

Version 1.01
NCMA-ICPI
Quality Control Program for
Dry-Cast Manufactured
Concrete Products Production
Plants



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About NCMA and ICPI

The National Concrete Masonry Association (NCMA) unites, supports, and represents our members who are producers and suppliers of concrete masonry systems – including concrete masonry, manufactured stone veneer, segmental retaining walls, and other hardscape systems. From small family-owned businesses to large corporations, our membership reflects the full spectrum of companies that provide the foundation for resilient building construction. The Association is an industry leader in providing technical assistance and education, marketing, research and development, and product and system innovation to its members and to the industry.

The Mission of the Interlocking Concrete Pavement Institute (ICPI) is to be the voice of the segmental pavement industry and advance segmental pavement systems as the preferred choice for sustainable and environmentally friendly pavements in North America. ICPI's mission is to increase awareness, acceptance and use of segmental concrete pavement systems in North America. Among ICPI's several strategic goals is technical excellence. One of several objectives under this heading is improving product and installation quality by establishing standards and programs to ensure quality control. This program for plant certification works towards achieving that objective.

About This Plant QC Certification Program

NCMA and ICPI member companies have exhibited a long-standing commitment to ensuring consistently high quality in the products and systems they manufacture. To that end, NCMA and ICPI have been actively engaged in developing a quality control certification program for plants producing dry-cast manufactured concrete products. The details of the Plant Quality Control Certification Program detailed herein represent the work and input of NCMA's and ICPI's committees and product specifiers interested in establishing a uniform set of quality control criteria specifically applicable to machine-made, dry-cast concrete products.

Statement of Revision

Version 1.01 – updated NCMA logo and NCMA description in 'About NCMA and ICPI'

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Section 1 – General and Administration

1.1 – Scope

This program establishes the minimum requirements and procedures producers of dry-cast manufactured concrete products must follow to assure the consistent production of quality manufactured concrete products used in institutional, commercial, industrial, and municipal engineered applications. This includes, but is not limited to, products used in concrete masonry (CMU) construction, segmental retaining wall (SRW), articulating concrete block (ACB), interlocking concrete pavement (ICP), precast concrete paving slabs, and permeable interlocking concrete pavement (PICP) systems. The purpose of this program is to provide manufacturers the ability to independently control their production process and provide timely delivery of product while at the same time providing their clients assurances that product of acceptable quality is produced on a consistent basis. This program can be applied to dry-cast concrete products including, but not limited to:

- Concrete Building Brick manufactured to comply with ASTM C55 or CSA A165.2
- Loadbearing Concrete Masonry Units manufactured to comply with ASTM C90 or CSA A165.1
- Nonloadbearing Concrete Masonry Units manufactured to comply with ASTM C129
- Prefaced Concrete Masonry Units manufactured to comply with ASTM C744 or CSA A165.3
- Solid Concrete Paving Units manufactured to comply with ASTM C936 or CSA A231.2
- Precast Concrete Paving Slabs manufactured to comply with CSA A231.1
- Concrete Grid Paving Units manufactured to comply with ASTM C1319
- Segmental Retaining Wall Units manufactured to comply with ASTM C1372
- Concrete Roof Pavers manufactured to comply with ASTM C1491
- Concrete Facing Brick manufactured to comply with ASTM C1634
- Fly Ash Facing Brick manufactured to comply with ASTM C1790
- Articulating Concrete Block manufactured to comply with ASTM D6684

1.1.1 Application

This program requires producers of dry-cast manufactured concrete products to perform quality control sampling, testing, auditing, and record-keeping for products they produce under this program. Because the consistent production of quality products hinges on the implementation of a quality system, this program emphasizes that each facility must define the practices and procedures that are appropriate to their processes, products, and markets rather than relying solely on the test results of finished products, which may not capture the source or sources of production variables that impact product quality. As such, it is the intent of this program that acceptance or rejection of a product be based on the total program implemented at a given facility rather than the results of individual test results.

The program does not apply, and shall not be construed to apply, to the certification of individual products or product lines. This program is limited solely to the certification of a process adopted by a manufacturing facility to ensure products produced are of consistent quality and plans are adopted and implemented to mitigate errors prior to, during, or subsequent to production. As physical requirements for products can vary greatly depending upon the intended application, this program does not define or certify minimum properties or characteristics for manufactured concrete products within its scope. Participation in this program does not relieve the producer of the responsibility of complying with any other associated project requirements.

Commentary – Reference to the ASTM and CSA standards cited in this section are intended to define and quantify the types of products this quality control program is intended to apply. Because these standards define the minimum physical requirements and properties a product must meet, individual projects may stipulate physical attributes that exceed these minimum requirements. To that end, the quality control

*program defined herein explicitly cites compliance to the “governing standard or specification” for cases where a project specification exceeds the minimum requirements defined by ASTM or CSA. While this program can be used to document the quality and consistency of all manufactured concrete products, the intent and context of this program is applicable to products used in commercial and public infrastructure projects requiring engineered analysis and a high level of quality control. For the purposes of this program, the term dry-cast, as taken from ASTM C1232-10b, shall be considered as follows:
dry-cast, adj—manufacturing concrete products using low frequency, high amplitude vibration to consolidate concrete of stiff or extremely dry consistency in a form.*

1.2 – Quality Control

Quality control is an essential component of the overall manufacturing process. A good quality control plan implemented by a manufacturing facility will ensure that quality products are produced, errors are minimized, and in the end should prove to be a cost effective business investment. An effective quality control program requires a commitment and understanding of the program from all employees involved in the production process. The commitment to quality starts with the support of management in providing the necessary tools, personnel, and guidance required to successfully implement an effective quality control program.

Commentary – The provisions and requirements of this quality control program do not replace inspection and/or testing of products that may be required by building codes or similar regulations, as the scope of such quality assurance requirements extend far beyond the physical properties of manufactured concrete products. A designer or specifier may, however, relax or defer specific quality control testing when products are sourced from manufacturing facilities that meet the requirements of this program.

1.2.1 Quality Manager.

Each company must employ/contract at least one Quality Manager (however named) who, irrespective of other duties and responsibilities, shall have defined responsibility and authority for ensuring that the management system related to quality is implemented and followed at all times. The Quality Manager shall have direct access to the highest level of management at which decisions are made regarding plant policy or resources. The Quality Manager must have ready access to, and be familiar with, the Quality Control Plan, facility procedures and operations, product specifications, and material standards.

The Quality Manager is responsible for developing and updating the plant’s quality control program and for monitoring activities involving the production, inspection, testing, curing, labeling, and shipping of products. In the event the Quality Manager is absent during production, the Quality Manager may delegate specific duties to other qualified persons in accordance with the plant’s Quality Control Plan. The Quality Manager has the authority to stop production if necessary.

Commentary – It is possible for a Quality Manager to oversee the quality control plan at more than one plant, provided that the plant’s Quality Control Plan provides explicit procedures and responsibilities in the absence of the Quality Manager. In the event that a plant’s quality control plan can be monitored remotely, then the Quality Manager does not need to be physically located at the plant location. The intent of this provision is that a single individual is responsible for the overall quality at each plant or group of plants. Because a single individual cannot reasonably be expected to monitor activities 24-7, the Quality Manager can designate an individual or individuals to perform the roles and responsibilities of the Quality Manager in his or her absence.

1.2.2 Training.

Training must be provided to familiarize personnel with production and quality control procedures related to their specific areas of responsibility. Training is required for new employees or when existing employees are affected by:

1. A change is made to the Quality Control Plan;
2. Implementation of corrective or preventive action; or
3. Training is deemed necessary by the Quality Manager at a frequency that does not exceed 12 month intervals.

1.2.3 Quality Control Plan.

The Quality Control Plan adopted and implemented by a plant defines the practices and procedures each plant certified under this program must follow and enforce. While no two Quality Control Plans are identical, many plans are similar and each must address, at a minimum, the requirements of this program. The manufacturer must provide a plant-specific Quality Control Plan covering all aspects of the production process that must be followed during all phases of production. The Quality Control Plan must accurately represent the plant's practices and procedures and include, as a minimum, the requirements of this program and the following:

- Title Page – including company name and plant location.
- Individual Qualifications and Responsibilities – including information as required in Section 1.2.1 of this program.
- Training, Including On-Going Training – including information as required in Section 1.2.2 of this program.
- Facility Components – including plant layout, configuration and location.
- Manufacturing Products – including specifically identifying which products are covered under this program as defined in Section 1.1 of this program.
- Standard Operating Procedures – each standard operating procedure must include procedures for corrective actions that address cause analysis and the selection, implementation, and monitoring of corrective actions as well as the identification and implementation of preventive actions that contribute to the ongoing maintenance and improvement of the facility's quality system, including:
 - Constituent Materials Acceptance for:
 - Cementitious Materials – including mill certificates, color samples, and sample retention of cementitious materials for future evaluation.
 - Fine and Coarse Aggregates – including visual inspection of load(s) received, documentation of compliance testing for ASTM C33/C331 from supplier, gradation from supplier, in-house verification of gradation, storage, contamination prevention, drainage, and presence of ice or snow.
 - Admixtures or Additives – including documentation of compliance testing for ASTM C979 for pigments and applicable internal QC procedures from supplier.
 - Water – including reports obtained from municipal suppliers or test reported conducted on well water, as applicable.
 - Other materials routinely or occasionally used.
 - Assessing Impacts on Quality Control under Varying Conditions – including consideration of environmental changes (wet weather, snow and ice contamination of aggregate, hot and cold temperatures, and pre-wetting of aggregate for temperature or moisture control) as well as non-environment impacts (changes in personnel, equipment, or materials).

- Batch Mix Design – including provisions for: selection of correct mix design for the product being manufactured, quantities and tolerances for constituent materials, procedures for controlling and maintaining mix design, verification of mix design, and compatibility of face/blended mixes.
- Mold Inspection – including provisions for: visual inspection, cleaning, shipping, repairs, dimensional tolerances, replacement criterion, and storage.
- Machine Set Up – including a written procedure for machine and mold combination set up that is specific and applicable to the equipment used and products to be manufactured.
- Material and Batching – including: criteria for adjustments or measurement for water compensation, admixture and additive dosing verification and control systems, scales verification, mix sequencing and timing, and color verification.
- Production Assessment for:
 - Wet-Side Procedures for verifying – dimensions, density, yield, moisture content and control, texture, color, corners and edges, de-burring/surface cleaning, and pallet integrity.
 - Dry-Side Procedures for verifying – dimensions, texture, color, check(s) for project-specific requirements (i.e., admixtures or additives), split dimensions and appearance, appearance (chips, cracks, etc.), and alignment and clearance of molded features.
- Curing – including a written plan that is applicable to the process and product being manufactured; including procedures that address changes in curing process to account for ambient temperature swings.
- Bundling/Cubing, Labeling, Handling and Storage of Items – including a written procedure for the product being manufactured; including specific customer requirements, if applicable. See Section 2 of this program.
- Post Production Treatments – including written procedures for in-line and off-line post-production treatments or processing.
- Shipping – including procedures for the verification of product ordered versus product shipped.
- Retained Samples – including the implementation of a system to retain and store duplicate samples for customer submittals and/or testing. Samples must be traceable to a specific project.
- Documentation – including the requirements of Sections 1.2.3 and 1.2.4 of this program.
- Internal Review/Management Meetings – including procedures to define a continuous improvement process. See also Section 1.2.7 of this program.
- Test Equipment – including procedures for verifying equipment used for in-house measurements or assessments.
- Auditing – including the requirements of Section 1.2.8 of this program.
- Product Identification – including requirements of Section 2 of this program.
- Quality Control Assessment Procedures – including requirements detailed in Section 3 detailing:
 - Method(s) of Correlating In-Line Assessments;
 - Procedures for Verification of In-Line Assessments; or
 - In-House Processes and Procedures, as applicable.
- Control of Non-conforming Product – including requirements of Section 4 of this program.

The Quality Control Plan must be kept current and applicable to the facility's equipment, processes, personnel, testing, product standards, and other procedures covered by the Quality Control Plan. The Quality Control Plan must be reviewed at least annually by the Quality Manager.

Commentary – It is common for a single facility engaged in the production of manufactured concrete products to produce more than one type of product. Likewise, a single facility may manufacture a single product line that is used in different applications; such as residential versus commercial projects. Some of these products may not fall within the scope of this program as defined in Section 1.1 or elsewhere as delineated within the plant's Quality Control Plan. Section 1.2.3 requires that products manufactured under this program be uniquely and explicitly identified in the plant's Quality Control Plan.

A critical component of any standard operating procedure is ensuring that when problems are identified they can be quickly resolved and steps taken to prevent the issue(s) from reoccurring at some future time. As such, this program requires that corrective actions be established for each standard operating procedure that is required to be covered in a plant's Quality Control Plan.

1.2.4 Quality Control Records.

The maintenance of accurate quality control records is essential. These records provide documentation of the manufacturer's compliance with their Quality Control Plan and this program. At a minimum, the following records must be maintained, but not less than that required by the state or province statutes of limitations:

- Documentation of 3 month batch plant scale checks plus one external certification annually.
- Certification and calibration records for in-house test equipment or equivalent documentation when testing is conducted externally.
- Daily production records, including mix designs for each production run.
- Test results and quality control measurements as required for the product being manufactured.
- The manufacturer's internal audit reports and management reviews.
- Third-party surveillance/audit reports.
- Processes and procedures warranting corrective measures and actions taken to address such requests.
- A record of training events, topics covered, and personnel in attendance.
- A record of management meetings, topics covered, and personnel in attendance.

Commentary – The required length of time to maintain records is not intended to be fixed for all activities and operations, as different records may need to be maintained for varying lengths of time. The intent of this requirement is to provide the Quality Manager with sufficient historical information to identify trends in the data obtained and avoid potential problems in the future. The in-house batch scale verification can be accomplished directly through measurement, or indirectly through alternative means, such as referenced yields on a given batch or batches. The retention of documents must be sufficient to allow external auditors to verify compliance with the plant's Quality Control Plan.

1.2.5 Document Availability.

The following documents must be kept current and available to management, plant supervisor(s), and quality control personnel:

- Quality Control Plan
- Applicable product specifications
- Specifications referenced in the Quality Control Plan
- Methods and procedures referenced in the Quality Control Plan

1.2.6 Test Equipment.

Test equipment used in documenting the properties of finished products in accordance with Section 5 of this program is required to be verified for measurement accuracy in accordance with the requirements of ASTM C1093. Verification frequency for equipment used for in-house assessment or measurement practices, as defined in Section 3.1.1 of this program, shall be defined in the plant's Quality Control Plan.

1.2.7 Management Reviews.

Plant management and other personnel as designated by the company must review the plant's performance as it relates to production activities and the Quality Control Plan. Management reviews must be conducted on an annual basis at a minimum.

Commentary – A key component of any quality control plan is a self-assessment program where plant management and key production personnel review the implementation of the Quality Control Plan. The purpose of these reviews is to ensure that a plant's quality control goals, objectives, practices, and procedures are maintained, improved, and implemented. Feedback from production, sales, and other plant personnel is encouraged and should be reviewed during these meetings. These management meetings are held at least annually, but may occur more frequently depending upon the specific plant needs. Management reviews typically encompass the following:

- *the results of quality control testing or related physical assessments, including non-conforming results;*
- *customer feedback and complaints;*
- *the outcome of recent internal and external audits;*
- *corrective and preventive actions;*
- *reports from managerial and supervisory personnel;*
- *changes in the volume and type of work;*
- *the suitability of policies and procedures;*
- *recommendations for improvement; and*
- *other relevant factors, such as quality control activities, resources, and staff training.*

Not all of these topics need to be addressed at each management meeting, however, the Quality Manager should keep a record of each item discussed to assure that all areas are reviewed on an on-going basis. Management meetings may be conducted in person, by conference call, or online depending upon the specific needs of a plant.

Annual management meetings should not preclude production and quality assurance personnel meeting on an ongoing basis to review the implementation of the quality system as necessary and applicable to each plant's process.

1.2.8 Auditing.

While a manufacturer's Quality Control Plan may contain adequate details describing production and quality control procedures, it is necessary that they be properly implemented in order to assure quality products are produced on a consistent basis. At least one audit must be conducted by an independent third-party not associated with the plant as part of the initial certification and recertification requirements (See Section 7). Each facility must define internal auditing requirements. The independent audit must cover all aspects of the Quality Control Plan. A written report documenting the Quality Control Plan activities audited, audit findings, and corrective actions to address non-conforming items must be prepared. Subsequent audits must review prior corrective actions to ensure that the issues have been resolved and proper preventative measures have been implemented.

Commentary – This program requires that each facility define within their Quality Control Plan the frequency in which internal audits are conducted. It is strongly recommended that internal audits be conducted prior to external audits to help ensure that records and related documentation is in place and the Quality Control Manager is prepared for the external audit.

1.2.9 Auditor Qualifications.

The Quality Manager is responsible for designating an individual(s) to perform the internal audit. The designated individual(s) must be trained and knowledgeable about the plant's Quality Control Plan, and as much as feasibly possible and practical, independent of the quality control program. The Quality Manager must contract an independent third-party to perform an external audit of the plant's Quality Control Plan as part of the initial certification and recertification requirements (See Section 7). The external auditor must be certified to conduct audits by the American Society for Quality, or equivalent nationally recognized auditor certification program.

Commentary – Depending upon a plant's specific staffing needs and size, it is not always possible to select an internal auditor that is completely independent of the plant's quality control program. In some cases it is only practical for the Quality Manager to perform the internal auditor duties.

1.2.10 Safety.

While the adoption and implementation of a safety program is an essential component of the manufacturing environment, this program does not address plant safety. Some agencies may require that plants have an active safety and health program for all production personnel.

Section 2 – Product Identification

Each cube of units must be capable of being identified with, as a minimum, the following information: company name, plant name, product name or description, and lot number or similar unique and traceable identification.

Section 3 – Sampling and Testing

The quality control processes performed to assess the finished product(s) produced by a plant consist of two parts: 1) those performed internally by the plant on an ongoing basis to assess product quality; and 2) those performed periodically by a laboratory to verify in-house assessment procedures or to document the physical properties of the finished product(s).

3.1 – Quality Control

The producer must implement procedures to monitor the quality of the finished products being manufactured on an ongoing basis that at a minimum meet the requirements of this section. If the governing specification requires additional testing or assessment, such tests must be performed as required.

3.1.1 Assessment

The Quality Control Plan must define the processes and procedures used by the facility to evaluate or measure characteristics or properties of products, and where necessary develop correlations between assessed properties and standardized properties.

Commentary – The assessment provisions of Section 3.1.1 allow for the producer to define internal practices to achieve a consistent level of quality in a finished product. This may include options such as

in-line or in-house assessment of properties or characteristics that are correlated to a given property of a finished product. Through this process, the Quality Control Plan must define what measurements are being taken and how they are obtained, the frequency of those measurements, and correlations or comparisons to standardized properties and/or procedures.

3.1.2 Frequency

The Quality Control Plan must define the frequency for which properties are assessed or measurements are taken for the internal practices adopted.

Commentary – The performance assessment approach of Section 3.1.2 does not define a minimum testing or assessment frequency. This practice must be defined by the producer for the property being measured. For example, it is impossible to conduct compressive strength evaluation on each unit produced. It is possible, however, to weigh pallets of product in-line on an on-going basis and define an internal procedure correlating unit or pallet weight to another physical property.

3.1.3 Verification

The Quality Control Plan must define procedures to verify correlations established between assessed properties obtained under Section 3.1.1 and standardized properties obtained through ASTM procedures. Such verification must be conducted at a frequency necessary to establish confidence in the correlation(s), but not less than annually.

4.0 –Control of Non-Conforming Products

If the test results for a sample indicate a product does not meet the specification requirements, a second sample (herein referred to as ‘check sample’) is to be immediately obtained by the Quality Manager.

If the check sample indicates the product meets the specification requirements, the Quality Manager is to identify and record on the test report form what was determined to be the reason for the original failure and then may resume normal testing procedures.

If the check sample indicates the product does not meet the specification requirements, the Quality Manager is to initiate an investigation to determine the cause of the failure. The investigation is to include a review of the sampling procedures, the equipment used in the production and the testing of the product, and the testing procedures of the individual performing the test. If the cause(s) can be attributed to one of the above categories, the Quality Manager is to take corrective action to bring the product, equipment, or procedure into compliance. The Quality Manager is to then record the corrective action on the test report form and take another check sample after the corrections have been made.

If the second check sample indicates the product meets the specification requirements, the plant may resume normal production, sampling, and testing procedures.

If the second check sample indicates the product does not meet the specification requirements, the Quality Manager must separate the non-conforming product. Non-conforming product that has been shipped must be recalled, replaced, or otherwise resolved to the satisfaction of the customer. The Quality Manager is to continue the investigation into these failures until such time as the cause(s) of the failure have been identified and resolved to the satisfaction of the Quality Manager.

Section 5 – Laboratory Qualifications

Laboratories performing testing on final products in accordance with ASTM or CSA standards shall be accredited under ASTM C1093, or equivalent.

Section 6 – Constituent Material Acceptance

The Quality Control Plan must include procedures for receiving, handling, and storing materials including receipt, evaluation, and filing of certification records when required to assure the quality of each of the materials used in production. Indicate the basis of acceptance required for each material. The procedures should be documented in the Component Material Acceptance section of the Quality Control Plan per Section 1.2.3.

Commentary – This program does not stipulate or require a minimum assessment or testing frequency for constituent materials used in the production of manufactured concrete products. Any quality control program implemented at a plant will need to assess and quantify the materials used in production; the magnitude and frequency of which will vary depending upon the source of materials and how they are used in production. For example, sieve analysis should be a standard practice for aggregates received and used in production

Section 7 – Certification Process

7.1 Initial Program Certification

Plant's wishing to be certified under this program must contract with an independent, third-party auditor (with credentials according to Section 1.2.9) who will review the Quality Control Plan implemented to verify that the facility's quality control program meets the requirements of this program. The contracted auditor will submit a report in writing to the plant, ICPI, and NCMA summarizing the findings and recommending whether the plant is eligible for certification or if corrective actions are required before certification can occur. If non-conformities are reported by the auditor, corrective action and objective evidence of correction shall be supplied to the auditor, who will notify NCMA and ICPI of satisfactory corrective action(s). Based upon the findings of an independent, third-party auditor, NCMA and ICPI will issue a certificate, valid for one year from the date on the letter from the auditor, certifying the plant for participation in the program.

7.2 Program Recertification

Prior to the end of certification, the plant will again contract with an independent third-party auditor to audit the plant's documentation to verify that the requirements of the Quality Control Plan are being followed continuously. The contracted auditor will submit a report in writing to the plant, ICPI, and NCMA summarizing the findings and recommending whether the plant is eligible for recertification or if corrective actions are required before recertification can occur. Letters from auditors will be accepted with dates up to one month before the certification expiration date until three months following the expiration date. Recertification is valid for 2 years, dated from the previous certification expiration date. Plants that allow their certification to lapse must reapply for certification under Section 7.1 of this program.