7310.1. Description. This specification will govern for the fabrication of machine-made precast concrete box culverts and reinforced concrete (RC) pipe and for the qualification of fabrication plants that produce these products. This specification is intended as a minimum guideline for the qualification of machine-made precast box culverts and RC pipe plants. In all cases, except where specifically modified herein, products must conform to Item 462, “Concrete Box Culverts and Storm Drains,” and Item 464, “Reinforced Concrete Pipe,” of the Department’s Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

7310.2. Material Producer List. The Materials and Pavements Section of the Construction Division (CST/M&P) maintains a Material Producer List (MPL) of fabrication plants conforming to the requirements of this specification. Box culverts and RC pipe produced by fabricators appearing on the MPL, entitled “Reinforced Concrete Pipe and Machine-Made Precast Box Culvert Fabrication Plants,” require no further Department inspection and testing unless deemed necessary by the Department project engineer or CST/M&P. Only machine-made precast box culverts and RC pipe produced by fabrication plants listed on the MPL can be used on Department projects.

7310.3. Qualification Process.

A. Qualification Request. Request plant approval by submitting a written request to the Texas Department of Transportation, Construction Division, Materials and Pavements Section (CP-51), 125 East 11th Street, Austin, Texas 78701-2483.

The request should include the following:

- company name,
- physical and mailing addresses,
- contact person, phone number, and email address,
- list of products to be evaluated for qualification purposes,
- written plant quality control and production procedures, as required by Article 7310.6 of this specification,
- American Concrete Pipe Association (ACPA) Plant Certification for reinforced concrete storm sewer pipe products or National Precast Concrete Association (NPCA) Plant Certification for reinforced concrete storm sewer products (ACPA Conditional Plant Certifications or NPCA Probationary Certifications are acceptable
provided the plant demonstrates to the Department that certification conditions have been met),

- ACPA Plant Certification for box culverts or NPCA Plant Certification for box culverts (ACPA Conditional Plant Certifications or NPCA Probationary Certifications are acceptable provided the plant demonstrates to the Department that certification conditions have been met),

- copy of the most recent ACPA or NPCA audit report and written response to ACPA or NPCA for any specific deficiencies noted in the audit report for box culverts and/or RC pipe, and

- list of on-site Quality Control (QC) personnel with copies of their QC certification(s) and a detailed description of their quality control related experience, as required by Article 7310.9 of this specification.

B. Evaluation. CST/M&P will review the qualification request documentation. If the qualification request includes the required information, CST/M&P will perform an initial Department-directed plant audit to ensure compliance with this specification.

1. Qualification. If the audit verifies compliance with this specification, the Department will list the fabrication plant on the MPL. CST/M&P reserves the right to perform additional audits (announced or unannounced) at its discretion for the plant to remain on the MPL as an approved fabrication plant of box culverts and reinforced concrete pipe. CST/M&P also reserves the right to require ultimate load three-edge bearing testing during RC pipe plant audits.

Fabrication plants listed on the MPL must annually attain and submit the following in order to maintain approval status:

- current ACPA or NPCA Plant Certification for reinforced concrete storm sewer pipe products,

- current ACPA or NPCA Plant Certification for box culverts,

- copy of the most recent ACPA or NPCA audit report and written response to ACPA or NPCA for any specific deficiencies noted in the audit report for box culverts and/or RC pipe, and

- successful completion of any additional Department-directed audits and any follow-up plant audits by adequately implementing corrective actions for all deficiencies.

Failure to attain and provide the above may result in the removal from the MPL.

2. Failure. Plants that fail to qualify under this specification may not furnish box culverts or RC pipe for Department projects.

C. Random Inspection and Testing. The Department reserves the right to inspect, sample, and test box culverts and RC pipe at any time to ensure compliance with Item 462, “Concrete Box Culverts and Storm Drains,” Item 464, “Reinforced Concrete Pipe,” and
this specification. Provide facilities and access to allow for inspection of materials, the process of fabrication, and the finished box culverts and RC pipe.

D. Disqualification. Any fabricator that fails to comply with the requirements of this specification is subject to removal from the MPL, is prohibited from furnishing product to Department projects, and may not bid any work for a minimum of 30 days from the date of disqualification, or as determined by CST/M&P.

Causes for disqualification include, but are not limited to:

- repetitive poor quality and workmanship of box culverts or RC pipe,
- falsification or incomplete documentation, or
- shipping product that does not meet specifications.

If a fabricator is removed from the MPL, all previously produced products assigned to the Department will be subject to review and removal from Department assigned inventory. If the Department removes a fabricator from the MPL, the Department may permit subcontracting pending product quantities for active projects to another Department-approved fabrication plant for the specific product.

E. Requalification. Once the disqualification period established by CST/M&P has elapsed, the fabricator may begin the requalification process. The fabricator must pass an additional ACPA or NPCA Plant Certification audit and Department-directed audit and provide the Department with evidence of corrected deficiencies.

The fabricator must bear all Department expenses associated with requalification.

F. Inactive Fabricator. If a fabricator does not furnish any box culverts or RC pipe to Department projects for a period of 2 years, CST/M&P may remove the fabricator from the MPL due to inactivity.

CST/M&P will consider future qualification after the producer indicates it will furnish box culverts or RC pipe to Department projects and is in compliance with this specification.

7310.4. Materials.

A. Concrete. Use one of the mix design Options 1–8 meeting the requirements for structural concrete in Item 421.4.A.6, “Mix Design Options,” except the reference to Table 5 will not apply. When sulfate-resistant concrete is required, use mix design Option 1, 2, 3, or 4 given in Item 421.4.A.6 using Type I/II, II, V, IP, or IS cement. Do not use Class C fly ash in sulfate-resistant concrete.


3. Chemical Admixtures. Furnish admixtures conforming to DMS-4640, “Chemical Admixtures for Concrete,” unless otherwise approved by the Engineer. Do not use calcium chloride.
4. **Water.** Furnish water conforming to Item 421, “Hydraulic Cement Concrete.”

5. **Fine and Coarse Aggregate.** Furnish aggregates conforming to Item 421, “Hydraulic Cement Concrete,” except the requirement for gradation will not apply.

B. **Reinforcing Steel.** Furnish reinforcing steel from mills conforming to Item 440.2.A, “Approved Mills.” Base metal rod to be cold-drawn for helical RC pipe cage production need not be furnished by a Department-approved reinforcing steel mill.

C. **Hydraulic Cement Concrete Curing Materials.** Furnish concrete curing compounds conforming to DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants.”

7310.5. **Fabrication.** Provide RC pipe and machine-made precast box culverts that conform to the design shown on the plans and to the following, except as otherwise noted in this specification:

- ASTM C 76 or ASTM C 655, unless otherwise shown on the plans, for circular pipe,
- ASTM C 506 for arch pipe,
- ASTM C 507 for horizontal elliptical pipe, or
- ASTM C 1577, unless otherwise shown on the plans, for box culverts.

Maintain on file approved shop drawings for machine-made precast box culverts when required. Shop drawings must be approved by the Department.


B. **Equipment.** Provide concrete plants and mixing equipment, hauling equipment, and testing equipment in accordance with Item 421.3, “Equipment.” Truck mixers will not be permitted.

1. **Mixer Moisture Control Units.** Verify accuracy of mixer moisture control units at least every 90 days, by a third party or by plant quality control personnel, utilizing Tex-409-A or ASTM C 566. Aggregate samples must be representative of the materials used for the particular concrete batch tested. Calculated results of the compared values should not vary more than 4% of the water quantity for the batch tested. Correct mixer moisture control units that do not meet this tolerance.

   When approved for use, other procedures for verifying the accuracy of mixer moisture control units must be per the equipment manufacturer’s recommendations.

2. **Concrete Compression Testing Machine and Three-Edge Bearing Testing Machine.** Calibrate the concrete compression testing machine and three-edge bearing testing machine in accordance with ASTM C 497. Calibrate at least once every 12 mo. or whenever accuracy is questioned.
C. **Mixing Concrete.** Provide box culverts that are machine-made. Provide RC pipe that is machine-made or cast by another approved process. Concrete for RC pipe cast by a process other than machine-made must meet the requirements of Item 424.3.B.4, “Quality of Concrete.”

Provide uniform placement of the concrete in the form and consolidation by mechanical devices that will assure a dense concrete. Mix concrete in a central batch plant or other approved batching facility where the quality and uniformity of the concrete is assured. Do not use truck-mixed concrete.

Do not place mixed and discharged concrete back into the concrete mixer.

Measure mixing water, consisting of water added to the batch and water occurring as surface moisture on the aggregates, by volume or weight for each batch. Measure batch materials within the tolerances of Item 421.4.D, “Measurement of Materials,” Table 9 or Table 10, as applicable.

Mix concrete per Item 421.4.E.1, “Central-Mixed Concrete.” When a volumetric mixer is approved for use, mix concrete per Item 421.4.E.4, “Volumetric Mixer-Mixed Concrete.”

D. **Concrete Placement.** Do not place concrete in contact with any material coated with frost or having a temperature 32°F or lower. Place concrete only when its temperature at time of placement is a minimum 45°F and a maximum 95°F.

E. **Lifting Holes**

1. **Machine-Made Precast Box Culverts.** Provide no more than four lifting holes in each section. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes of sufficient size for adequate lifting devices based on the size and weight of the box section. Do not cut more than 5 in. in any direction of reinforcement per layer for lifting holes. Repairs must be per the applicable Annex of this specification.

2. **RC Pipe.** Do not place more than two holes for lifting and placing in the top section of precast pipe. Cast, cut, or drill the lifting holes in the wall of the pipe. The maximum hole diameter is 3 in. at the inside surface of the pipe wall and 4 in. at the outside surface. Do not cut more than 5 in. in any direction of reinforcement per layer for lifting holes. Repairs must be per the applicable Annex of this specification.

F. **Curing.** Begin curing after form removal and before the formation of plastic shrinkage cracks.

1. **Machine-Made Precast Box Culverts.** Cure box culverts in accordance with ASTM C 1577.

2. **RC Pipe.** Other curing methods permitted in ASTM C 76, when approved, must consist of enclosures that prevent the entrance of outside air so that RC pipe is kept moist.
3. **Steam Enclosures.** Provide curing enclosures with unique identification numbers. Provide a minimum of one temperature recording device per the following:
   - every 250-pipe section, or fraction thereof, and
   - every 30-box culvert section, or fraction thereof.

G. **Damage Evaluation and Repairs.** Evaluate damaged box culverts and RC pipe in accordance with the applicable Annex of this specification.
   - Use repair materials meeting the material property requirements of:
     - DMS-4655, “Concrete Repair Materials,” Table 7,
     - DMS-6100, “Epoxies and Adhesives,” or
     - batched concrete. Provide concrete from the same mix design used in the damaged member. Concrete used for repairs must also be batched in accordance with approved procedures.
   - Continuously moist cure cementitious patch material for a minimum of 72 hours using wet mats, water spray, or ponding. Membrane curing compounds meeting the requirements of DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants,” may be used in lieu of moist curing.

H. **Physical Test Requirements.**

1. **Machine-Made Precast Box Culverts.** Make compressive test specimens in accordance with ASTM C 497. Make a minimum of four test specimens for each day’s production run and each mix design. Cure test specimens in the same manner and for the same duration as the boxes they represent until tested. Test a set of compressive strength specimens, consisting of two per set, in accordance with ASTM C 39. Final material acceptance may be determined by compressive strength cores when 28-day concrete compressive strength test specimen failures occur. Cores must be obtained, prepared, and tested for compressive strength in accordance with ASTM C 497. Failed test results from compressive strength cores will be cause for rejection of the lot.

2. **RC Pipe.** Perform Three-edge bearing tests in accordance with ASTM C 497. Test for the load to produce a 0.01-in. crack or 15% in excess of the required D-load, whichever is less. Tested pipe that satisfies the requirements of Annex A1 may be used for construction.

   As an alternate to the three-edge bearing test, concrete pipe 66 in. in diameter and larger may be accepted on the basis of compressive strength of cores cut from the wall of the pipe. Determine the compressive strength of the samples. Obtain, cure, prepare, and test the cores in accordance with ASTM C 497. Plug and seal core holes in the pipe wall after testing. (Cylinder compression testing is not allowed for acceptance testing.)

3. **Concrete Fittings and Transitions.** Make compressive test specimens in accordance with ASTM C 497. Make a minimum of two test specimens for each mix design per
month if using a concrete mix design different from the batched mix design used for the member. Cure test specimens in the same manner and for the same duration as the fittings they represent until tested. Test a set of compressive strength specimens, consisting of two per set, in accordance with ASTM C 39. Test specimens must meet the minimum compressive strength requirement of the parent member (box culvert or RC pipe section).

I. Tolerances.

1. **Machine-Made Precast Box Culverts.** Ensure that box culvert sections meet the following fabrication tolerances:
   - permissible variations listed in ASTM C 1577,
   - slab and wall thicknesses in excess of plan requirements that do not affect proper jointing, and
   - the sides of the section at each end must not vary from being perpendicular to the top and bottom by more than 1/2 in. when measured diagonally between opposite interior corners.

   Deviations from the above tolerances will be acceptable if the sections can be fitted at the plant or job site and joint openings at any point do not exceed 1 in. Use match marks for proper installation on sections that have been accepted in this manner.

   a. **Boxes for Jacking Operations.** For boxes to be used for jacking operations (as defined in Item 476, “Jacking, Boring, or Tunneling Pipe or Box,”) meet the following additional requirements:
      - The box ends must be square such that no point deviates more than 3/8 in. from any plane placed on the end of the box that is perpendicular to the box sides, and
      - The slab and wall thickness must not be less than specified on the plans and must not exceed the specified thickness by more than 1/2 in.

2. **RC Pipe.** Ensure that RC pipe meet the permissible variations of the applicable ASTM specification.

J. **Marking.** Clearly mark each section of box culvert and RC pipe in accordance with the applicable ASTM specification. In addition, mark the following information on each section when applicable:
   - for box culverts, provide a unique identification number for each unit during fabrication,
   - fabricator’s designated approval stamp for each approved unit,
   - designation “SR” meeting sulfate-resistant concrete plan requirements (when applicable),
   - for box culverts, match marks for proper installation, when required per Section 7310.5.1.1,
for box culverts without lifting holes, mark one end of each box section on the inside and outside walls to indicate the top and bottom as it will be installed.

- RC pipe size, and

- Box culverts and RC pipe to be used for jacking and boring.

K. **Storage of Product.** Store RC pipe and box culverts in a manner that prevents damage to the members.

1. **Machine-Made Precast Box Culverts.** Store box culvert sections on a level surface. Do not place any load on the sections until design strength is reached and curing is complete.

L. **Shipping.**

1. **Machine-Made Precast Box Culverts.** Ship box culvert sections after design strength, curing, and all other requirements have been met. Design strength must be determined per Section 7310.5.H.1.

2. **Reinforced Concrete Pipe.** Do not ship pipe fewer than 3 days after casting unless a representative three-edge bearing (3EB) test is performed prior to shipping confirming D-Load strength compliance. Concrete core compression testing may be performed in lieu of 3EB testing for 66-in. diameter pipe and larger.

7310.6. **Quality Control and Production Procedures.** Submit and maintain ACPA QCast or NPCA Quality Control procedures and the following plant-specific written quality control and production procedures for acceptance that include the following, at minimum, to ensure product compliance with Department specifications:

- procedures for verification of Department project material requirements, special provisions, and general notes;
- procedures for storing reinforcing steel (reference Item 440.3.C, “Storage”);
- procedures for verifying accuracy of mixer moisture control units;
- proposed concrete mix designs, including concrete cylinder or core strength test data for each design;
- batching procedures for ensuring concrete mixing/batching operations are producing homogenous concrete mixtures for the provided mix designs;
- batching procedures for concrete fittings and transitions, including concrete component materials, and mixing proportions if using a concrete mix design different from the batched mix design used for the member;
- procedures for verifying steel cage designs meet the appropriate ASTM and Department specifications for box culverts and RC pipe prior to fabrication;
- procedures for properly verifying steel reinforcement cages for box culverts. Include minimum area per ft. for each $A_s$ steel cage designation for the specified fill height(s), required splice lap lengths, reinforcing steel cage length and width, weld locations and
spacing, wire reinforcement spacing, and overall conformance with steel cage designs. Verify lifting hole cut outs meet the requirements of this specification;

- procedures for properly verifying RC pipe reinforcing steel cages during fabrication (i.e., minimum steel area per ft. per steel cage design, required splice lap length, and reinforcing steel cage length and diameter);

- procedures for properly performing pre-pour inspections. Provide a complete visual pre-pour inspection at initial set up that includes form and core dimension inspection, reinforcing steel cover, form release agent application, embedded items, etc.;

- procedures for properly positioning reinforcing steel cages during casting operations. For RC pipe, include specific procedures for maintaining elliptical steel positioning, if used;

- procedures for monitoring and minimizing production defects such as delamination, honeycombing, and open texture;

- procedures for curing concrete, including a layout of steam curing enclosures. Identify each steam curing enclosure with a unique designation;

- procedures for properly performing post-pour inspections of finished sections. For box culverts, include verification checks to ensure the diagonal measurements are within tolerance;

- procedures for minimizing damage, including repetitive damage to finished product during stripping, handling, and transporting;

- procedures for evaluating damaged units per the Annex of this specification;

- procedures for handling and storage to prevent damage. Include maximum stacking heights for finished sections;

- procedures for standardized repairs of damaged units. Repair procedures must be in accordance with the Annex of this specification;

- procedures for properly performing pre-pour inspections of concrete fittings and transitions;

- procedures for fabricating concrete fittings and transitions. Include procedures for reinforcement placement, welding reinforcing steel, concrete placement and consolidation, and curing;

- procedures for properly performing post-pour inspection of concrete fittings and transitions. Include evaluation and repair procedures for damaged concrete fittings and transitions.

- procedures for marking each unit per Section 7310.5.J;

- procedures for certifying product compliance per Article 7310.8;

- procedures for marking each approved unit with fabricator’s designated approval stamp. The monogram stamp must be Department-approved and listed on the MPL prior to being used;

- procedures for identifying, marking, and isolating rejected units;

- procedures for establishing shipping criteria per Section 7310.5.L.
• designated on-site Quality Control personnel and their certifications (must be QC personnel meeting the certification requirements of Article 7310.9 to perform testing as specified in Table 1 and the inspection duties listed above).

Submit updated procedures and proposed Quality Control personnel for review when requesting changes to the approved Quality Control and Production Procedures and Quality Control personnel. Include date of revision for each submittal.

7310.7. Documentation. Maintain the following documentation, at a minimum, available upon request to the Department:

• appropriate special provisions and general notes (project specific or statewide, until superseded);

• shop drawings for box culverts, when required, approved by the Department per Article 7310.5 (minimum 2-year retention or until superseded);

• mill test reports and shipping invoices received for reinforcing steel furnished by Department-approved mills (minimum 1-year retention);

• mill test reports and shipping invoices received for reinforcing steel rod to be subsequently cold-drawn during helical RC pipe cage production (minimum 2-year retention);

• all required test results (including tensile strength, bend, and reduction of area) for circumferential wire reinforcement that is cold-drawn during helical RC pipe cage production at the fabricator’s facility (minimum 2-year retention). Test circumferential wire in the cold-drawn state;

• shipping invoices, mill test reports, and certifications for concrete component materials from Department-approved sources (minimum 1-year retention);

• current concrete mix designs with pertinent concrete cylinder and core strength data (until superseded);

• completed reinforcing steel cage inspection worksheets for RC pipe for each pipe size, class, and wall design at the start of each production run and a minimum of one additional check after 6 hours of production. If discrepancies exist, increase minimum cages to four or more until discrepancies are resolved (minimum 2-year retention);

• completed reinforcing steel inspection worksheets for box culverts for each size, and fill height(s) at the start of each production run and a minimum of one additional check after 6 hours of production. If discrepancies exist, increase minimum cages to four or more until discrepancies are resolved (minimum 2-year retention);

• Department Form 596, “Concrete Batch Ticket,” or equivalent for each concrete batch (minimum 3-month retention);

• completed post-pour inspection worksheets for RC pipe. Measure and document post-pour dimensional inspections for a minimum two pipe sections per size, class, wall design, and cast date. If discrepancies exist, increase minimum sections to four or more until discrepancies are resolved (minimum 2-year retention). Provide visual post pour inspection of all RC pipe;
• completed post-pour inspection worksheets for box culverts. Measure and document post-pour dimensional inspections for a minimum two box sections per size, fill height(s), and cast date. If discrepancies exist, increase the minimum sections to four or more until discrepancies are resolved (minimum 2-year retention). Provide visual post pour inspection of all boxes;

• completed Department Form MMBC “Precast Concrete Worksheet (Machine-Made Box Culverts),” or equivalent for produced box culverts (minimum 7-year retention);

• welded splice test results for RC pipe steel reinforcement (minimum 2-year retention);

• current National Ready Mix Concrete Association (NRMCA) certification or a current inspection report signed and sealed by a licensed professional engineer indicating that concrete measuring and mixing equipment meets the requirements of ASTM C 94 as referenced in Item 421.3.A, “Concrete Plants and Mixing Equipment.” (retain until superseded) (not required for volumetric mixers), and

• completed Department-furnished spreadsheet, or equivalent for tracking damage and deficiencies to box culverts (minimum 2-year retention).

7310.8. Certification of Product. QC personnel must certify product conformance with all plans and specifications, which includes, at a minimum, the following:

A. Machine-Made Precast Box Culverts.

• Tracking damage and deficiencies on the Department-furnished spreadsheet, or equivalent, and certifying that the repairs and the corrective measures were properly performed and inspected by initialing the spreadsheet;

• Certifying that pre-pour and post-pour inspections, repairs (if applicable), compressive strength testing, and final product acceptance were properly performed and inspected by initialing the Department Form MMBC, or equivalent; and

• Marking completed and approved product by placing fabricator’s designated approval stamp on each section. The fabricator’s designated approval stamp must be Department approved and listed on the MPL prior to use.

B. RC Pipe.

• Marking completed and approved product by placing fabricator’s designated approval stamp on each section. The fabricator’s designated approval stamp must be Department approved and listed on the MPL prior to use.

7310.9. Quality Control Personnel and Testing. Provide an adequate number of qualified QC personnel for each specific production operation (box culverts and RC pipe). QC must be on-site and independent of production personnel, as determined by the Engineer. QC personnel must be proficient in utilizing the applicable specifications and test methods noted in Table 1 and in verifying compliance with the quality control and production procedures referenced in Article 7310.6. QC personnel must maintain current certifications as follows.
A. **Quality Control Personnel (On-Site) for Machine-Made Precast Box Culverts.**
   - PCI Level I Quality Control Technician for QC personnel performing quality control functions listed in Article 7310.6 and testing as noted in Table 1.
   - ACI Concrete Strength Testing Technician or ACI Concrete Laboratory Testing Technician Level 1 for QC personnel performing concrete compressive strength testing.

B. **Quality Control Personnel (On-Site) for RC Pipe.**
   - PCI Level I Quality Control Technician or ACPA Quality Aspects in Production Course or NPCA Production and Quality School Level I Certification for QC personnel performing quality control functions listed in Article 7310.6 or testing as noted in Table 1.
   - ACI Concrete Strength Testing Technician or ACI Concrete Laboratory Testing Technician Level 1 for QC personnel performing concrete compressive strength testing.

The plant may use commercial laboratory personnel or facilities to perform concrete compression testing as noted in Table 1, provided they meet the following requirements.

- Technicians must possess the following:
  - ACI Concrete Strength Testing Technician or
  - ACI Concrete Laboratory Testing Technician Level 1 certification for QC personnel performing concrete compressive strength testing.
- For testing performed at the commercial lab, the lab must be AASHTO accredited in the specific test(s) to be conducted.
<table>
<thead>
<tr>
<th>Material</th>
<th>Test Method</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Aggregate</td>
<td>Moisture Content per Tex-409-A or ASTM C 566[^2]</td>
<td>minimum 1 per day</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>Moisture Content per Tex-409-A or ASTM C 566[^2]</td>
<td>minimum 1 per day</td>
</tr>
<tr>
<td>Reinforcing Steel (RC Pipe only)</td>
<td>ASTM A 82 when base metal rod is cold – drawn during helical cage production. Required tests: tensile, bend, and reduction of area</td>
<td>per ASTM A 82</td>
</tr>
<tr>
<td></td>
<td>ASTM A 370 for Welded Splices[^3] not lapped to a minimum</td>
<td>once every 6 months per wire diameter</td>
</tr>
<tr>
<td></td>
<td>1) 20 diameters for deformed bars &amp; wire or</td>
<td></td>
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<td></td>
<td>2) 40 diameters for plain bars &amp; wire</td>
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<tr>
<td>Concrete</td>
<td>Making of Dry Cast Concrete Cylinders per ASTM C 497[^1]</td>
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<tr>
<td></td>
<td>Box Culverts – a minimum of 4 test specimens for each day’s production run and mix design</td>
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<tr>
<td></td>
<td>Box Culverts – For material acceptance, a minimum of 1 set consisting of 2 test specimens per each day’s production run and mix design; retests per Section 7310.5.H.1</td>
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<tr>
<td></td>
<td>RC Pipe – per ACPA or NPCA</td>
<td></td>
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<td></td>
<td>Box Culvert &amp; RC Pipe Concrete Fittings and Transitions – a minimum of 1 set consisting of 2 test specimens per mix design per month if using a concrete mix design different from the batched mix used for the member</td>
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<tr>
<td></td>
<td>RC Pipe – per ACPA or NPCA</td>
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<tr>
<td>Concrete Absorption</td>
<td>per ASTM C 497[^2]</td>
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<tr>
<td>Concrete Pipe</td>
<td>Three Edge Bearing Test[^5,6] and Concrete Cores[^4] per ASTM C 497</td>
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<td></td>
<td>per ACPA or NPCA</td>
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</table>

1. When aggregate weighing hoppers or storage bins are equipped with properly maintained electronic moisture probes for continuous moisture determination, these moisture tests are not required daily. Electronic moisture probes, however, must be verified weekly against Tex-409-A or ASTM C 566 test results to ensure that the compared values do not vary more than 0.3%. The sample for the moisture verification test must be representative of the material located where the electronic moisture probe is registering moisture readings.

2. QC personnel with current PCI Level 1 Quality Control Technician, ACPA Quality Aspects in Production Course certification, or NPCA Production and Quality School Level 1 certification must perform this test, with the exception that plant personnel qualified by these QC personnel may perform aggregate moisture content testing.

3. Perform a minimum of three pull tests (tensile strength test). Weld splice test specimens from welded wire reinforcement must develop at least 50% of the minimum specified tensile strength of the steel referenced in ASTM A 82 and ASTM A 496. Retest must be in accordance with ASTM A 370.

4. QC personnel with current ACI Concrete Strength Testing Technician or ACI Concrete Laboratory Testing Technician Level 1 certification must perform this test. Commercial laboratories meeting the requirements of Article 7310.9 may perform this test.

5. Test for the load to produce a 0.01 in. crack or 15% in excess of the required D-load, whichever is less.

7310.10. Archived Versions. Archived versions are available.
ANNEX

(Mandatory Information)

A1. CRITERIA FOR EVALUATION OF DAMAGED REINFORCED CONCRETE PIPE

A1.1. Scope. This information is to be used to assist in determining if the type and extent of damage to reinforced concrete pipe will be cause for rejection or allowable repair.

Evaluation guidelines are included for the following conditions:

- Fractures or Cracks,
- Manufacturing Defects, and
- Damaged Ends.

A1.1.2. Definitions.

- Honeycomb—voids that may extend deeper than the surface, due to inadequate concrete consolidation, grout leakage, and/or a dry/stiff concrete mix.
- Initial Set of Concrete—the stage when cement hydration begins in concrete and when concrete can no longer be adequately consolidated.
- Open Texture—surface voids typically due to an insufficient amount of mortar or a dry/stiff concrete mix.
- Slab Off—a separation (delamination) of freshly placed concrete, prior to initial set, that typically occurs at a steel reinforcement plane.
- Spall—physical damage (breakage) of hardened concrete that may occur during handling, storage, etc.

A1.2. Fractures or Cracks.

A1.2.1. Causes for Rejection Due to Fractures or Cracks.

- Any fracture or crack that visibly passes through the wall of the pipe
- Any fracture or crack that is 0.01 in. wide or greater at the surface and 12 in. or longer regardless of position in the wall of the pipe
- Any fractures or cracks not covered above that are numerous and extensive

If a visible crack exists on the inside wall and QC is unable to observe the opposite side of the wall in question, the producer will have the option of either eliminating the obstruction or removing the section from the lot.
A1.2.2. Acceptable Conditions Due to Fractures or Cracks.

- A single end crack that does not exceed the depth of the joint
- Fractures or cracks not passing through the wall, provided they are:
  - Less than 0.01 in. wide or
  - 0.01 in. wide or greater and less than 12 in. long. These 0.01 in. minimum width surface fractures or cracks must be repaired in accordance with Section 3.7 or 3.8 of the Department’s Precast Concrete Repair Manual.

A1.3. Manufacturing Defects. Any defect that indicates imperfect proportioning, mixing, or molding is cause for rejection, including:

- Offsets in form seams that would prevent adequate concrete cover over reinforcing steel,
- Excessive moisture in concrete causing pipe walls to sag during production or creating undesirable “rifling” type tool marks 1/4 in. or greater in height inside the barrel of the pipe, see Figure A1.3,
- Delamination in the body of the pipe when viewed from the ends or when determined from hammer testing, or
- Evidence of inadequate concrete cover for reinforcing steel.

Figure A1.3. Rejectable Manufacturing Defects—“Rifling” Tool Marks. If marks are 1/4 in. or greater in height

A1.3.1. Causes for Rejection of Surface Defects Due to Honeycomb or Open Texture.
- Honeycomb that extends to a depth greater than the size of the coarse aggregate and exposes reinforcing steel,
- Open texture that causes undesirable concrete permeability, or
- Any less severe surface condition that affects the majority of the pipe section surface and could reduce the durability and service life of the member.

Figure A1.4. Rejectable Manufacturing Defect.
A1.3.2. Causes for Rejection Due to Slab Offs and Spalls.

- Slab off areas not repaired prior to initial set of concrete, for pipe less than 42 in. in diameter.
- More than two slab off areas in a pipe section will be cause for rejection.
- Any spall in the pipe wall extending to the reinforcing steel, for pipe less than 42 in. in diameter, will be cause for rejection, except spalls at lifting holes that extend to reinforcing steel may be authorized for repair per Section A1.3.3 by QC. See Figure A1.5.

Minor spalls at the lifting holes may be repaired at the same time the lifting hole is plugged in the field after installation of the pipe.

![Figure A1.5. Rejectable and Repairable Manufacturing Defects—Spalls.](image)

A1.3.3. Acceptable Conditions due to Slab Offs and Spalls. Slab off areas extending to the reinforcing steel may be repaired prior to initial set of concrete per one of the following methods:

- Placing the member back in the form and filling the slab off area with concrete using standard RC pipe casting techniques, or
- Trowel-applying batched concrete from the same mix design into the slab off area if not greater than 18 in. in any direction.

Spall areas in the pipe wall not greater than 18 in. in any direction and not extending to the steel reinforcement, except at lifting holes, may be repaired per one of the following methods:

- Type VIII epoxy mortar conforming to DMS-6100 and repaired in accordance with Section 3.1 of the Department’s Precast Concrete Repair Manual, or
- Cementitious repair materials conforming to DMS-4655, Table 7 and repaired in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.

Spalled areas at lifting holes that extend to reinforcing steel use cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.

For 42 in. diameter pipe and greater only:

- Slab off or spall areas not greater than 18 in. in any direction and extending to the reinforcing steel may be repaired after initial set of concrete per one of the following options:
• Areas with a maximum depth of 1 in., use:
  ▪ Type VIII epoxy mortar conforming to DMS-6100, and repair in accordance with Section 3.1 of the Department’s Precast Concrete Repair Manual, or
  ▪ Cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.

• Areas with a depth greater than 1 in. and up to 2 in., use:
  ▪ Cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual, or
  ▪ Batched concrete from the same mix design used in the member and repair in accordance with Section 3.2 of the Department’s Precast Concrete Repair Manual.

More than two slab off areas in a pipe section will be cause for rejection.

A1.4. Damaged Ends. Damage to either the bell or spigot end of the pipe may be authorized for repair and accepted by QC per the following:

• Damage less than 1 in. in depth from the end of the bell or spigot—the total pipe circumference may be repaired.

• Damage 1 in. and greater in depth from the end of the bell or spigot and not exceeding the depth of the joint—total cumulative damage does not involve more than 50% of the pipe’s circumference, and no individual spall can be more than 25% of the pipe’s circumference. See Table A1.1 for allowable repairs.
### Table A1.1
Permissible Repair Criteria
(End Damage 1 in. and Greater in Depth Within the Joint)

<table>
<thead>
<tr>
<th>Pipe Size (in.)</th>
<th>Permissible Cumulative Damage Length (in.) (50% circumference maximum)</th>
<th>Permissible Individual Damage Length (in.) (25% circumference maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>18-1/2</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>23-1/2</td>
<td>11-3/4</td>
</tr>
<tr>
<td>18</td>
<td>28-1/4</td>
<td>14</td>
</tr>
<tr>
<td>24</td>
<td>37-3/4</td>
<td>19</td>
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<tr>
<td>27</td>
<td>42-1/4</td>
<td>21-1/4</td>
</tr>
<tr>
<td>30</td>
<td>47</td>
<td>23-1/2</td>
</tr>
<tr>
<td>36</td>
<td>56-1/2</td>
<td>28-1/4</td>
</tr>
<tr>
<td>42</td>
<td>66</td>
<td>33</td>
</tr>
<tr>
<td>48</td>
<td>75-1/4</td>
<td>37-1/2</td>
</tr>
<tr>
<td>54</td>
<td>84-3/4</td>
<td>42-1/2</td>
</tr>
<tr>
<td>60</td>
<td>94-1/4</td>
<td>47</td>
</tr>
</tbody>
</table>

**Note 1**—L1 + L2 + L3 must not exceed 50% of the pipe circumference. See example.

**Note 2**—L1, L2, or L3 must not exceed 25% of the pipe circumference. See example.

**Note 3**—Pipe Circumference = 2πr, where r = pipe radius = Pipe Diameter / 2; therefore, Pipe Circumference = πd, where d = pipe diameter. See example.

**Example:**
To determine the circumference of a 24 in. pipe, multiply the pipe diameter by π:

\((\pi = 3.1416)\), Circumference = 24 in. x 3.1416 = 75.4 in.,

Determine 50% of the pipe circumference:

75.4 in. x 0.50 = 37.7 in. (37 ¾ in.) – permissible cumulative damage length (L1 + L2 + L3)

Determine 25% of the pipe circumference:

75.4 in. x 0.25 = 18.85 in. (19 in.) – permissible individual damage length (L1, L2, or L3)

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**Figure A1.6.** Damaged End—Bell End
A1.4.1. **Causes for Rejection Due to Damaged Ends.**

- Joint end damage 1 in. and greater in depth that exceeds the length dimensions noted in Table A1.1.
A2. CRITERIA FOR EVALUATION OF DAMAGED MACHINE-MADE PRECAST BOX CULVERTS

A2.1. Scope. This information is to be used to assist in determining if the type and extent of damage to machine-made precast box culverts will be cause for rejection or allowable repair. Evaluation guidelines are included for the following conditions:

- Fractures or Cracks,
- Manufacturing Defects, and
- Damaged Ends.

A2.1.2. Definitions.

- **Honeycomb**—voids that may extend deeper than the surface, due to inadequate concrete consolidation, grout leakage, and/or a dry/stiff concrete mix.
- **Initial Set of Concrete**—the stage when cement hydration begins in concrete, and when concrete can no longer be adequately consolidated.
- **Open Texture**—surface voids typically due to an insufficient amount of mortar or a dry/stiff concrete mix.
- **Slab Off**—a separation (delamination) of freshly placed concrete, prior to initial set, that typically occurs at a steel reinforcement plane.
- **Spall**—physical damage (breakage) of hardened concrete that may occur during handling, storage, etc.

A2.2. Fractures or Cracks.

A2.2.1. Causes for Rejection Due to Fractures or Cracks.

- Any fracture or crack that visibly passes through the wall or slab of the box culvert
- Any fracture or crack that is 0.01 in. wide or greater at the surface and 12 in. or longer and extends beyond the first layer of steel reinforcement, regardless of the position in the wall or slab of the box culvert
- Any fractures or cracks not covered above that are numerous and extensive

If a visible crack exists on the inside wall and/or slab and QC is unable to observe the opposite side of the wall and/or slab in question, the producer will have the option of either eliminating the obstruction or removing the section from the lot.
A2.2. Acceptable Conditions Due to Fractures or Cracks.

- A single end crack that does not exceed the depth of the joint
- Fractures or cracks not passing through the wall, provided they are:
  - less than 0.005 in. wide—acceptable without repair except when located on the inside surface of the bottom slab.
  - less than 0.005 in. wide and located on the inside surface of the bottom slab—repair in accordance with Section 3.7 or 3.8 of the Department’s Precast Concrete Repair Manual.
  - greater than or equal to 0.005 in. wide but less than 0.01 in. wide—repair in accordance with Section 3.7 or 3.8 of the Department’s Precast Concrete Repair Manual, or
  - Greater than or equal to 0.01 in. wide and not extending beyond the first layer of steel reinforcement—repair in accordance with Section 3.7 or 3.8 of the Department’s Precast Concrete Repair Manual.
A2.3. **Manufacturing Defects.** Any defect that indicates imperfect proportioning, mixing, or molding is cause for rejection, including:

- Offsets in form seams that would prevent adequate concrete cover over reinforcing steel,
- Excessive moisture in concrete causing box culvert walls or slabs to sag during production,
- Delamination in the body of the box culvert when viewed from the ends or when determined from hammer testing, or
- Evidence of inadequate concrete cover for reinforcing steel.

A2.3.1. **Causes for Rejection of Surface Defects Due to Honeycomb or Open Texture.**

- Honeycomb or open texture on the top surface of the bottom slab that exposes reinforcing steel, regardless of size,
- Open texture on the top surface of the bottom slab causing undesirable concrete permeability,
- Honeycomb or open texture at locations other than the top surface of the bottom slab, extending to steel reinforcement, that exceeds 18 in. in any direction, or
- Any less severe surface condition that affects the majority of the box culvert section surface and could reduce the durability and service life of the member.
A2.3.2. **Acceptable Conditions of Surface Defects Due to Honeycomb or Open Texture.**
- Honeycomb or open texture surface conditions less severe than stated in Section A2.3.1 are acceptable if properly repaired. Repair these areas using cementitious repair materials conforming to DMS-4655, Table 7. Perform repairs in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.

A2.3.3. **Causes for Rejection Due to Slab Offs and Spalls.**
- Slab off areas occurring on the top surface of the bottom slab,
- Slab off areas not repaired prior to initial set of concrete and exceeding 18 in. in any direction,
- More than two slab off areas in a box culvert section,
- More than two spalls within the same slab or wall section of a box culvert, or
- Any spall in the slab or wall section extending to the reinforcing steel that exceeds 18 in. in any direction.

A2.3.4. **Acceptable Conditions Due to Slab Offs and Spalls.** Slab off areas extending to the reinforcing steel may be repaired prior to initial set of concrete per one of the following methods:
- Placing the member back in the form and filling the slab off area with concrete using standard box culvert casting techniques, or
- Trowel-applying batched concrete from the same mix design into the slab off area if not greater than 18 in. in any direction.

Slab off or spall areas not greater than 18 in. in any direction and extending to the reinforcing steel may be repaired after initial set of concrete per one of the following methods:
- Areas with a maximum depth of 1 in., use:
  - Type VIII epoxy mortar conforming to DMS-6100 and repair in accordance with Section 3.1 of the Department’s Precast Concrete Repair Manual, or
- Cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.

- Areas with a depth greater than 1 in. and up to 2 in., use:
  - Cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual, or
  - Batched concrete from the same mix design used in the member and repair in accordance with Section 3.2 of the Department’s Precast Concrete Repair Manual.

- Areas with a depth greater than 2 in., use batched concrete from the same mix design used in the member and repair in accordance with Section 3.2 of the Department’s Precast Concrete Repair Manual.

- Spalled areas at lifting holes that extend to reinforcing steel use cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.

Minor spalls at the lifting holes may be repaired at the same time the lifting hole is plugged in the field after installation.

A2.4. Damaged Ends. Damaged areas at the tongue or groove end of the box culvert may be repaired as follows:

- Areas with a maximum depth of 1 in. from the end of the tongue or groove which may involve the entire joint end, use:
  - Type VIII epoxy mortar conforming to DMS-6100 and repair in accordance with Section 3.1 of the Department’s Precast Concrete Repair Manual, or
  - Cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual.
• Areas with a depth greater than 1 in. and up to 2 in. from the end of the tongue or groove, not exceeding the depth of the joint, and not exceeding the length dimensions noted in Table A2.1, use:
  ▪ Cementitious repair materials conforming to DMS-4655, Table 7 and repair in accordance with Section 3.3 of the Department’s Precast Concrete Repair Manual, or
  ▪ Batched concrete from the same mix design used in the member and repair in accordance with Section 3.2 of the Department’s Precast Concrete Repair Manual.

• Areas with a depth greater than 2 in. from the end of the tongue or groove, not exceeding the depth of the joint, and not exceeding the length dimensions noted in Table A2.1, use:
  ▪ Batched concrete from the same mix design used in the member and repair in accordance with Section 3.2 of the Department’s Precast Concrete Repair Manual.

### Table A2.1

**Permissible Repair Criteria**

(End Damage Greater than 1 in. in Depth Within the Joint)

<table>
<thead>
<tr>
<th>Box Span (ft.)</th>
<th>Permissible Cumulative Damage Length (in.) (50% of box span maximum)</th>
<th>Permissible Individual Damage Length (in.) (25% of box span maximum)</th>
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</thead>
<tbody>
<tr>
<td>3</td>
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<tr>
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<td>33</td>
</tr>
<tr>
<td>12</td>
<td>72</td>
<td>36</td>
</tr>
</tbody>
</table>

*Note 1—L1 + L2 + L3 cumulative damage length must not exceed 50% of the box span noted above. (See Figure A2.5)*

*Note 2 - L1, L2, or L3 (an individual damage length) must not exceed 25% of the box span noted above. (See Figure A2.5)*
Example:
To determine the permissible cumulative damage length of a 5 ft. × 5 ft. box, multiply the span (5 ft.) by 50%:

5 ft. = 60 inches; 60 inches × 0.50 = 30 in.

Therefore: \( L1 + L2 + L3 \) must be less than or equal to 30 in.

To determine the permissible individual damage length of a 5 ft. × 5 ft. box, multiply the span (5 ft.) by 25%:

5 ft. = 60 inches; 60 inches \( \times 0.25 = 15 \) in.

Therefore: \( L1, L2, \) or \( L3 \) must be less than or equal to 15 in.

A2.4.1. **Causes for Rejection Due to Damaged Ends.**

- Joint end damage greater than 1 in. in depth that exceed the length dimensions noted in Table A2.1.