate larger than 1 in. (25 mm) shall not exceed 20% of bedding material by weight.
- Excavate bell holes in the bedding when installing bell-and-spigot pipe so the pipe rests on its barrel, not on the bell.

4.5 Geotextile Filter Fabrics

Where coarse open-graded bedding or embedment materials are placed adjacent to finer native soils, groundwater flow can cause migration of fines into the coarser material — resulting in loss of pipe support and increased backfill load. Geotextile filter fabrics or graded stone filters should be used at these boundaries when:

- Significant groundwater flow is anticipated during or after construction.
- Permeable embedment materials adjoin fine-grained native soils in the lower side or haunch zone.
- The project engineer has identified a particle migration risk based on gradation analysis.

Filter fabric selection should be based on the gradation of the adjacent soils. The designer must specify and detail the appropriate fabric type, overlap requirements, and placement extent.

5. Pipe Placement and Grade Control

5.1 Setting Pipe to Line and Grade

- Install each pipe section to the horizontal alignment and vertical grade shown on the project plans and specifications.
- Before lowering each section into the trench, visually inspect both the bell and spigot joint surfaces for chips, cracks, or damage that could compromise the joint seal. Use AASHTO R 73 acceptance criteria to determine whether the section is acceptable, repairable, or rejectable prior to installation.
- Prepare the bedding grade under the middle third of each pipe section's outside diameter immediately before setting that section.
- Grade adjustments must never be made by exerting force on the pipe barrel with excavating equipment, by lifting and dropping the pipe, or by packing material under an already-placed section, otherwise localized cracking can occur. If a section is off-grade, completely unjoin it, correct the bedding grade, and rejoin.
- Verify the invert elevation of each section after setting and before proceeding to the next joint.
- See Section 6 Joint Installation for sealing connections during placing.

5.2 Rotational Orientation

- Elliptical and arch pipe must be set to the correct rotational orientation as marked and as specified on project plans before joining. Incorrect orientation can result in the reinforcement being placed in the wrong load position.
- For round pipe with eccentric (beveled) joints or skewed gaskets, confirm manufacturer requirements for rotational alignment.

5.3 Curved Alignment

Horizontal and vertical curves can be accommodated by deflecting joints within manufacturer-specified limits, by using specially fabricated radius pipe, or by a combination of both methods.

- Joint deflection for curves: the maximum allowable deflection per joint is limited by the joint design and gasket type. Exceeding the allowable deflection risks gasket rollout, joint separation, or cracking of the pipe wall at the joint.
- ASTM C443 and C1618 joints are routinely tested with one side of the joint opened ½ inch from the fully homed position, allowing full joint functionality when installed to fit a curve.
- Achieve the required curve gradually by distributing deflections over as many joints as possible rather than concentrating it at a few joints.

CRITICAL: Always confirm maximum joint deflection limits with the specific pipe manufacturer prior to layout. Gasket design and joint geometry vary among manufacturers and affect allowable deflection.

5.4 Service Connections

Service laterals connecting to RCP mains require careful detailing to maintain pipeline integrity.

- Precast tees and wye fittings manufactured to the same standard as the mainline pipe are the preferred connection method. These should be specified in advance and installed as part of the pipeline sequence.
- For connections made by stubbing laterals into predetermined wall openings, use approved non-shrink grout to completely fill all voids. Allow adequate curing time before backfilling. For grouted concrete-to-concrete connections in soil-tight applications, refer to the NPCA Guide to Grouted Concrete-to-Concrete Connections for Soil Tight Applications (available at precast.org).
- All service connections must be appropriately restrained and bedded to prevent differential settlement at the connection point.

6. Joint Installation

The joint system of precast RCP provides structural continuity, watertightness, and the flexibility to accommodate minor differential movement between sections. Several joint types are in common use. Always follow the pipe manufacturer's written joint assembly instructions, as torque values, lubrication requirements, and specific procedures vary by manufacturer, joint design, and pipe diameter.

6.1 Rubber Gasket Joints

Rubber gasket joints are the primary watertight joint system for RCP in demanding applications. They provide positive sealing and accommodate minor angular deflection within allowable limits. Three common gasket configurations are used:

Confined O-Ring Gasket

- Thoroughly clean and inspect the spigot groove and bell interior surfaces. Remove all dirt, debris, ice, and standing water.
- Lubricate the joint surfaces liberally using the manufacturer's approved lubricant.
- Seat the O-ring gasket in the confined groove. Run a smooth, rounded tool between the gasket and the spigot groove around the full circumference to equalize the gasket and confirm it is uniformly seated without twists or gaps.
- Center the spigot in the bell of the next unit. Lower the unit carefully, keeping it plumb, and allow it to seat. Do not allow the gasket to roll out of the groove during seating — if the gasket is displaced, disassemble and restart.

Profile Gasket

- Apply the profile gasket dry onto the offset spigot shoulder with the gasket nose pointing toward the spigot end. Do not use lubricant on the gasket at this stage.
- Run a smooth, rounded tool between the gasket and the pipe spigot around the full circumference to equalize the gasket diameter.
- Apply lubricant generously to the exterior of the gasket and the bell interior of the receiving section.
- Align the spigot with the bell around the complete periphery. Lower the next pipe section with the barrel level and the joint square, allowing it to seat under its own weight. Maintain plumb alignment throughout to prevent gasket dislodgement.

Prelubricated Gasket

- Apply dry onto the spigot shoulder — no additional lubricant is required on the gasket itself.
- Verify that the internal lubricant within the gasket's attached rubber tube is uniformly distributed before assembly.
- Align, lower, and seat as described above for profile gaskets.

CRITICAL: After each joint is assembled, visually verify that the gasket is uniformly visible around the full circumference at the joint interface. Where manufacturer-provided joint inspection ports exist, use a feeler gauge to confirm uniform gasket compression. Any joint that cannot be verified must be fully disassembled and reassembled.

6.2 Preformed Flexible (Butyl or Bituminous) Sealant

- Use only the manufacturer-recommended sealant type, size and quantity for the specific application, pipe diameter and annular joint space.
- Clean bell/groove and spigot/tongue surfaces thoroughly. Surfaces must be free from all dust, debris, ice, and standing water. If temperature is below 40°F (5°C) or moisture is present, apply a primer recommended by the sealant manufacturer.
- On spigot-up configurations: place the sealant against the vertical face of the spigot. Wrap completely around the unit without stretching. Overlap the ends and knead firmly together to form a void-free, unified splice. Remove all protective backing paper before joining.
- If the bell faces up: place sealant against the vertical portion of the bell and follow the same procedure.
- Lower the next section carefully into final position without disturbing the sealant. Align steps (if present) and allow the unit to seat under its own weight.

6.3 Mortar Joints

- Set the pipe to the correct elevation and alignment. Center the pipe in the bell or at the joint interface.
- Using approved non-shrink grout, completely fill all voids around the pipe at the joint.
- Follow the grout manufacturer's mixing, placement, and curing instructions. Do not backfill until the grout has achieved adequate strength per manufacturer specifications.

6.4 External Bands

External bands (coupling bands with attached rubber gasket seals) may be specified as an alternative joint system, particularly for repair or connection to existing pipe sections.

- External bands must be sized to match the specific pipe outside diameter and joint configuration.
- Clean the pipe exterior surface in the band contact zone thoroughly before installation.
- Follow the band manufacturer's torque specifications for tightening hardware. Under-torquing allows leakage; over-torquing can damage the gasket.
- Protect external band hardware from corrosion per project specifications.

6.5 Joint Testing — Individual Joints

On critical sanitary sewer installations, individual joint testing may be required before backfilling to confirm watertightness at each joint:

- Air testing of individual joints: using manufacturer-supplied or approved joint test packers, pressurize the annular joint space to the specified pressure and monitor pressure drop over the test period.
- Water (hydrostatic) testing of individual joints: fill the annular space with water to the specified head and measure leakage.
- Record all test results. Joints that do not pass must be disassembled, the gasket or sealant replaced, and the joint retested before backfilling.

7. Haunch and Embedment Backfill

7.1 Haunch Zone

The haunch zone — from the bedding surface up to the pipe springline — is the most structurally critical fill zone. Voids or under-compaction here significantly reduce effective pipe load capacity. See ASTM C1479/C1479M Figure 2 (Round Pipe Standard Trench/Embarkment Installations) for a diagram of the haunch zone and surrounding bedding regions.

- Place haunch material in uniform lifts on both sides of the pipe simultaneously to prevent lateral pipe displacement.
- Use the soil type and achieve the compaction density required for the designated installation type (see Section 4.2 table).
- Select compaction equipment appropriate for the lift thickness and proximity to the pipe. Hand tampers or small mechanical plate compactors are typically required immediately adjacent to the pipe wall.
- Maximum aggregate size in the haunch is the same as specified for the bedding. For Type 3 and 4 installations using in situ soils, maximum particle size shall not exceed 3 in. (75 mm) or half the bedding thickness, whichever is less.
- "Dumped" fill without controlled compactive effort must not be used in Type 1 or Type 2 haunch zones — it will not provide the required structural support.

7.2 Lower Side Zone

- The lower side zone (from the bedding to the springline along the trench wall) provides lateral confinement and acts as a structural shelf that resists earth load on the pipe. In trench installations, undisturbed natural soil with equivalent firmness may serve this function (see Section 4-2 table). See ASTM C1479/C1479M Figure 2 for the location of the lower side zone relative to the haunch and bedding.
- Where trench wall soil in this zone is soft, saturated, or otherwise inadequate, remove and replace with compacted fill to the specified level.
- Placed soil in the lower side must be free of debris, organics, frozen material, or stones with diameter exceeding half the compacted lift thickness.
- Deposit and compact soil uniformly on both sides of the pipe simultaneously to prevent lateral displacement.

7.3 Overfill (Above Springline to Final Grade)

- Place overfill in uniform lifts per project specifications, compacting uniformly on both sides of the pipe to prevent lateral displacement.
- Overfill within one pipe outside diameter above the springline and below the pipe crown shall be compacted to at least the same density as the majority of the overfill above.
- To reduce load concentration on the pipe, it is recommended that the soil immediately over the pipe not be compacted for a depth of approximately $D_o/3$ above the crown, unless project specifications require otherwise.
- When using vibratory or impact compaction equipment with less than 2 ft (0.6 m) of cover over the pipe, the contractor must demonstrate to the engineer's satisfaction that installation will not damage the pipe. Compaction stresses decrease as pipe diameter increases; for most installations, 2 ft (0.6 m) of cover is sufficient to distribute compaction forces safely.

7.4 Final Backfill

After the embedment zone is complete and inspected, final backfill may proceed to grade.

- Final backfill material should be clean, free of large rocks (exceeding 6 in. or as specified), frozen lumps, and organic matter.
- Continue placing and compacting in lifts per project specifications through the full backfill depth.
- Where settlement-sensitive surfaces (roadways, structures, utilities) exist above, compact the final backfill to the density specified by the engineer. In open-cut road crossings, coordinate with the roadway engineer regarding sub-base and pavement restoration requirements.

8. Trench Sheathing, Shields, and Construction Traffic

8.1 Sheathing Removal

- Unless designed to remain permanently in place, pull sheathing in vertical increments to permit simultaneous backfill placement and compaction for the full trench width at each increment.
- Removal must not disturb previously placed pipe or compacted fill. Monitor the adjacent trench wall for any soil movement during extraction.

8.2 Trench Shield Advancement

- When trench shields or boxes are advanced, previously installed and backfilled pipe must not be disturbed or displaced.
- The owner should consider whether deadman anchors or other pipe restraint is needed when shields are moved through installed sections.
- Fill and compact any voids created by shield movement immediately before proceeding.

8.3 Construction Equipment Crossings

When construction equipment must cross an installed RCP pipeline, the pipe must be protected from overload. Consult the project engineer when unusual or heavy construction traffic is anticipated.

- If construction equipment must cross an installed pipeline before final cover is established, construct a compacted overfill ramp to a minimum height of 3 ft (0.9 m) over the pipe crown, or to a height at which equipment loads on the pipe do not exceed the design strength.
- The ramp shall extend at least one pipe outside diameter (or 3 ft / 0.9 m, whichever is greater) beyond each side of the pipe and grade down to existing ground level at no steeper than 1V:6H.
- For high construction traffic volumes crossing the same pipeline, periodically change the crossing location to minimize the risk of lateral pipe displacement from repeated loading.

9. Connections to Structures

9.1 Manholes and Precast Structures

- Install manholes and other structures in a manner that minimizes differential settlement between the pipe and the structure. Refer to the NPCA Recommended Installation Procedures for Storm and Sanitary Sewer Manholes (available at precast.org).
- Resilient connectors are often the preferred pipe-to-structure connection. Clean pipe and boot surfaces before insertion. Insert the pipe flush with the manhole interior wall (or per jurisdiction requirements), centered in the connector. Install all take-up clamps in the provided groove(s) and tighten to the manufacturer's recommended torque. Grouting around flexible connectors in a way that restricts their designed movement must be avoided.
- Compression-type connectors: bevel the pipe end approximately $\frac{3}{4}$ in. (19 mm). Clean and lubricate the connector and pipe exterior. Insert beveled end, keep the pipe level, and push flush with the manhole interior.
- Mortar joints at structures: use approved non-shrink grout to completely fill all voids. Allow adequate curing time before backfilling. For grouted concrete-to-concrete connections in soil-tight applications, refer to the NPCA Guide to Grouted Concrete-to-Concrete Connections for Soil Tight Applications (available at precast.org).
- Any pipe stubs installed in structures must be restrained from blowout due to groundwater pressure or testing loads.

9.2 Precast Concrete Fittings

- Tees, wyes, and other precast fittings must be bedded, installed, and overfilled using the same material and compaction as the adjacent pipeline to prevent differential settlement at fitting locations.

9.3 Lift Hole Treatment

- Where lift holes are required to be sealed by the authority having jurisdiction, fill with a resilient plug or approved non-shrink cementitious grout.
- When embedded anchors are used, fill resulting voids with non-shrink grout after rigging removal.

10. Pipe End Protection

- Cover or plug open pipe ends whenever work is suspended overnight or for extended periods. This prevents entry by animals, personnel, and accumulation of sediment and debris.
- Covers or plugs must be braced or fastened to prevent displacement by trench water, wind, or accidental contact.
- If watertight plugging is used on an empty line, evaluate the risk of pipe flotation due to groundwater and take preventive measures if necessary.

11. Soil Density Verification

Field verification of soil compaction in the pipe embedment zone is essential to confirm that the specified installation type has been achieved. The project engineer or inspector should specify the testing frequency, method, and acceptance criteria.

11.1 Testing Methods

- Nuclear moisture-density gauge (ASTM D6938 / AASHTO T 310): the most common field method; provides rapid results and can be used in confined trench conditions with appropriate technique.
- Sand cone (ASTM D1556 / AASHTO T 191): a traditional alternative for areas where nuclear equipment is not available or permitted.
- Lightweight deflectometer (LWD) or dynamic cone penetrometer (DCP): supplemental methods for qualitative stiffness assessment; calibration to density is required.
- Standard Proctor compaction test (ASTM D698 / AASHTO T 99).

11.2 Testing Locations and Frequency

- Test at each lift of haunch and lower side material — these zones are most critical and most prone to inadequate compaction.
- Testing frequency should be specified by the engineer based on project risk and size. A typical minimum is one test per 100–200 linear feet of pipe per lift layer, with additional tests at any location where compaction appears questionable.
- Test locations should include both sides of the pipe and vary along the pipe run — not always at the same longitudinal station.

11.3 Acceptance Criteria

- Compare field density results to the Standard Proctor maximum dry density (ASTM D698) at the tested moisture content.
- Any zone that does not meet the specified compaction level must be reworked and retested before additional fill is placed above it.

12. Acceptance Testing

Acceptance testing verifies the watertightness and structural integrity of the completed pipeline. Specific requirements depend on the pipeline type (storm, sanitary sewer, or culvert), the authority having jurisdiction, and the project specifications. Testing before final backfill is preferred where feasible.

12.1 Visual Inspection

Visual inspection is the first and most basic acceptance check and should be performed on every installation:

- Inspect the interior of the completed pipeline by walking or CCTV to verify: sections are on line and grade, joints are fully home with no excessive gaps or misalignment, no through-wall cracks or significant spalling, no debris or soil accumulation inside the pipe.
- Check that all service connections are properly made and that pipe stubs in structures are correctly aligned and restrained.
- CCTV inspection (closed-circuit television per NASSCO PACP protocol) may be required on sanitary sewer installations and on storm drain installations in sensitive areas. Conduct per the applicable specification.
- Pipe inspection reports shall be reviewed by a licensed professional engineer in accordance with the standard of practice including ASTM C1840, AASHTO LRFD Bridge Construction Specifications – Section 27, and AASHTO Guide Specifications for Highway Drainage.

12.2 Line and Grade Verification

- After backfilling to the springline, verify that pipe invert elevations have not changed from those measured after initial placement.
- Immediately investigate any section that shows deviation from design grade in excess of allowable tolerances.

12.3 Low-Pressure Air Testing

Low-pressure air testing is not recognized as an acceptable test method for acceptance of sanitary sewer RCP. See Section 12.6 Vacuum Testing.

12.4 Infiltration Testing

Infiltration testing measures groundwater entering the pipeline from outside, applicable when the groundwater table is above the pipe invert:

- Observe and measure actual infiltration flows at the downstream end of the test section using a weir, bucket-and-stopwatch method, or calibrated flow meter.
- Allowable infiltration limits are specified in project documents (typically expressed in gallons per day per inch of diameter per mile, or equivalent metric units).
- Pipe sections showing excessive infiltration must be located by internal inspection or joint testing and repaired.

12.5 Exfiltration Testing

Exfiltration testing measures water leaking out of the pipeline under a specified head, applicable when the groundwater table is below the pipe:

- Fill the test section with water to the specified head above the highest pipe invert (typically 2 ft / 0.6 m minimum above the crown at the upper end of the test section, or as specified).
- Allow the water level to stabilize before beginning the measurement period. Measure the volume of water required to maintain the specified head over the test period.

- Allowable exfiltration rates are specified in project documents. Test sections that exceed allowable limits must be repaired and retested.

12.6 Vacuum Testing

Vacuum testing (negative pressure / low-pressure air) is an alternative to positive pressure air or hydrostatic testing:

- Per ASTM C1214: plug all pipe openings, draw the test section to the specified vacuum level, and measure the time for vacuum to drop a specified amount. Pass/fail criteria are based on pipe diameter and test section length.
- Vacuum testing after backfilling requires special consideration of soil and hydrostatic loads on the pipe wall; consult the applicable standard and project specification for appropriate test pressures and procedures.

12.7 Mandrel Testing

Any pipe material can accumulate sediment and debris over time, requiring periodic maintenance. However, there is no practical reason for testing newly-installed concrete pipe with a mandrel since concrete pipes are rigid and do not deflect like flexible pipes.

13. Quality and NPCA Plant Certification

Specifying RCP from an NPCA Plant Certification Program certified producer provides a verified, third-party quality assurance layer beyond product specification compliance alone. NPCA-certified plants are audited annually by independent inspectors against rigorous standards covering:

- Raw materials and mix design documentation
- Production equipment calibration and maintenance
- Concrete mixing, consolidation, and curing procedures
- Product testing (three-edge bearing, absorption, crush strength)
- Dimensional tolerances and joint surface finish
- Record keeping and traceability

To specify and verify NPCA certification:

- Include a requirement for current NPCA Plant Certification in project specifications.
- Request the producer's current NPCA Plant Certification certificate as part of the submittal package.
- Verify certification status at [precast.org](https://www.precast.org) — the NPCA certified plant directory is publicly accessible.

NOTE: NPCA Plant Certification does not replace project-specific quality control, testing or inspection requirements — it complements them by providing independently verified manufacturing quality as a baseline.

Disclaimer

These recommended procedures do not claim to address all safety-related issues associated with the installation of precast reinforced concrete pipe, nor do they imply that compliance with these procedures guarantees the proper function or performance of any specific installation. Site conditions vary, and it is the responsibility of the contractor, engineer, and owner to determine appropriate safety, health, and environmental practices and to verify compliance with all applicable federal, state, and local regulatory requirements. The engineer of record is responsible for project-specific design, specification, and acceptance decisions. NPCA assumes no liability for the use or misuse of this guide.