

Colorado Department of Transportation

Fabrication Inspection of Pre-stressed and Precast Concrete Products



Version 2.0

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1.0 Scope

- 1.1 This manual defines fabrication inspection procedures, fabrication inspection frequencies, and inspector qualification requirements for Colorado Department of Transportation (CDOT) concrete products. These guidelines will help evaluate product quality and acceptance by assuring that materials and fabrication operations conform to the Contract.
- 1.2 Levels of Quality Assurance (QA) inspection will vary as product specifications and operational conditions change. These guidelines will help to evaluate acceptability of Contractor Quality Control (QC), procedures, work systems, and finished products.

2.0 Referenced Documents

- 2.1 Sections 2 through 8 of this manual are intended for concrete products that receive tensioning at some stage of fabrication. Section 9 refers to concrete products that are not designed with tensioning.
- 2.2 Referenced documents shall be used in accordance with all applicable CDOT Specifications. Other documents to be utilized shall include the latest edition of the following manuals:

Precast/Prestressed Concrete Institute (PCI) Manuals

- MNL-116: Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
- MNL-117: Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products
- MNL-137: Manual for the Evaluation and Repair of Precast, Prestressed Concrete Bridge Products
- MNL-135: Tolerance Manual for Precast and Prestressed Concrete Construction

3.0 QA Personnel Qualification

Fabrication inspection Agency QA personnel shall have training, certification, and work experience as described in this section.

- 3.1 The Agency shall employ a QA Manager certified by PCI at Level II or III. All Agency Inspectors shall have certification for ACI Concrete Field Testing Technician - Grade 1. All certifications shall be maintained as required by the issuing institution. Valid certifications for Inspection Agency personnel shall be submitted to CDOT Staff Bridge Fabrication and Construction Unit (referenced as CDOT Staff Bridge throughout this document), and/or the Owner, prior to beginning fabrication inspection work.

3.2 PCI Quality Control Technician/Inspector Certification requirements for inspection of bridge girders and other designated structural items are as follows:

- **PCI Level I** - Inspectors with PCI Level I certification can inspect all facets of the work with moderate supervision from a Senior Inspector, rated PCI Level II or III. Senior Inspectors shall supervise Level I as needed to ensure compliance with inspection requirements. Level I Inspectors shall have 2 years of concrete related experience in the civil engineering industry.

Level I inspectors shall report inspection discrepancies to the supervisor. Report significant discrepancies in writing, including corrective measures taken.

Required QA/QC reports and records, as listed in this Plan, shall be submitted to CDOT Staff Bridge, and/or the Owner, for storage into the permanent project records system.

- **PCI Level II** - Inspectors with PCI Level II certification are required to have the ability to determine concrete product acceptance and fabrication conformance for variable production methods. Level II shall be capable of recognizing, evaluating, and resolving non-conforming fabrication situations.

Level II inspectors shall be proficient with intermediate concepts of precast and pre-stress work systems including, tensioning systems, steel and reinforcing details, concrete mix design, concrete curing procedures, materials acceptability, non-destructive test analysis techniques, and product repair methods.

Level II inspectors shall review and analyze QC reports and records for specification compliance before issuing Form #193. Unresolved issues shall be reported in writing to CDOT Staff Bridge, and/or the Owner, for proper resolution and final product acceptance. Final Form #193 reports shall show names and titles for the Inspector, the QA Manager, and the Agency's Professional Engineer.

- **PCI Level III** - In addition to Level II duties, Level III QA personal shall have comprehensive experience with precast and pre-stress work systems, detailed familiarity with differing fabrication processes, thorough understanding of written requirements, tensioning systems, concrete mix designs, materials testing, and product repair methods.

Level III inspectors may assist the Engineer in establishing acceptance criteria for concrete products where none are otherwise available or products are in dispute.

4.0 General QA/QC Information

- 4.1 The Contractor's QC Manager is QA's primary contact person for information exchange concerning fabrication operations and product quality. The QC section is responsible for ensuring accuracy and compliance with all fabrication operations requirements.
- 4.2 Unacceptable work methods, inspection procedures and testing practices observed by QA shall be conveyed to the QC Manager for rectification. Recurring unacceptable work and unresolved product disputes shall be resolved by the Owner's Engineer in conformance with CDOT Standard Specification subsection 108.06 - Character of Workers; Methods and Equipment.
- 4.3 QA shall communicate fabrication details and information among the Contractor, CDOT, staff, and project personnel. Consult with these parties to clarify issues regarding product status, quality, and acceptance issues.
- 4.4 QA shall utilize the following practices and procedures to evaluate and verify acceptability of work systems and finished fabricated products that conform to specifications and tolerances:
 - Randomly monitor all stages of production operations and QC practices to ensure compliance with the Contract.
 - Random physical measurements and counts of materials placed into the work, to verify correct amounts and placements.
 - Schedule sampling and physical testing of materials to ensure conformance with test requirements.
 - Identification, evaluation, and resolution of defects and needed repairs; verify contractor's corrective actions taken to achieve product acceptability.
 - Check Contractor test equipment and calibration tags for accuracy and conformance to agency requirements.
 - Pre-Acceptance of as-built products at the fabrication site, with written conveyance of CDOT Form #193 to CDOT Staff Bridge and the Field Project Engineer. See Section 8 for comments on document conveyance.
 - Compilation and submittal of required QC/QA records to CDOT Staff Bridge, and/or the Owner, for their permanent project records.

5.0 Fabrication Inspection Procedures and Practices

5.1 QA Pre-fabrication Inspection Tasks and Procedures

- Review Contractor's equipment calibration tags, records, and personnel certifications prior to the start of work.
- Create a permanent project file that includes product plans, drawings, required documentation, reports, and pertinent records. Provide complete file copy to Staff Bridge, and/or the Owner.
- Review and study project plans, specifications, and drawings. The Project Engineer and the Owner shall be notified when fabrication begins, including start and stop dates for Phase work.
- Obtain materials samples for pre-testing when required. Previous test reports and certificates may be reviewed for specification compliance in lieu of testing, when materials are visually examined to ensure they correspond with existing reports and certificates. Report failing materials tests to the Contractor, CDOT Staff Bridge, and/or the Owner.
- Pre-fabrication schedules, procedures and practices for sampling and testing materials are shown below:
 - **Seven-Wire Strand** - take random samples prior to fabrication and as new supplies come into use. Strand and other pre-stressed materials shall conform to requirements in CDOT Specification 714. Sample and submit strand for testing as follows:
 - Obtain random 66-inch long samples from strand reel pack lots to be used. Portions of previously tested reel packs do not need retesting unless there is concern about present condition.
 - Collect Certified Mill Test Reports (CMTR), and corresponding stress/strain graphs, for permanent project records. Examine CMTR's and Product Invoices for accuracy and statement of U.S. domesticity. Match these documents to Contractor reel pack tag numbers in use.
 - Inspect general physical condition of strands before and during production operations. Refer to PCI MNL-116 for information on strand product quality.
 - Submit physical test samples to a test laboratory currently certified for strand product testing by the American Materials Reference Laboratory (AMRL). The lab shall provide a formal test report of actual results, which also shows product requirements. File test

reports with corresponding CMTR's and keep with permanent projects records.

- **Reinforcing Items** - inspect before initial setup and spot check intermittently during production and when stock varies. Identify size, grade, and domesticity of items by mill or tag markings when possible. Resolve other product questions by reviewing product literature or CMTR's in the plant files.
- **Concrete Mix Designs** - Review and evaluate Contractor's mix designs for adequacy. Discuss questions with staff, CDOT Staff Bridge, and the Contractor. Unresolved questions shall be discussed with CDOT Central Materials Laboratory - Concrete Unit. Ensure that mix designs comply with concrete item specifications, plan notes, and Project Special Provisions.

5.2 Miscellaneous Fabrication Materials and Testing - QA

- QA reserves the option to test material or products at any time before, during, or after fabrication according to CDOT Specification Section 106 and Section 618.
- When the Contractor changes materials or product sources, review new source reports to determine if testing is needed. Emergency material or substitutions may be allowed with permission from the Design Engineer of Record and the Project Engineer.
- Decisions regarding testing of new materials shall be the prerogative of the Owner. When new materials require testing, samples shall be submitted to an accredited laboratory certified by AMRL or Cement and Concrete Reference Laboratory (CCRL), as test needs apply. The laboratory shall provide written report of test results. File all test reports with manufacturer's submittals and keep with permanent project records.

5.3 Operational Conformance During Fabrication - QA

- Fabrication is defined as any preparation, set up procedure, or practice which exists as part of production operations, or may be incorporated into finished products.
- QA shall randomly monitor and evaluate production methods, finished products and QC functions throughout the entire fabrication, curing, and storage processes. Physical measurements, visual inspection, instrument readings, witness observation, and records review, shall be used to verify conformance with the Contract.

6.0 QA Fabrication Inspection Frequencies

6.1 Frequency of QA activities shall be determined by QA based on variable situations including, but not limited to:

- Product design requirements.
- Unique operational details and fabrication methods.
- Method changes to normal operation practices.
- Changes in material or supplier sources.
- Previously identified problematic fabrication areas.
- Changes in QC personnel or general QC performance.
- Recent production performance and overall product quality.

6.2 Frequency - Pre-Pour Operations

PCI Product dimensional tolerances may be found in PCI Manual MNL-135. Review project specifications, as there may be different tolerance requirements.

- **Form conditions** - inspect initial setup and at least weekly thereafter. Check for presence of excessive rust, debris, or contaminants. Check local smoothness tolerances, alignment, fit-up, and general positioning before casting.
- **Placement, position, clearance, and shape of mild reinforcing items, plates, and embeds** - for initial setup, choose several random areas. Make random measurements and checks for dimensional placement, line and grade, proper clearance, adequate chairing support, actual quantities vs. plan quantities. Check at least every other setup thereafter.
- **Void and block outs** - inspect initial setup and at least every other setup thereafter. Note shape, position, length, location, and method of securement for incorporated items. Inspect more frequently for large or odd-shaped voids.
- **Stressing operations** - witness at least 50% of first tensioning operation, per project, and at least 20% of every other setup thereafter. Observe initial and final tension operations and verify that readings and elongation measurements are accurately recorded in accordance with CDOT Specification 618.
- **Dimensional checks for tensioned strand** - check random positions of several individual and bundled strands on initial setup and every setup where strand positions change. Check at least twice weekly thereafter. Ensure that strands are placed within allowable PCI tolerances, and that straight strands do not sag near mid-length of setups.
- **Position of hold-down devices** - check layout, horizontal, and vertical measurements of all hold-down devices on the first setup and every setup where design positions change. Check at least twice weekly thereafter. Ensure that hold-downs are positioned within

allowable PCI tolerances. Check to see if hold-downs lift up from soffit, or tilt off-center, causing out of tolerance situations.

6.3 Frequency - Concrete Casting Operations

- Monitor casting process as needed for temperature, weather variations or other special circumstances. Note consolidation and finish operations. Note unusual or non-routine events. Witness at least 70% of first cast, and at least 30% of every other cast thereafter.
- Spot check QC test procedures and data sheets for conformance and accuracy as needed. Determine overall acceptability of operations and accuracy of QC recorded data.
- Check form spread and void shifting during cast. Ensure that chairing and bracing firmly hold void systems in place. Make several random deck thickness checks and compare to product dimensional tolerances. Make thorough checks on first cast, and at least every other cast thereafter.
- QA reserves the right to request additional concrete sampling and testing when unusual circumstances occur such as inclement weather, temperature extremes, inconsistent batching operations, long mid-pour delays, mix segregation, or mix variability.

6.4 Frequency - QA Post-Casting Operations

PCI Product dimensional tolerances may be found in PCI Manual MNL-135. Review project specifications, as there may be different tolerance requirements.

- Check release strengths and monitor curing procedures often. The curing temperatures should be checked daily to assure they are within the specification range of 50-160 degrees F. Consider variable factors such as temperature, weather, materials conditions, curing system variances, equipment conditions, and personnel allocation.
- QA representative shall collect daily cast reports and cylinder test samples from QC. Submit test samples to an accredited CCRL Laboratory for QA strength acceptance testing. Representative cylinders shall be molded for each 50 cubic yards or portion thereof, for each different concrete mix design used per day, per product line. The lab shall provide written report of test results. Keep QA test reports with permanent project records.
- Compare QA/QC concrete test results for consistency. Report all QA tests under minimum strength requirements to CDOT Staff Bridge, the Contractor, and agency staff. Deficient strengths may require referee cores according to CDOT Specification 618.

- If the Contractor objects to referee coring, calculations may be submitted to support lower strengths. Calculations shall be stamped by a Colorado Licensed Professional Engineer. CDOT Staff Bridge, and/or the Owner, shall decide method of acceptance, either referee coring or stamped calculations.
- All submitted calculations, core test results and written decisions involving disputed strengths shall be filed with permanent project records.
- Monitor product camber and sweep, using QC measurements for initial status. Take QA measurements when uncertainty exists.
- Request load-weights for units with high camber; and remedial actions for sweep problems. Watch storage methods.

7.0 QA Post Fabrication Acceptance Criteria

7.1 Prior to shipment, evaluate finished products before written acceptance is conveyed. Minimum inspection frequencies are defined in this subsection. Numbered items with bold highlights require written documentation, and filing into permanent project records.

- **QA Concrete strength test reports - 100% for every cast.**
- Dimensional checks of finished product - 20% of total units.
- Random checks for location and position of reinforcing and appurtenant items - as determined by QA.
- **Inspection of significant or major repairs (if any) - 100%.**
- Evaluate acceptability of girders and large members - 100%.
- Evaluate acceptability of panels and small members - 25%.
- **Collect, review, and compile QC records for stressing, casting, pre-pour, and post-pour operations - 100%.**
- **Compile strand product tests with CMTR's - 100%.**
- **Collect pre-shipment girder camber reports from QC - 100%.**

7.2 Significant and major repairs shall conform to requirements in CDOT Specification 618. Document all questionable or unacceptable repairs. Provide report to CDOT Staff Bridge, and/or the Owner, for resolution.

8.0 QA Product Pre-Acceptance

8.1 Pre-accepted products shall be documented on CDOT Form #193. All issued Form #193's shall be filed with the permanent project records. The Inspection Agency Engineer shall review and sign the Form #193 line designation for Professional Engineer, prior to form conveyance to CDOT Staff Bridge, the Field Project Engineer, and/or the Owner.

- 8.2 Copies of all required documentation, reports and records shall be packaged and delivered to CDOT Staff Bridge, and/or the Owner, for storage into permanent records systems. The preferred means for document and information transfer is requested to be accomplished by electronic conveyance when possible.
- 8.3 When remedial efforts for excessive sweep or significant variation from plan camber are not successful, provide written report of the variations to CDOT Staff Bridge, and/or the Owner, and the Designer for pre-acceptance evaluation and resolution. Obtain a copy of the final decision in writing, and file with permanent project records.
- 8.4 Girders shall receive an Owner approved pre-acceptance marking when QA determines that contract requirements have been met. Smaller products such as individual deck panels or wall segments do not require individual marking, however, QA shall notify the project of product acceptability prior to shipment.
- Pre-acceptance markings may not be required when QA delivers Form #193's to required parties prior to product shipment.

9.0 Inspection of Precast and Specialty Concrete Items (does not contain tensioning)

- 9.1 Other concrete products classified by the following CDOT Items, may have multiple sub-categories:
- Item 504 - Concrete Retaining Wall Systems.
 - Item 601 - Precast Concrete Products - Various.
 - Item 603 - Concrete Pipe, Culvert, and 3-sided Structures.
 - Item 604 - Concrete Drainage Items, Vaults and Basins.
 - Item 607 - Concrete Sound Barrier, Post and Fence.
 - Item 622 - Concrete Buildings and Tanks.
- 9.2 A CDOT Form #193 is not required for above-listed products, unless stated in the Contract.
- 9.3 When above-listed products require fabrication inspection, QA must determine inspection guidelines and frequencies. Contract plans, product complexity, order of precedence, and Engineer's directions shall be used to establish necessary inspection criteria.
- 9.4 Products requiring fabrication from PCI certified plants shall be inspected by PCI certified Inspectors, as defined in Section 3. Other inspections shall be done by ACI certified personnel, as defined in Section 3, or as required in the Contract.

9.5 QA Oversight Inspection Practices

Common concrete products with simple inspection requirements can be inspected on an occasional basis when individual workloads permit per subsection 9.3. Inspection for startup operations is most important. When the Inspector is confident that operations are acceptable, frequency of inspection and testing can be reduced to a weekly or other basis. QA and the Project Engineer shall determine the reduced frequency(s).

- Request assurance test cylinders from Contractor's QC section. Submit test samples to a CCRL accredited lab for testing and formal report. Records requested by the Project Engineer should be saved and submitted upon request. When questions regarding materials acceptability exist, QA shall request to view Fabricator's CMTR's or materials certificates on file at the plant.
- All required CMTR's, Certificates of Compliance, Certified Test Reports, and Materials/Product Warranties, are the responsibility of the Contractor's QC section. QC shall provide all records and documents requested by the Engineer.
- All Oversight Inspection disputes involving workmanship, materials, and finished products, shall be decided by the Field Project Engineer.

Table 1 Revision History

Version	Effective Date	Summary of Changes
1.0	November 3, 2016	-
2.0 (current)	January 3, 2024	Updated formatting, updated references, minor clarification language added