PCI Precast/Prestressed Concrete Institute

Manual for Quality Control for Plants and Production of Structural Precast Concrete Products

MNL 116-21

Fifth Edition

Precast/Prestressed Concrete Institute
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First Edition, 1970
Second Edition, 1977
Second Edition, Second Printing, 1982
Second Edition, Interim Printing, 1984
Third Edition, 1985
Third Edition, Interim Printing, 1997
Third Edition, Interim Printing, 1998
Third Edition, Interim Printing, 1999
Fourth Edition, 1999
Fifth Edition, 2021

Library of Congress Control Number: 2021936622
Print book ISBN 978-1-7350062-3-9
Ebook ISBN 978-1-7350062-4-6
https://doi.org/10.15554/MNL-116-21

Cover photo: Rocky Mountain Prestress

Publisher's Cataloging-In-Publication Data
(Prepared by The Donohue Group, Inc.)

Names: Precast/Prestressed Concrete Institute, issuing body, publisher.
Title: Manual for quality control for plants and production of structural precast concrete products / Precast/Prestressed Concrete Institute.
Description: Fifth edition. | [Chicago, Illinois] : Precast/Prestressed Concrete Institute, 2021. | Originally published as: Manual for quality control for plants and production of precast prestressed concrete products. | "MNL 116-21-" | Includes index.
Identifiers: ISBN 9781735006239 (print) | ISBN 9781735006246 (ebook)
Subjects: LCSH: Precast concrete--Quality control--Handbooks, manuals, etc. | Concrete construction--Formwork--Quality control--Handbooks, manuals, etc.
Classification: LCC TA683.7 .M36 2021 (print) | LCC TA683.7 (ebook) | DDC 624.183414--dc23

Printed in the U.S.A.

FOREWORD

This is the fifth edition of PCI MNL 116, which was first completed in 1966. As in previous editions, the manual presents two parts concurrently: the Standards and Commentary. The Standards are on the left side of the page and the corresponding Commentary is on the right side for convenient reference. This revision was undertaken to update the manual to current standards.

The late William E. Dean, of Howard Needles Tammen Bergendoff and former Florida State Bridge Engineer, wrote the first manual. It was then reviewed by the PCI Technical Activities Committee and edited by PCI staff. After three years of experience with the PCI Plant Certification Program, the manual was revised and printed in 1970. The second edition in 1977 was developed by the PCI Plant Certification Committee to update references and standards as well as to incorporate certain revisions. In 1985, the third edition was developed and written by the consulting firm of Ross Bryan Associates Inc. under contract to PCI. The PCI Plant Certification Committee developed the fourth and fifth editions. Committee members who worked on the fifth edition are as follows:

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The Plant Certification Committee wishes to thank the consulting members of the committee who assisted in the development of this manual revision, and the American Concrete Institute and American Welding Society for the use of tables and diagrams from their publications.

†Deceased.

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INTRODUCTION

MNL 116, FIFTH EDITION

The Standards and Commentary are presented in a side-by-side column format with the Standards placed in the left column and the corresponding Commentary text aligned in the right column. The Standards have been printed in the same typeface as shown in this paragraph.

The Commentary is printed in the same typeface as shown in this paragraph. Additionally, a "C" precedes Commentary section numbers to help further distinguish the Commentary from the Standards.

The information in this manual is intended to serve as standards for quality control for the manufacture of precast concrete products and as a complete guide for the development of an internal manufacturing quality control program. The Standard portion serves as a specification reference document, while the Commentary provides additional information and discussions of the Standards. The manual was developed for plant-produced, precast concrete members, or precast, prestressed concrete members manufactured by the process of pretensioning, post-tensioning, or a combination of the two methods. The principles established herein are, however, applicable to site-cast precast concrete or prestressed concrete.

The manual was written by or under the direction of the PCI Plant Certification Committee. Pertinent information and requirements have been obtained from publications and standards of the Precast/Prestressed Concrete Institute (PCI), American Concrete Institute (ACI), Portland Cement Association (PCA), American Welding Society (AWS), U.S. Bureau of Reclamation, and other organizations. This, combined with experience gained through more than 50 years of operation of the PCI Plant Certification Program, has contributed to the development of the manual.

The fundamental intent of this manual is to provide a basis for establishing a satisfactory quality control program for general precast operations. It should be augmented, as required by the specifier or producer, for addressing specialized products and operations. The value of the manual, in regard to establishing a standard of quality that will be recognized and respected by the general public, depends on the appropriate application by the owner, designer, specifier, and producer.

Routine conformance to the requirements of the Standards should result in products of consistent and optimum quality when used with proven procedures. Optimum quality is considered the level of quality that appropriately satisfies the project requirements for intended use and economics of the product. Satisfactory conformance with the Standards in this manual is required for certification in the PCI Plant Certification Program for the Bridge and Commercial (Structural) Product Groups. For an explanation of the Program requirements and procedures, see Appendix D, PCI Plant Certification Program.

This manual is divided into two parts. The first part contains Divisions 1 through 7, which form the basis for PCI Plant Certification in Product Groups B and C, (Structural) Product Groups. It is conformance to these Standards that is audited during each PCI plant inspection and provides the criteria for evaluation of the plant's capabilities.

The final part, Appendices, contains summaries of useful information for both the manufacturer and specifier.

The dimensional tolerances referenced in Division 7 are contained in PCI MNL 135 and were developed by the PCI Tolerance Committee and approved by the PCI Technical Activities Council and PCI Board of Directors.

SPECIAL FINISHES

Standards for structural precast concrete products that are produced with architectural finishes and in accordance with the structural tolerances in this manual are included at the end of each division. Examples of such products are exposed columns and spandrel beams used on the exterior of parking structures. At the end of each division, only those sections that pertain to the application of special finishes are listed. The special provisions are identified with an "A" preceding the section number. The criteria established in this manual govern except as specifically modified by these special provisions for architectural finishes. The section numbers are the same as the corresponding section in the main portion of the Standards. Where a special provision for architectural finishes does not have a matching section for basic structural products, the provision is placed at the end of a section or the division with numbering continued sequentially. Conformance with these additional Standards has been recognized in the PCI Plant Certification Program by certification in two product categories. These Product Categories were designated as "Bridge Architectural" (BA) or "Commercial Architectural" (CA) within the Bridge Products and Commercial (Structural) Products Groups, respectively. With the implementation of the new architectural certification categories, these are now designated as Product Category AD. For descriptive information about the product groups and categories and the products and projects that are represented by these categories, visit the PCI website (www.pci.org).

This manual incorporates proven standards of practice that provide an acceptable level of quality, but there is no intent to place a ceiling on excellence. The degree of success in specifying and obtaining optimum quality for products will depend on the combined efforts of designers and manufacturers to define and coordinate their individual requirements, responsibilities and expectations.

No manual of this type can be all-inclusive. The requirements and recommendations given herein are a general presentation of the important factors governing the quality of structural precast concrete. Their value depends on rational application and a determination on the part of the individual producer to establish a standard of quality that will be recognized and respected by the specifier.

The Standard indicates the requirements to obtain an acceptable level of quality, but not the means or methods for doing so. It is not the intention of the manual to restrict individual plant techniques. For example, a manufacturer's methods for mixing, placement, consolidation, and curing of concrete will be acceptable, provided these methods can consistently result in uniform and durable concrete of the specified quality.

The information contained in the Commentary is not part of the Standards and shall not be used in judging quality control or production procedures.

The Commentary contains suggestions to help in carrying out the requirements or intent of the Standard.

This manual was been prepared on the basis of current good practice. As significant changes in materials or process technology occur, revisions will be made to this manual.

Note: The production of precast concrete may involve hazardous materials, operations, and equipment. This manual does not purport to address the safety issues associated with production. It is the responsibility of the producer to establish appropriate safety and health practices and determine the applicability of regulatory limitations.

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DEFINITIONS

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, and cement used as an ingredient in concrete, mortar, or grout to impart special characteristics.

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

Aggregate, structural lightweight – Aggregate with a dry, loose weight of 70 lb/ft^3 (1121 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 0.04 in. [0.04 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/molds into which concrete is to be cast, or of the air surrounding an element during curing.

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 product with a specified standard of uniform appearance, surface details, color, and texture.

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

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

Batching – The process of weighing or volumetrically measuring, and introducing into the mixer, the ingredients for a batch of concrete.

Bingham fluid – A fluid characterized by a non-null yield stress and a constant viscosity regardless of flow rate.

Bleeding – A form of segregation in which some of the water in a mixture rises to the surface of freshly placed concrete; also known as water gain.

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

Blocking – (SCC) 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 form/mold. This property is of increased importance in SCC because of the absence of vibration energy to dislodge these blockages.

Bondbreaker – 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.

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.

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

Bull float – A tool comprising a large, flat, rectangular piece of wood, aluminum, or magnesium usually 8 in. (200 mm) wide and 42 to 60 in. (1 to 1.5 m) long, and a handle 4 to 16 ft (1 to 5 m) in length used to smooth the unformed surfaces of freshly placed concrete.

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

Camber – (1) The deflection that occurs in prestressed concrete elements due to the net bending resulting from application of a prestressing force; It does not include dimensional inaccuracies. (2) A built-in curvature to improve appearance.

Central-mixed concrete – Concrete mixed in a central stationary mixer and delivered to the casting area by buckets, truck mixer, truck agitator or nonagitating truck.

Certification – Assurance by an authorized and competent third-party organization, based on objective criteria and not subject to undue influences from the manufacturer or purchaser, or to financial considerations, that a manufacturer has the capability to produce precast concrete products in conformity with PCI standards and project specifications.

Chuck – See **strand anchor**.

Chuck lift-off test – The process of applying force to a strand and documenting the force when the chuck is observed moving away from the supporting structure.

Clearance – Interface space (distance) between two items.

Coarse aggregate – Aggregate predominately retained on a U.S. standard no. 4 (4.75 mm) sieve; or that portion of an aggregate retained on a no. 4 (4.75 mm) sieve.

Cohesiveness – The tendency of the SCC concrete constituent materials to stick together, resulting in resistance to segregation, settlement, and bleeding.

Cold weather – A period when, for more than three consecutive days, the following conditions exist: (1) the average daily air temperature is less than 40°F (5°C) and (2) the air temperature is not greater than 50°F (10°C) for more than one-half of any 24-hour period. The average daily temperature is the mean of the highest and lowest temperature occurring during the period from midnight to midnight.

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 – A device for the attachment of precast concrete units to each other or to the building or structure.

Covermeter – See **R-meter**.

Crazing – A network of visible, fine hairline cracks in random directions breaking the exposed face of a panel into areas from 1/4 to 3 in. (6 to 75 mm) across.

Creep – The time-dependent deformation (shortening) of prestressing steel or concrete under sustained loading.

Curing – The maintenance of moisture and temperature within freshly placed concrete during some defined period following placing, casting, or finishing to assure satisfactory hydration of the cementitious materials and proper hardening of the concrete.

Deflected strand – Strand that is deflected from a straight-line position in a member to enhance the moment-resisting capacity of the member. Deflected strands may be spaced apart or bundled together. If bundled at a point, the strands 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.

Draft – The slope of concrete surface in relation to the direction in which the precast concrete element is withdrawn from the mold; it is provided to facilitate stripping with a minimum of mold breakdown.

Dunnage – See **blocking**.

Dynamic stability – A characteristic of a fresh concrete mixture that ensures uniform distribution of all solid particles and air voids as the concrete is being transported and placed. Dynamic stability provides an indication of passing ability and blocking resistance. It also provides a measure of segregation resistance to prevent segregation resulting from energy inputs during placement and transport (such as free-fall). Dynamic stability also provides a measure of resistance to flow separation over distance and around corners in the form/mold.

Ease of placement – Characterizes the amount of labor required to place the concrete during casting operations.

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.

Exposed aggregate concrete – Concrete manufactured so that the aggregate on the face is left protruding.

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

Filling capacity – A combination of fluidity and stability (passing ability) characteristics. It is the ability of the concrete to completely fill an intricate form/mold or a form/mold containing obstacles such as reinforcement.

Fine aggregate – Aggregate passing a 3/8 in. (9.5 mm) sieve and almost entirely passing a no. 4 (4.75 mm) sieve and predominately retained on a no. 200 (75 µm) sieve, or that portion of an aggregate passing a no. 4 (4.75 mm) sieve and predominately retained on a no. 200 (75 µm) sieve.

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

Fluidity – The ability of a concrete mixture to flow. Inherent in this ability is the mixture's rheological characteristics of yield stress and plastic viscosity.

Fly ash – A finely divided residue with pozzolanic properties that results from the combustion of ground or powdered coal and that is transported by flue gasses. Due to its spherical shape and fineness, it can improve the rheology of SCC.

Form/mold – The container or surface against which fresh concrete is cast to give it a desired shape.

Form/mold release agent – A substance applied to the form/mold for the purpose of preventing bond between the mold and the concrete cast in it.

Formed surface – A concrete surface that has been cast against a form/mold.

Free-fall (of concrete) – The distance concrete falls unrestricted between the placement device and the form or mold surface.

Friction loss – In post-tensioning applications, the stress (force) loss in a prestressing tendon resulting from friction created along 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.

Ground (granulated) blast furnace slag (GGBFS) – A fine granular, mostly latent hydraulic binding material that can be added to SCC to modify the rheological properties of the material.

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 to receive the precast concrete units, for example, 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 hardware necessary for the installation of the precast concrete units.

Harped strand – Strand that is deflected vertically within the formwork to provide an increase in calculated moment capacity relative to strand with a straight profile.

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

Hot weather – A period when, for more than three consecutive days, the following conditions exist: (1) the average daily air temperature is greater than 77°F (250°C) and (2) the air temperature for more than one-half of any 24-hour period is not less than 85°F (30°C). The average daily temperature is the mean of the highest and the lowest temperatures occurring during the period from midnight to midnight.

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

Jacking force – The maximum temporary force exerted by the jack while introducing the prestressing force to 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 SCC, or the degree to which the passage of concrete through the bars of the J-ring apparatus is restricted. A J-ring is an apparatus consisting of a rigid ring supported on sixteen 5/8 in. (16 mm) diameter rods equally spaced on a 12 in. (300 mm) diameter circle 4 in. (100 mm) above a flat surface. See ASTM C1621/C1621M.

Laitance – Residue of weak and nondurable material consisting of cement, aggregate fines, or impurities brought to the surface of plastic concrete by bleed water.

L-box test – A test used to test the horizontal and confined flowability of SCC and/or to check that the placement of SCC will not be compromised by unacceptable segregation and jamming or blocking of aggregates. See Appendix 1 of PCI TR-6.

Lifting beam – A solid or fabricated metal beam or truss, suspended from a hoist or crane, designed to provide multiple lifting points. The lifting beam enables the user to attach the load at more than one point, thereby securing and controlling the load's movement.

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.

Lift-off test – See **chuck lift-off test**.

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

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 mixture containing only the cement and fine aggregates (sand).

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

Mold – See **form/mold**.

Passing ability – The ability of SCC to flow under its own weight (without vibration) and completely fill all spaces within intricate forms/molds, containing obstacles, such as reinforcement.

Paste – The fraction of the concrete mixture comprising powder plus water and air and admixture.

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

Placeability – The ability to place an SCC mixture in the time span associated with the typical production mixing, transport, and placement such that the material remains homogeneous while exhibiting all of the required SCC fresh concrete properties.

Plastic 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.

Plastic viscosity – A material's internal resistance to flow under an applied shearing stress. Once the yield stress of a mixture is overcome, the plastic viscosity dominates flow.

Post-tensioning – A method of prestressing concrete whereby the tendon is kept from bonding to the fresh concrete, then elongated and anchored directly against the hardened concrete, imparting stresses through end bearing.

Powder – Material of particle size passing a no. 100 sieve (0.15 mm).

Powder additions – Finely divided inorganic material used in SCC to improve certain properties or to achieve special properties. These are additions to the current content of the SCC mixture.

Precast engineer – The person or firm that designs precast concrete members for specified loads and may direct the preparation of the shop drawings.

Pretensioning – A method of prestressing in which prestressing reinforcement is tensioned before concrete is cast.

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

Quality – (1) The appearance, strength, and durability that are appropriate for the specific product, particular application, and expected performance requirements. (2) The totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs.

Quality assurance (QA) – The planned activity and systematic actions necessary to provide adequate confidence to the owner and other parties that the products or services will perform their intended functions. Quality assurance is a management tool.

Quality control (QC) – Actions related to the physical characteristics of the materials, as well as to processes and services, that provide a means to measure and control the characteristics to predetermined quantitative criteria. Quality control is a production tool.

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

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

Retarder, surface – A material used to produce exposed aggregate concrete by retreating or delaying the hardening of the cement paste on

a concrete surface within a time period and to a depth to facilitate removal of this paste after the concrete element is otherwise cured.

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

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

Reveal – (1) Groove in a panel face generally used to create a desired architectural effect; also known as rustication. (2) The depth of exposure of the coarse aggregate in the matrix after production of an exposed aggregate finish.

Rheological properties – Properties dealing with the deformation and flow of fluids, primarily in relation to a fresh SCC mixture.

R-meter – An electronic device used to locate and size reinforcement in hardened concrete; also know as a covermeter.

Rustication – A groove in a panel face for architectural appearance; 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/mold face, including the release agent, adhere to the concrete. Some probable causes are an excessively rough form/mold 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 mixture, insufficient fines, water in the form/mold when placing the concrete, poor vibration practices, and low temperature when placing concrete.

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

Segregation – (1) The unintentional separation of the constituents of concrete or aggregate particles. In concrete, the coarse aggregate and drier material remaining behind and the mortar and wetter material flowing ahead. This also occurs in a vertical direction when fresh concrete is overvibrated or dropped vertically into the forms/molds and the mortar and wetter material rise to the top. (2) In aggregate, the coarse particles roll to the outside edges of the stockpile. (3) In SCC, segregation may occur during transport, movement of the SCC within the forms/molds, or after placement.

Segregation resistance (stability)— The ability of SCC to remain homogeneous in composition during transport, placement, and after placement.

Self-consolidating concrete (SCC) – Concrete that can flow around reinforcement and consolidate under its own weight without additional effort and without exceeding specified limits of segregation.

Self-leveling concrete – A subset of SCC for horizontal applications (slabs, floors, surfaces that will only be minimally finished). This type of SCC will seek a level grade in confined forms/molds and will reach maximum density without vibration.

Self-stressing form/mold – A form/mold provided with suitable end bulkheads and sufficient strength to resist the total prestressing force.

Setup – The process of preparing forms/molds for casting, including installation of materials (reinforcement and hardware) before 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.

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

Shrink-mixed concrete – Concrete that is partially mixed in a stationary mixer then mixed completely and delivered to the casting site in a truck mixer.

Shop drawings – (1) Collective term used for erection drawings, production drawings, and hardware details. (2) Diagrams of precast concrete members and the connecting hardware, developed from information needed for both field assembly (erection) and manufacture (production) of the precast concrete units.

Slump flow – Test method used to measure the unconfined flow and stability of SCC. See ASTM C1611/C1611M.

Specially finished structural precast concrete – A product fabricated using forms/molds and techniques common to the production of structural elements as defined in MNL 116, and having specified surface finishes that require uniformity and detailing more demanding than typically required for structural elements. These surface finish requirements should be clearly specified and verified with appropriate samples and mock-ups.

Spread – The distance of lateral flow of concrete determined as the average diameter of the circular deposit of SCC at the conclusion of the slump flow test. See ASTM C1611/C1611M.

Spreader beam – A structural member used to spread the ends of a sling to limit the loading to a vertical load only.

Stability – Resistance to segregation and/or settlement of aggregates during transport, placement, and subsequent to placement. The ability of SCC to remain homogeneous in composition by resisting actions that tend to cause the paste and aggregates to separate during transport, placement, and subsequent to placement.

Static segregation resistance – The characteristic of a fresh SCC mixture that ensures uniform distribution of all particles and air voids once all placement operations are complete and until the onset of setting, without excessive settlement or bleeding. See ASTM C1610/C1610M.

Static stability – The characteristic of a fresh concrete mixture that ensures uniform distribution of all solid particles and air voids once all placement operations are complete and until the onset of setting. Static stability provides a measure of resistance to the tendency to segregate due to gravity effects. This includes resistance to the tendency to settle, air migration within the mixture, and bleeding.

Stickiness – The property of concrete that relates to its propensity to adhere to finishing tools and other surfaces.

Strand – A group of wires laid helically over a central core wire. A seven-wire strand would thus consist 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.

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

Strongback/stiffback – A steel or wooden member that is attached to a panel for the purpose of adding stiffness during handling, shipping, and/or erection.

Structural lightweight concrete – Structural concrete made with lightweight aggregate with an air-dry unit weight of the concrete in the range of 90 to 115 lb/ft^3 (1440 to 1850 kg/m^3) and a 28-day compressive strength of more than 2500 psi (17.24 MPa).

Superplasticizer – A high-range water-reducing (HRWR) admixture that produces concrete of significantly higher slump without addition of water.

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.

T-50 – A test to determine a relative measure of viscosity of SCC. Measured while performing a slump flow test, T-50 is the time it takes the concrete to reach a 500 mm (19.68 in.) diameter circle. See ASTM C1611/C1611M. Also referred to as the T-20 test when measurements are made in inches.

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-tensioned applications, a complete assembly consisting of anchorages, prestressing steel (strand), corrosion-inhibiting coating, and sheathing. It imparts the prestressing force to the concrete.

Thixotropic behavior – The property of a material that will allow it to exhibit a low viscosity while flowing, but stiffen and resist flowing after a short period at rest.

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

> **Product tolerances –** Variations in dimensions relating to individual precast concrete members.
>
> **Erection tolerances –** Variations in dimensions required for acceptable matching of precast concrete members after erection.
>
> **Interfacing tolerances –** Variations in dimensions associated with other materials in contact with or in close proximity to precast concrete.

Transfer strength – The minimum concrete strength specified for the individual concrete elements before transfer of the prestressing force. This is sometimes called detensioning strength or release strength.

Truck-mixed concrete – Concrete that is completely mixed in a truck mixer as it is delivered to the casting site.

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 only by the anchorage.

Unconfined fluidity – A concrete mixture's capacity to flow into and completely fill an open form/mold; characterizes ease of placement (ACI 304).

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

Viscosity – One of the rheological constants of fresh concrete, fresh mortar, and fresh paste when they are regarded as Bingham fluids. The magnitude of the change in the applied stress required for changing the unit flow velocity.

Viscosity modifying agent (VMA) – 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 qualitative visual assessment of the stability of an SCC mixture after performing a slump flow test. See ASTM C1611/C1611M.

Water gain — See **bleeding**.

Water–cementitious material ratio (w/cm) – The ratio of the amount of free water to the amount of cementitious material.

Water-to-powder ratio – The ratio of the amount of free water to the amount of solids comprising the paste (material passing a no. 100 [0.15 mm] sieve) in a concrete or mortar mixture.

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

Wedges – Pieces of tapered metal with teeth that bite into the prestressing steel (strand) during transfer of the prestressing force; also know as jaws. The teeth are beveled to assure gradual development of the tendon force over the length of the wedge. These are standard internal portions of a strand chuck assembly.

Workability – The property of freshly mixed concrete or mortar that determines the ease and homogeneity with which it can be mixed, placed, consolidated, and finished. It is a complex combination of aspects of fluidity, cohesiveness, transportability, compactability, and stickiness.

Yield stress – One of the rheological constants of fresh concrete, fresh mortar, and fresh paste when they are regarded as Bingham fluids. The minimum stress required to make the concrete flow.

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Division 1
Quality System

Division 1
Quality System

DIVISION 1 —QUALITY SYSTEM

Standard

1.1 OBJECTIVE

Quality control shall be an accepted and functioning part of the plant operation. Plant management must make a commitment to quality before quality programs can be effectively adopted or implemented at the operational level. Management shall establish a company standard of quality based on uniform practices in all stages of production and shall require strict observance of such practices by all levels of personnel. Quality control personnel shall serve to confirm and oversee these practices, and shall report to the general manager, chief engineer, or other nonproduction management.

1.2 PLANT QUALITY ASSURANCE PROGRAM

1.2.1 General

The plant shall implement and maintain a documented quality assurance program in addition to this manual. Each plant shall have a unique plant Quality System Manual (QSM) based on operations at that facility.

The QSM shall, as a minimum, cover the following:

a. Management commitment to quality.

b. Organizational structure and relationships, responsibilities, and qualifications of key personnel.

c. Management review of the quality assurance program at regular intervals, not to exceed one year, to ensure its continuing suitability and effectiveness. This review will include handling

Commentary

C1.1 OBJECTIVE

The general objective of this manual is to define the required minimum practices for the production of precast concrete products and for a program of quality control. Overall product quality results from individual as well as company efforts.

Construction project specifications and manuals can prescribe and explain proper quality control criteria for all phases of production consistent with producing products of the highest quality. However, to ensure that such criteria are followed, inspection personnel and a regular program of auditing all aspects of production should be provided.

The individuals in control of operations should have the commitment to produce products of proper quality, and should delegate authority for assignment of the responsibilities necessary to achieve the desired results. Consistent quality can only be achieved if proper procedures are established and then carried out.

While the guidelines in this division address the quality control function, it is recognized that the primary responsibility for quality rests with production personnel. Accordingly, the production personnel should understand the role of quality control and work to ensure effective monitoring, timely responses, corrective actions, and improvement.

Although production personnel are responsible for the quality of products, it is necessary to have a system of checks and balances. Quality control inspections provide this check-and-balance system and consequently are a vital tool for management. The number of persons required to effectively perform the quality control functions will vary with the size and extent of plant operations.

Supervisory personnel are an integral part of the process and should be committed to the quality standards. The production of quality products requires uniformity of management's expectations for all areas of operations and types of products.

C1.2 PLANT QUALITY ASSURANCE PROGRAM

C1.2.1 General

The use of a written QSM requires an initial effort by plant management for development of the document. It further requires periodic updating to establish new practice guidelines to address changes in products, procedures, and facilities.

Plant procedures should be documented as specific instructions to operating personnel. This will help to ensure uniformity in daily operations and the training of current and new employees. See *Preparation Guidelines for a Quality System Manual of a PCI-Certified Plant* (QSM-1) for guidelines on developing a QSM.

The best possible design and use of the highest-quality materials do not ensure product quality. Quality is established through adherence to proven production procedures.