PCI™ Precast/Prestressed Concrete Institute

Quality Control Technician/Inspector Level I & II Training Manual

TM-101

Fifth Edition

QUALITY CONTROL TECHNICIAN/ INSPECTOR LEVEL I & II TRAINING MANUAL

TM-101

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PCI
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Quality Control Technician/Inspector Level I & II Training Manual,
TM-101

Fifth Edition, First Printing

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Foreword

This is the fifth edition of the *Quality Control Technician/Inspector Level I & II Training Manual* published by the Precast/Prestressed Concrete Institute (PCI) and known as TM-101. The first edition was published in 1987. It was the initial baseline for training for the original personnel certification program for plant quality control personnel, which was called the Technician/Inspector Certification Program. Personnel certification began in 1984, with the first Level I Certification awarded at the beginning of 1985.

Members of the PCI Personnel Training and Certification Committee wrote this manual and members of the Quality Personnel Training Committee edited the fourth edition. Committee members writing the original manual and editing subsequent editions were:

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**Member of the second Revision Committee

Dedication

This manual is dedicated to Dino Scalia, who died suddenly in 2001. Dino was the first chair of the Personnel Training and Certification Committee and was the driving force behind the original Quality Control Technician/Inspector Certification Program. He was an active participant and a motivator for our committee, and his contributions to this manual were invaluable. He will be missed.

Introduction
TM-101, Fifth Edition

Layout and organization of this manual

This training manual is intended to assist persons as they work to understand and implement the requirements of the Precast/Prestressed Concrete Institute (PCI) Plant Certification Quality Control Programs. Those requirements are defined by standards and explained by commentary in the plant quality control manuals PCI MNL-117, *Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products*, and PCI MNL-116, *Manual for Quality Control for Plants and Production of Structural Precast Concrete Products*. This training manual is designed to explain how to implement the requirements of the plant quality control programs and further explain what they mean.

This manual is also designed as a self-study guide for persons preparing to take the Level I and Level II Plant Quality Personnel Certification examinations.

- **Level I Certification** covers basic material that should be understood by all quality control personnel.
- **Level II Certification** covers Level I material and also more advanced concepts that should be understood by experienced quality control personnel, especially those at structural plants. All of the information tested exclusively at Level II is identified throughout this text by double lines to the right of the text (as shown here).

Review questions are included at the end of each chapter to assist in understanding the material and preparing for both of the certification examinations. These questions are identified for Level I and Level II. Answers and solutions to all of the review questions are in Appendix D.

NEW FOR THE FIFTH EDITION

In this latest edition of TM-101, this training manual aligns itself with the updated plant certification manuals, MNL-116 and MNL-117. The chapter and section numbers in this text match the chapter and section numbers in the plant certification manuals.

In addition Level I and Level II *personnel* certification requirements align with the various PCI *plant* certification categories that require training. We have reorganized the material that is classified Level I and Level II, moving all of the prestressing information in Chapter 5 of this manual into Level II. As a result, you will not find any prestressing calculations or definitions on any Level I exam.

This does not change any current PCI certification - if you are already Level I certified, then you are still a qualified PCI Level I Quality Control Technician. Level I technicians are still required to understand concrete and conventional reinforcement. We will add prestressing at Level II.

PCI Certification Programs

PCI has three certification programs:

- Plant Certification
- Plant Quality Personnel Certification
- Erector Qualification & Certification

Plant certification began in 1967 with 36 U.S. plants certified in one general category. At the time of publication of this edition of TM-101, there were approximately 280 precasting plants certified by PCI in the Untied States, Canada, and Mexico.

PCI Plant Certification is available in four different product groups:

Group A – Architectural Products*
Group B – Bridge Products
Group C – Commercial Products
Group G – Glass-Fiber-Reinforced Concrete (GFRC) Products

* Subgroups BA and CA address bridge and commercial products with architectural finishes, respectively

A more complete description of all groups and categories is available from PCI.

The mandatory requirements for PCI Plant Certification are contained in separate manuals:

- *Manual for Quality Control for Plants and Production of Structural Precast Concrete Products*, PCI MNL-116
- *Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products*, PCI MNL-117
- *Manual for Quality Control for Plants and Production of Glass-Fiber-Rein-forced Concrete Products*, PCI MNL-130

This training manual relates to the requirements contained in the structural (MNL-116) and architectural (MNL-117) quality control manuals only. The production and quality control of GFRC, which is covered in PCI MNL-130, is beyond the scope of this manual.

Training of quality control personnel employed by or working with precasting plants has always been an important part of the PCI Plant Certification Program. PCI member plants are required to employ at least one person at the plant who is certified by the Plant Quality Personnel Certification Program.

- For plants that do not prestress, at least one individual performing quality control functions shall be certified as Level I in the PCI Plant Quality Personnel Certification (PQPC) program.
- For plants that prestress, at least one individual performing quality control functions shall be certified as Level II in the PQPC program.
- At least one individual involved in the testing of fresh concrete (or directing such tests) shall maintain a current ACI Concrete Field Testing Technician, Grade I Certification or approved equivalent certification.

Plant Quality Personnel Certification

This program began in 1985 when PCI created the Technician/Inspector Certification Program, with one level of certification. A second level of certification was added in 1987, and Level III certification was added in 1995. This manual is for Levels I and II certifications only. The training manual for Level III is a separate document, TM-103.

A detailed listing of requirements for PCI Plant Quality Personnel Certification is contained in section 28 of the *PCI Policies and Procedures Manual*. The following is a summary of some of the requirements.

- **Level I** requires a candidate to have at least six months of experience in a precasting plant, pass a timed examination with a score of 70% or higher, and be certified by ACI as a Field Testing Technician, Grade I. Certification is valid for five years from the date of the PCI Level I Certification examination.
- **Level II** requires a candidate to have at least one year of experience in a precasting plant, pass a timed examination with a score of 70% or higher, hold a current PCI Level I Certification, and be certified by ACI as a Field Testing Technician, Grade I. Certification is valid for five years from the date of the PCI Level II Certification examination.
- **Level III** requires a candidate to have at least two years experience in a precasting plant, attend a Level III Training School, pass a timed examination with a score of 70% or higher, and hold a current PCI Level II Certification. Certification is valid for life, with re-registration required every five years.

ACI Certification

The ACI Field Testing Technician Grade I Certification must be obtained from an ACI local chapter or affiliate organization. Some state departments of transportation and other organizations have equivalent or similar programs that may be acceptable. Certification requires passing a written test and a practical field test covering the following ASTM Standards:

- ASTM C31 *Standard Practice for Making and Curing Concrete Test Specimens in the Field*
- ASTM C138 *Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete*
- ASTM C143 *Standard Test Method for Slump of Hydraulic-Cement Concrete*
- ASTM C172 *Standard Method of Sampling Freshly Mixed Concrete*
- ASTM C173 *Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method*
- ASTM C231 *Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method*
- ASTM C1064 *Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete*

Field Certification

PCI's field certification program began in 1999 and has grown to a program that certifies the capability of precast concrete erectors. Each member company must have all of its primary erection crews audited twice a year by a PCI-Certified Field Auditor. A PCI-Certified Company Auditor also audits each company's quality and safety records once a year. Contact PCI for more information about this program.

DEFINITIONS

Abutment – A stationary anchorage system that is independent of bed or casting mold, used to withstand tensioning loads with various strand patterns; the structure against which the tendons are stressed and anchored.

Accelerated Curing – The intentional addition of heat to the concrete environment to expedite curing. For the systems described in this manual, all curing is at atmospheric pressure.

Admixture – A material other than water, aggregates, hydraulic cement, and fiber reinforcement used as an ingredient in concrete, mortar, or grout and added to the batch immediately before or during its mixing to modify the properties of the fresh or hardened concrete.

Aggregate – Granular material, such as sand, gravel, and crushed stone, used with a cementing medium to form a hydraulic-cement concrete or mortar.

Aggregate Aspect Ratio – The ratio of length to width of individual pieces of coarse aggregate. This ratio sometimes affects the characteristics of conventional and self-consolidating concretes.

Aggregate, Structural Lightweight – Aggregate with a dry, loose density of 70 lb/ft^3 (1120 kg/m^3) or less.

Air-Entraining Admixture – A chemical added to the concrete for the purpose of providing minute bubbles of air (generally smaller than 1 mm) in the concrete during mixing to improve the durability of concrete exposed to cyclical freezing and thawing in the presence of moisture.

Ambient Temperature – The temperature of the air surrounding the forms and molds into which concrete is to be cast, or of the air surrounding an element during casting.

Anchorage – The means by which the prestressing force is permanently transmitted from the prestressing steel to the concrete. In post-tensioning applications, a mechanical device comprising all components required to anchor the prestressing steel and transmit the prestressing force to the concrete.

Architectural Precast Concrete – A precast concrete product with a specified standard of uniform appearance, surface details, color, and texture. Tolerances for architectural precast concrete products are generally more stringent than for structural products.

Architectural Precast Concrete Trim Units – Wet-cast concrete products with a high standard of finish quality and of relatively small size that can be installed with equipment of limited capacity. Includes units such as sills, lintels, coping, cornices, quoins, medallions, bollards, benches, planters, and pavers.

Assembly Drawings – See Hardware Details.

Backup Mixture – The concrete cast into the mold after the face mixture has been placed and consolidated.

Bed – Usually a permanent part of the plant infrastructure that may include abutments for prestressing and a form for casting.

Bleed Water – The water that rises to the surface of freshly placed conventional or self-consolidating concrete.

Blocking – (1) Materials used for keeping concrete elements from touching each other or other materials during storage and transportation. (2) The condition in which pieces of coarse aggregate combine to form elements large enough to obstruct the flow of the fresh concrete between the reinforcing steel or other obstructions in the concrete formwork.

Bond Breaker – A substance placed on a material to prevent it from bonding to the concrete or between a face material, such as natural stone, and the concrete backup.

Bonded Tendon – Prestressing tendon that is bonded to concrete either directly or through end anchorage and grouting.

Bonding Agent – A substance used to increase the bond between an existing piece of concrete and a subsequent application of concrete, such as a patch.

Bowing – An overall out-of-planeness condition where two parallel edges of the panel are in the same plane and the portion of the panel between the edges is out of plane.

Bull Float – A tool comprising a large, flat, rectangular piece of wood, aluminum, or magnesium that is usually 8 in. (200 mm) wide and 42 in. (1070 mm) to 60 in. (1520 mm) long, and that has a handle 4 ft (1220 mm) to 16 ft (4880 mm) in length used to smooth the unformed surfaces of freshly placed concrete.

Bugholes – Small holes on formed concrete surfaces formed by air or water bubbles, sometimes called blowholes.

Bundled Strand – Strands that are grouped together in a bundle to concentrate the prestressing force. Bundled strand are in contact with each other and must be splayed out to the end of the member to allow bond to develop with each strand from the end to the bundle point.

Bundling – The practice of placing several parallel elements of reinforcement in contact with each other.

Calibration – The testing of a system by loading to determine accuracy as checked against a National Bureau of Standards certified load cell or proving ring.

Camber – The deflection that occurs in prestressed concrete elements due to the net bending resulting from application of a prestressing force (not including dimensional inaccuracies).

Certification – Assurance by a competent third-party organization, operating with objective criteria and that is not subject to undue influences from the manufacturer or purchaser or to financial considerations, that elements are consistently produced in conformity with specification. It not only proclaims compliance of a product with a specification, but also that the manufacturer's quality control arrangements have been approved and that a continuing audit is carried out.

Clearance – Interface space (distance) between two items. Clearance is normally specified to allow for the effects of product and erection tolerances and for anticipated movement, such as deflection, volume-change movement, and the like.

Clear Distance – The least distance between the surface of the reinforcement and the referenced surface. The referenced surface may be the form, adjacent reinforcement, embedments, concrete surface, or other surfaces.

Coarse Aggregate – Aggregate predominately retained on the U.S. Standard no. 4 sieve; that portion of an aggregate retained on the no. 4 sieve.

Compaction – The process whereby the volume of the concrete is reduced to the minimum practical space by the reduction of voids usually obtained through vibration, tamping, or a combination of both.

Connection – Device for the attachment of precast concrete units to each other, to the building, or to the structure.

Consolidation – The process of inducing a closer arrangement of the solid particles in freshly mixed concrete or mortar during placement by vibration, centrifugation, rodding, tamping, or some combination of these actions. In self-consolidating concrete, consolidation occurs by gravity flow of the material.

Cover – The distance between the surface of the reinforcement and the nearest concrete surface.

Covermeter – See R-meter.

Crazing – A network of visible, fine, hairline cracks in random directions breaking the exposed face of a panel into areas ranging from $^1/_4$ in. to 3 in. (6 mm to 75 mm) across.

Creep – The time-dependent dimensional change, usually shortening or camber change, that takes place as a result of sustained compression loading and for prestress force on concrete elements.

Curing – The maintenance of humidity and temperature of freshly placed concrete during some defined period following placing, casting, or finishing to ensure satisfactory hydration of the cementitious materials and proper hardening of the concrete; where the curing temperature remains in the normal environmental range (generally between 50 ºF [10 ºC] and 90 ºF [32 ºC]), use the term normal curing; where the curing temperature is increased to a higher range (generally between 90 ºF [32 ºC] and 150 ºF [66 ºC], use the term accelerated curing.

Deflected Strand – Strand that is deflected from a straight-line position in a member to enhance the moment-resisting capacity of the member. Deflected strand may be spaced apart or bundled together. If bundled at a point, the strand must be splayed out from the bundle to the end of the member to develop bond on each strand.

Detensioning of Strand or Wire – The transfer of strand or wire tension from the bed anchorage to the concrete.

Detensioning Strength – The strength of the concrete cast on a particular line at the time the prestressing force is transferred.

Dimensions – The following are several different categories of dimensions relevant to precast concrete fabrication.

Actual dimensions – The measured dimensions of the precast concrete member after casting.

Basic dimensions – The dimensions shown on the contract drawings or called for in the specifications; also called the nominal dimension.

Working dimensions – The planned dimension of the precast concrete member obtained from its basic dimensions, joint or clearance dimensions, and other adjustments. For example, a double-tee with a basic dimension of 8 ft 0 in. (2438 mm) and a joint width of 1 in. (25 mm) on both sides would have a working dimension of 7 ft 11 in. (2413 mm).

Draft – The taper given to features of a mold or form to allow the precast concrete piece to be removed from the mold or form without damage.

Dry-Mix Concrete – Concrete designed with low water-cement ratios and slumps; often referred to as zero slump concrete.

Dunnage – Materials used for keeping concrete elements from touching each other or other materials during storage and transportation.

Dynamometer – A device that will measure the tension applied to it when connected between two tensile forces.

Elastic Shortening – The shortening of a member that occurs immediately after the application of the prestressing force.

Elongation – Increase in length of the prestressing steel (strand) under the applied prestressing force.

Erection Drawings – Drawings that show the relationship of the precast concrete members and their connections in the erected structure and provide information necessary to properly erect and connect the various members.

Exposed-Aggregate Concrete – Concrete manufactured so that the aggregate protrudes from the face of the member.

Face Mixture – The concrete at the exposed face of a unit used for specific appearance purposes.

Fine Aggregate – Aggregate passing the $^{3}/_{8}$ in. (10 mm) sieve and almost entirely passing the no. 4 sieve and predominately retained on the no. 200 sieve; or that portion of an aggregate passing the no. 4 sieve and predominately retained on the no. 200 sieve.

Fineness Modulus – See Section 6.2.3 of this training manual.

Flatness – The degree to which a surface approximates a plane; see Smoothness.

Flowability – The ability of fresh concrete to flow in a confined or unconfined form of any shape, reinforced or not, under gravity and/or external forces and assuming the shape of its container.

Fly Ash – A finely divided residue with pozzolanic properties that results from the combustion of ground or powdered coal and is transported by flue gasses.

Form – The container or surface against which fresh concrete is cast to give it a desired shape; sometimes used interchangeably with mold. (The term *mold* is used in this manual for custom-made forms for specific jobs, while *form* is used for standard forms or forms of standard cross section.)

Formed Surface – A concrete surface that has been cast against a formwork.

Form-Release Agent – A substance applied to the form or mold for the purpose of preventing bond between the form or mold and the concrete placed in it.

Friction Loss – In post-tensioning applications, the stress (force) loss in a prestressing tendon resulting from friction created between the strand and sheathing due to curvature or wobble in the tendon profile during stressing.

Gap-Graded Concrete – A mixture with one or a range of normal aggregate sizes eliminated, and/or with a heavier concentration of certain aggregate sizes over and above standard gradation limits. It is used to obtain a specific exposed-aggregate finish.

Grout – A mixture of cementitious materials and water, with or without sand or admixtures.

Hardware – Items used in connecting precast concrete units or attaching or accommodating adjacent materials or equipment. Hardware is normally divided into three categories:

Contractor's hardware – Items to be placed on or in the structure in order to receive the precast concrete units, such as anchor bolts, angles, or plates with suitable anchors.

Plant hardware – Items to be embedded in the concrete units themselves, either for connections and precast concrete erector's work, or for other trades, such as mechanical, plumbing, glazing, miscellaneous iron, masonry, or roofing trades.

Erection hardware – All loose hardware necessary for the installation of the precast concrete units.

Hardware Details – Drawings that are used for the fabrication or procurement of hardware that is used either in the production of the precast concrete member or in its erection and connection; also called assembly drawings.

Harped Strand – Strand partially tensioned in the lowest position along the length of the member and subsequently lifted or harped at the ends of a member to enhance the moment capacity at the center of the member. This can reduce the applied stresses at the end of the member by reducing the total amount of prestress necessary to resist the applied load.

Heat of Hydration – Heat generated by the chemical reaction of the cementious materials and water in the concrete.

High-Range Water-Reducing Admixture – An additive to the concrete that is capable of producing large water reduction or great flowability without undue set retardation and without requiring the addition of water.

Homogeneous Mixture – A uniform concrete used throughout a precast concrete element.

Honeycomb – Stony or void areas in concrete due to incomplete consolidation or paste leakage from the form; may vary in size from small to large.

Initial Prestress – The stress (force) in the prestressing tendon immediately after transferring the prestressing force to the concrete.

Initial Set – The point at which the concrete mixture reaches a strength of 500 psi. (3.45 MPa) as determined by ASTM C403; see Preset Time.

Initial Strand Slippage – Slippage of strand into concrete at ends of products when the bed is initially detensioned.

Jacking Force – The maximum temporary force exerted by the jack while introducing the prestressing force into the strand.

Jaws –See Wedges.

Jig – A template or device to align parts of an assembly, usually for preassembling reinforcing steel and hardware cages, with a minimum of measurement to attain consistent accuracy from one cage to the next.

J-Ring Test – Test used to determine the passing ability of self-consolidating concrete, or the degree to which the passage of concrete through the bars of the J-ring apparatus is restricted.

K-Test – Test of filling ability using a box shaped like the bottom half of a concrete I-girder, with a series of obstacles simulating reinforcing bars or prestressing strands. The side of the box is made of acrylic glass to allow visual assessment of filling ability.

Laitance – Residue of weak and non-durable material consisting of cement, fine aggregate, or impurities brought to the surface of fresh concrete by bleed water.

L-Box Test – Test of horizontal and confined flowability of self-consolidating concrete.

Lifting Frame (or beam) – A rigging device designed to provide two or more lifting points of a precast concrete element with a predictable load distribution and prearranged direction of pulling force during lifting.

Lightweight Structural Concrete – Structural concrete made with lightweight aggregate with an air-dry density of the concrete in the range of 90 lb/ft^3 (1440 kg/m^3) to 115 lb/ft^3 (1840 kg/m^3) and a 28-day compressive strength of more than 2500 psi. (17 MPa).

Load Cell – Sensitive, electrically operated strain gauges attached to a calibrated cell to provide direct readings of compressive loads applied to the cell.

Loss of Prestress – The reduction of the prestressing force resulting from the combined effects of the prestressing steel, creep and shrinkage in the concrete, and elastic deformation.

Low-Relaxation Strand – Strand produced in accordance with ASTM A416 (supplement) that has relaxation loss limited by its method of manufacture.

Lubricate – To coat with a substance for the purpose of decreasing friction.

Machine-Cast Products – Products cast by one or more machines specifically designed for the purpose. Slipform and extrusion machines are types of equipment used to make solid or hollow-core slabs.

Mark Number – The individual identifying mark assigned to each precast concrete unit, designating its position in the building.

Master Gauge – A pressure gauge that has a minimum diameter of 8 in. and is calibrated every six months, used to check and/or monitor production gauges.

Master Mold – A mold that allows a maximum number of casts per project; units cast in such molds need not be identical, provided the changes in the units can be simply accomplished as pre-engineered mold modifications.

Matrix – The portion of the concrete containing only the cement and fine aggregates.

Metakaolin – Mineral admixture sometimes used to increase the powder content of concrete; also used to reduce efflorescence.

Miter – An edge that has been beveled to an angle other than 90 degrees.

Modulus of Elasticity – Ratio of normal stress to corresponding strain for tensile or compressive stresses within the elastic limit of the material.

Mold – The container or surface against which fresh concrete is cast to give it a desired shape; sometimes used interchangeably with form. (The term *mold* is used in this manual for custom-made forms for specific jobs, while *form* is used for standard forms or forms of standard cross section.)

Mortar Halo – A concentration of mortar that can form at the perimeter of the slump-flow patty. The width of this halo is one of the parameters evaluated in the visual stability index test used to judge the stability of fresh self-consolidating concretes.

Pattern or Positive – A replica of all or part of the precast concrete element sometimes used for forming the molds in concrete or plastic.

Plastic Shrinkage Cracking – Short cracks, often varying in width along their length, that occur in the surface of fresh concrete soon after it is placed and while it is still plastic.

Post-Tensioning – A method of prestressing concrete whereby the tendon is kept from bonding to the fresh (wet) concrete, then elongated and anchored directly against the hardened concrete, imparting stresses through end bearing. Post-tensioning tendons can either be unbonded (in a grease-filled sleeve) or bonded (encased in a duct that is grouted after the tendon is stressed).

Precast Specialty Engineer – The person or firm who designs precast concrete members for specified loads and who may also direct the preparation of the precast concrete shop drawings.

Preset Time – The time after mixing required to reach initial set (500 psi. [3.45 MPa]); see Initial Set.

Pretensioning – A method of prestressing concrete whereby the tendons are elongated and then anchored before the concrete in the member is cast around the tendons. The tendons are then released when the concrete is strong enough to receive the forces transferred from the tendon to the cured concrete through bond. Once the prestress force is transferred to the concrete member, the member will shorten and possibly camber.

Production Drawings – A set of instructions in the form of diagrams and text that contains all of the information necessary for the manufacturer to produce the unit.

Proving Ring – An elastic, alloy-steel ring used to calibrate or measure loads. A dial indicator inside the ring measures deflection under load, and calibration curves enable direct determination of the load. Standard high-capacity rings, certified by the National Bureau of Standards and accurate to 0.1 of 1%, are used to calibrate mechanical-force-measuring systems.

Quality – The appearance, strength, and durability that is appropriate for the specified product, its particular application, and its expected performance requirements. The totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs.

Quality Assurance – All those planned or systematic actions necessary to ensure that the final product or service will satisfy given requirements for quality and perform its intended function.

Quality Control – Those actions related to the physical characteristics of the materials, processes, and services, which provide a means to measure and control the characteristics of manufactured elements to predetermined, quantitative criteria.

Quality System Manual – A plant-specific manual documenting every item of the quality assurance program. It must conform to the PCI guidelines for its development.

Quirk Miter – A corner formed by two chamfered members to eliminate sharp corners and ease alignment.

Relaxation – The loss of stress in a prestressed steel strand that occurs over time due to the realignment of the steel properties while the strand is under stress.

Retarder – An admixture that delays the setting of cement paste and, therefore, of concrete.

Retempering – The addition of water or admixture and remixing of concrete that has started to stiffen in order to make it more workable.

Return – A projection that angles away from the main face of plane of view.

Reveal – Groove in a panel face generally used to create a desired architectural effect; the depth of exposure of the coarse aggregate in the matrix after production of an exposed-aggregate finish.

R-Meter – An electronic device used to locate and determine the size of reinforcement in hardened concrete.

Rustication – A groove in a panel face for architectural appearance; see also Reveal.

Sandwich Wall Panel – A prefabricated panel, which is a layered composite, formed by attaching two wythes or skins of concrete separated by an insulating core.

Scabbing – A finish defect in which parts of the form face, including release agent, adhere to the concrete. Some probable causes are an excessively rough form face, inadequate application of release agent, or delayed stripping.

Scouring – Irregular, eroded areas or channels with exposed stone or sand particles. Some probable causes of this finish defect are excessively wet concrete, insufficient fines, water in the form when placing the concrete, poor vibration practices, and low temperature when placing the concrete.

Sealer – A clear chemical compound that may be applied to the surface of precast concrete units for the purpose of improving weathering qualities or reducing water.

Segregation – The tendency for the coarse particles to separate from the finer particles during handling. In concrete, the coarse aggregate and drier materials remain behind and the mortar and wetter material flow ahead. This can also occur in a vertical direction when wet concrete is over-vibrated or dropped vertically into the forms, the mortar and wetter material rise to the top. In aggregate, the coarse particles roll to the outside edges of the stockpile.

Self-Consolidating Concrete (SCC) – A highly workable concrete that can flow through densely reinforced or geometrically complex structural elements under its own weight and adequately fill voids without segregation or excessive bleeding and without the need for vibration.

Self-Stressing Form – A form provided with suitable end bulkheads and sufficient cross-sectional strength to resist the total prestressing force.

Settlement – The condition in which the aggregates in self-consolidating concrete tend to sink to the bottom of the form, resulting in non-homogeneous concrete.

Setup – The process of preparing molds or forms for casting, including installation of materials (reinforcement and hardware) prior to the actual placing of concrete.

Sheathing – A covering that forms an enclosure around the prestressing steel to avoid temporary or permanent bond between the prestressing steel and the surrounding concrete.

Shop Drawings – Collective term used for erection drawings, production drawings, and hardware details; diagrams of precast concrete members and their connecting hardware, developed from information in the contract documents. They show information needed for both field assembly (erection) and manufacture (production) of the precast concrete units.

Shrinkage – The volume change in precast concrete units caused by drying, normally occurring during the hardening process of concrete.

Silica Fume – A fine, pozzolanic material composed mostly of amorphous silica; a byproduct of the production of elemental silicone or ferrosilica alloys. This fine, inorganic material can be added to concrete to modify its mechanical and flowing properties.

Slump Flow – Test method used to measure the unconfined flow and judge the stability of self-consolidating concrete.

Slump-Flow Spread – The numerical value in inches of flow determined as the average diameter of the circular deposit of self-consolidating concrete at the conclusion of the slump-flow test.

Smoothness – The absence of local irregularity or roughness.

Specially Finished Structural Precast Concrete – A product fabricated using forms and techniques common to the production of structural elements and defined in PCI's MNL-116, and having specified surface finishes that require uniformity and detailing more demanding than the requirements of MNL-116. These surface-finish requirements should be clearly specified and the ability to attain them should be verified with appropriate samples and mock-ups.

Spreader Beam – A frame of steel channels or beams attached to the back of a panel prior to stripping for the purpose of evenly distributing loads to inserts and for lifting the panel about its center of gravity.

Stability – The ability of self-consolidating concrete to remain homogeneous in composition by resisting actions that make the constituents separate from the mass during transport, placement, and after placement.

Stickiness – The property of concrete that causes it to adhere to finishing tools and other surfaces with which it comes in contact.

Strand – A group of wires laid helically over a central-core wire. A seven-wire strand is made of six outer wires laid over a single wire core.

Strand Anchor – A device for holding a strand under tension, sometimes called a strand chuck or vise.

Strand Chuck – A device for holding a strand under tension, generally consisting of a barrel, grooved jaws with an O-ring pulling them together, and a spring-equipped cap.

Strand Seating – The amount of movement by a tensioned strand into an anchorage chuck and its jaws as it is released from a tensioning ram and seated into the chuck under loading from initial to final tension.

Strand Slippage – Slippage of strand into the end of the product due to loss of bond with concrete.

Strand Splice – A mechanical method of connecting two lengths of strand together that will sustain the breaking strength of the strand.

Strand Stressing – Applying a specified force to a strand or tendon measured with a gauge and confirmed by measuring the strand elongation.

Strand Stringing – Installation of strands in a bed through the abutments and headers.

Stripping – The process of removing a precast concrete element from the form in which it was cast.

Strongback (Stiffback) – A steel or wooden member attached to a panel for the purpose of adding stiffness during handling, shipping, and erection.

Structural Precast Concrete – Precast concrete members that are intended to support external structural loads in addition to their own weight. They are fabricated using methods that are optimized to economically produce members with specified structural properties. Appearance requirements for these members are secondary to their structural requirements.

Superplasticizer – See High-Range Water-Reducing Admixture.

Surface Retarder – A material used to retard or prevent the hardening of the cement paste on a concrete surface to facilitate removal of this paste after curing. This is primarily used to produce an exposed-aggregate finish.

Sweep – A global variation in member horizontal alignment. This can sometimes be caused by horizontally eccentric prestress in narrow members or by temperature gradients through the element section.

Tendon – A high-strength steel element consisting of one or more wires, strands, or bars, or a bundle of such elements, used to impart prestressing forces to the concrete. In post-tensioning applications, it includes a complete assembly consisting of anchorages, prestressing steel (strand), corrosion-inhibiting coating, and sheathing.

Tolerance – Specified, permissible variations from stated requirements, such as dimensions, location, alignment, strength, and air entrainment.

Product tolerances – those variations in dimensions relating to individual precast concrete members.

Erection tolerances – those variations in dimensions required for acceptable matching of precast concrete members after erection.

Interfacing tolerances – those variations in dimensions associated with other materials in contact with or in close proximity to precast concrete.

Transfer – The act of transferring stress (force) in prestressing tendons from jacks or the pretensioning bed to the concrete member.

Transfer Strength – The minimum concrete strength specified for the individual concrete elements before the prestressing force may be transferred to them; also called detensioning strength or release strength.

U-Box Test – A U-shaped filling apparatus composed of two separate compartments used to measure the filling and passing ability of self-consolidating concrete.

Unbonded Tendon – A tendon in which the prestressing steel (strand) is prevented from bonding to the concrete. When unbonded tendons are used, prestressing force is permanently transferred to the concrete by only the anchorages.

Variation – The difference between the actual and the basic dimension. Variations may be either negative (less) or positive (greater).

Veneered Construction – The attachment of other materials, such as natural stone or clay products, to a concrete panel.

V-Funnel – A consistency-testing device used to provide a measurement of self-consolidating concrete flowability by determining the time for a measured amount of concrete to flow through a funnel of specific size and shape.

Viscosity – The measure of flowability of fresh concrete.

Viscosity-Modifying Admixture – A material that, when added to concrete, changes the viscosity and improves the stability of the mixture at a constant fluidity.

Visual Stability Index (VSI) Rating – A test involving the visual assessment of the slump-flow patty to evaluate several parameters as an indication of the stability of a self-consolidating concrete.

Warping – Twisting of a member, resulting in overall out-of-plane curvature of surfaces characterized by non-parallel edges.

Water to Cementitious Material Ratio (*w/cm*) – The ratio of the weight of free water in the concrete mixture to the weight of cementitious material.

Wedge (Jaws) – Piece of tapered metal with teeth that bites into the prestressing steel (strand) during transfer of the prestressing force. The teeth are beveled to ensure gradual development of the tendon force over the length of the wedge. These are standard internal portions of a strand chuck assembly.

Wedge Set – The relative movement of the wedges into the anchorage cavity during the transfer of the prestressing force to the anchorage.

Welding Procedure Specification (WPS) – The detailed methods and practices including all joint welding procedures involved in the production of a weldment.

Wet-Mix Concrete – Concrete designed for typical water-cement ratios, slumps, and handling and consolidation methods.

Workability – The ease with which a given set of materials can be mixed into concrete and subsequently handled, transported, placed, and finished with a minimum loss of homogeneity.

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Chapter 1 – Quality System

1.1 Objective

Quality control is a process of inspection, testing, and measurement that ensures that precast concrete members are produced in accordance with project requirements and specifications and plant standards. A plant's quality assurance program defines the quality control process.

Product quality must be consistent with the requirements of the established precaster's contract and project specifications. Quality control inspection and testing must be applied consistently and uniformly to all precast concrete manufacturing operations.

A quality control program is the set of actions and procedures by which top management's commitment to quality is implemented. The quality control program should be used as a tool for management to monitor the quality of its products. This program establishes a system of checks and balances for monitoring materials, operations, and products. Quality control personnel are not directly involved in manufacturing the products. Both the quality control program and the quality control personnel should be a normal part of plant operations.

1.2 Plant Quality Assurance Program

A quality assurance program includes the rules and procedures used to evaluate materials, procedures, and products for their conformance to plant and project standards. The PCI quality control manuals establish a basic set of requirements for a plant's quality assurance program.

Bridge and Commercial Products
Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, PCI MNL-116

Architectural Concrete Products
Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products, PCI MNL-117

Glass-Fiber-Reinforced Concrete (GFRC) Products
Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products, PCI MNL-130

The following list summarizes some of the most important quality control items:

1. Commitment of management to quality and implementation of a quality control program
2. Qualified personnel for all stages of design, production, and inspection
3. Testing and inspection of all materials used
4. Accurate, clear, and complete shop drawings
5. Monitoring product dimensions for specified tolerances
6. Accurate strand-tensioning procedures for prestressed products
7. Correct size and positioning of reinforcing bars and prestressing steel
8. Proper positioning of all embedded items
9. Proper proportioning and adequate mixing of concrete
10. Proper handling, placing, consolidating, and finishing of concrete
11. Appropriately controlled concrete-curing procedures
12. Proper procedures for detensioning strands in pretensioned members
13. Proper stripping procedures
14. Inspection for conformance with appearance standards and other dimensional requirements.
15. Implementation of appropriate correction of nonconformance items
16. Proper procedures for handling, storage, transportation, and erection
17. Complete records of inspections, testing, and equipment calibration
18. Certification of Material

1.2.1 General

The PCI quality control manuals (MNL-116, MNL-117, and MNL-130) require each plant to have a written plant quality system manual (QSM). The QSM must clearly define specific production tasks and personnel responsibilities to ensure uniformity in both plant operations and training for all employees. Highly varied tasks subject to human error or mistakes in judgment should be eliminated. The QSM should require regular meetings between quality control and production personnel to review information gathered during the quality control inspections. The goal is to identify and ensure the correction of improper production practices and equipment that need repair in order to achieve the required standard of quality.

The following items, as a minimum, must be included in the plant QSM:

- **Management commitment to quality**

  A quality assurance program is effective when the management of the precasting plant is committed to providing its customers with a quality product. If plant management consistently demonstrates its intention to manufacture quality products, plant personnel will accept the quality assurance program as a basic work requirement.

  A quality policy statement should focus and direct the quality system toward definite goals, giving the plant's personnel the motivation to develop and consistently implement the system. To the customers, the objectives are an expression to assure them that the plant will provide products that meet their needs.

- **Organizational structure and relationships, responsibilities, and qualifications of key personnel**

  To consistently produce quality products, all personnel must understand their responsibilities and their relationship within the entire plant team. This ensures that all requirements are met, and that each manufacturing activity is performed in proper sequence and according to accepted procedures.