# PLANT CERTIFICATION PROGRAM FOR PRODUCTION OF ARCHITECTURAL PRECAST CONCRETE PRODUCTS MANUAL


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# PLANT CERTIFICATION PROGRAM FOR PRODUCTION OF ARCHITECTURAL PRECAST CONCRETE PRODUCTS

The program outlined herein is directed to certify that plants of the Architectural Precast Association are qualified in facilities and management to produce Architectural Precast Concrete with a required level of competence to be considered as standard for the industry. It is to be emphasized that this program is aimed at certifying plants and not the Architectural Precast Concrete products they produce.

It is intended that a committee be formed within A.P.A. to administer this program. This committee will implement policies and directions as issued from time to time by the Board of Directors. It will insure that inspections are standardized and that certified plants are current on their inspections. It will approve inspection agencies and oversee the plant certification program. Files will be maintained at the office of the Director and an annual certificate will be issued from that office. Publicity of the program will originate from the Director's office.

The committee will administer inspections between the plants and the inspection agencies. Each plant will have one person serve as liaison during the inspections. The testing agencies inspector will remain at the plant for a full cycle of production and will prepare a written report on the inspections. This report will be given to the plant and a copy mailed to the committee. This written report will be distributed no later than two weeks after the inspections. It is expected that the inspection will be a pass/fail system with remarks from the inspector commenting on any observation found pertinent to the manufacturers ability to improve.

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## I. Introduction

Architectural precast concrete has become increasingly popular as a building product because of its economy, flexibility, durability and universal availability. With this increased use a highly specialized industry has developed. The successful use of Architectural Precast Concrete is dependent not only on the designers understanding of the product, but the ability of manufacturers to produce products which comply to the desired intent of the project.

The manufacture of Architectural precast concrete requires a great deal of craftsmanship. It may be designed to be a structural element or solely as an Architectural feature. Varied shapes such as coping, returns, soffits, jambs, sills, and etc. can be cast integrally with the panels. Inlay lettering as well as geometric or other designs can also be incorporated into the panel. This Program is intended to outline the basic requirements of precast concrete plants to assure the capability of producing quality precast concrete products.

Quality control begins with the dedication of each company to produce a fabricated product that conforms to the requirements specified in the contract documents; one that is in compliance with appropriate codes and the recommended standards and practices of the industry; and the requirements established in this plant certification program.

Once shape, size, materials and finishing techniques are established then methods of manufacture, handling and erection can be determined. Materials and performance standards for precast products, are normally stated in the final plans and specifications. They should be reflective of the capabilities and limitations of the manufacturer, while keeping in mind the intent of the designer.

The procedures listed herein are presented to serve as an outline for the processes which govern the manufacture of architectural precast concrete. Its value is dependent on the everyday practice and consideration of the individual producer and is to serve as a reference for others of particular interest. Personnel in the manufacturers organization must be trained, competent, and knowledgeable of current industry standards to achieve quality precast concrete usage.

## II. Quality Control Philosophy

A. General Objectives

The intent of this outline is to identify procedures to establish quality precast concrete and to assure responsibility for quality manufacturing. These procedures establish the criteria necessary to relate to personnel and other interested groups those steps and measures which are required to produce a quality product.

B. Factors for Quality Control

Management shall see that sufficient control procedures are provided to assure all functions performed throughout the overall fabrication process conforms to the quality standards outlined in this manual. The most important functions in the production process are:

1. Personnel: Qualified personnel responsible in the various areas of design, production, and delivery.
2. Record Keeping: Proper selection and inspection records for all materials used in production.
3. Shop Drawings: Clear and complete shop drawings for the production and erection of products.
4. Samples: Use of proper sample procedures for finish selections.
5. Concrete Mixes: Proper design and batching of concrete mixes.
6. Dimensions: Control of dimensions and tolerances.
7. Reinforcement: Proper placement and securing of reinforcement.
8. Embeds: Suitable selection and usage of attachments and proper location of all cast-in or other hardware items.
9. Concrete Placement: Proper handling, placing and consolidation of concrete.
10. Curing: Suitable curing methods.
11. Stripping: Proper stripping procedures.
12. Finishing: Consistent finishing procedures.
13. Delivery: Proper handling, storing and transporting of products.
14. Safety, Procedures and practices relating to personnel well being.

C. Management Influence

As with any production facility, the degree and success of quality control lies in philosophy and standards established by management. The success of a program is dependent on the degree to which management observes and requires adherence to established procedures. Management must also be concerned and aware of practices which influence the safe working conditions of the production facility.

D. Areas of Responsibility

The separate functions relating to the overall operation of a production facility are assigned to personnel responsible for their specific duties. These responsibilities, depending on the producer, may be assigned by management.

These functions are described as follows:

1. Sales/Estimating: Conducts pricing and procuring of contracts.
2. Engineering: Performs interpretation and conveying of information for the design, manufacture and installation of the product.
3. Production: All plant operations associated with the manufacturing process.
4. Quality Control: Verifies product conformance with shop drawings and specifications.
5. Delivery: Hauling of product to designated project location.
6. Project Coordination: Coordinating and/or installation of product according to design drawings.

## III. Quality Control Procedures

A. Samples

1. General: Precast concrete samples are used to give information of the proposed architectural treatment. They are used to show the type of material, the quality of the concrete, and the type of finish. They are related to specific projects and are to be considered only in this manner. Samples should show expected color variations, texture deviations and possible finishing problems.
2. Usage: Samples are used specifically for two purposes:
   a. Selection: Samples used for selection of finishes are general in intent and used to make a preliminary material and finish selection.
   b. Control: Control samples are produced as part of the contractual process. They are used to indicate possible finish variations, shape and finish relationships, and potential casting and consolidation problems.
3. Identification: All samples submitted are to be clearly identified by manufacturers name and identifying code number. A permanent file of sample code numbers with all related data shall be maintained by the manufacturer to ensure future duplication. The sample file is to contain all information on materials used, proportions of concrete mix, and methods for surface finishing. This information is to be available upon request.

B. Engineering

1. Responsibility: The manufacturer shall be responsible for forming, manufacturing, and installation procedures. The aim is to insure that finished projects conform within tolerances to the specified quality. The manufacturer shall review the design of the precast concrete products with respect to layout, connections, and handling stresses. Layout considerations should include jointing, manufacturing and installation tolerances, joint treatment, product sizing and finishes. In addition to the required project loadings, stresses must be considered for handling and installation. The manufacturer should notify in writing any variations he perceives as requiring precaution to the Architect/ Engineer and obtain written acknowledgment of those variations.
2. Form Design: Design should take into account production realities relative to drafts, transitions, and demarcation features. Form design should consider the following factors:
   a. Detailing: Drafting of product shape to facilitate stripping and finishing conditions.
   b. Shape design: Abrupt changes in concrete masses which could produce cracking due to concrete shrinkage.
   c. Rustications: Recessed features are design features used for various reasons. The reduction in thickness affects the structural design of the panel.
3. Shop Drawings: The primary function of precast shop drawings is the translation of contract documents into usable information for the manufacture, handling, and erection of the precast concrete units.
   a. Layouts: The erection drawings provide the precast manufacturer with his only practical means of communicating with the General Contractor, Architect, and Engineer. The drawings provide the Architect/Engineer with a means of checking interfacing with adjacent materials.
   b. Shop details: Good production drawings reduce plant cost and increase production efficiency by providing effective communications between the engineering, production, and erection areas of responsibility.
      Effective shop details indicate the following:
      1. Type, quantity and location of reinforcing.
      2. Type and position of all embed items.
      3. Panel identification and quantity.
      4. Surfaces requiring finishing.
      5. Comprehensive dimensions.
      6. Type and location of lifting/erection devices.

4. Connections and Reinforcing Design: The design or review of a given design for connections and reinforcing is the responsibility of the manufacturer. Stresses produced by handling and installation are in most cases more critical than in-place superimposed loadings and may require additional reinforcing.

C. Testing

1. General: Testing is the method of determining conformance to design and specification requirements. Testing procedures are assigned to the produced product, material to be incorporated in the product, and of machinery or equipment used in the manufacturing process.
2. Material Testing: The specified properties of all materials used in the manufacturing process are to be determined by appropriate testing according to ASTM Standards. These tests can be conducted by either the material supplier or the precast concrete manufacturer.
    a. Cement: Cement mill tests are usually supplied by the cement manufacturer for each shipment. Cement will meet requirements for the named Type in ASTM C 150 or C 595. Any mill certificates are to be kept on file and made available to projects when specified. Certificates of Compliance to ASTM Standards will be kept on file and verified annually.
    b. Aggregates: Aggregates for general mixes are obtained from reliable suppliers. Aggregates for facing mixes are often selected for their color and gradation and may deviate from normal standards. Aggregates will conform to ASTM C 33 or C 330. Gradations and other analysis of the standard aggregates will be kept on file and copies furnished to projects when specified. Standard aggregates ASTM certifications will be kept on file and verified annually.
    c. Water: Water obtained from municipal supply need not be tested. Water from a private well or other source will be chemically analyzed for potability. This analysis will be on file and verified annually.
    d. Reinforcing: Reinforcing bars, mesh and prestressing strand will be supplied with their respective mill certificates. Steel will meet requirements of applicable ASTM and ACI specifications. Any mill certificates are to be kept on file and made available to projects when specified. Certificates of Compliance to ASTM Standards will be kept on file and verified annually. A visual inspection will be made of all steel by plant personnel for scaling or excessive pitting before use in the product.

e. Admixtures: All relevant information of admixtures will be on file in the plant and copies furnished on projects as specified. Air-entering agents will conform to the requirements of ASTM C 260. Other admixtures will conform to requirements of ASTM C 494. ASTM Certificates of Compliance will be kept on file and verified annually.

f. Pigments: The color pigment supplier will certify that pigments or coloring agents are resistant to lime and other alkalies. Pigments shall conform to ASTM C 979. ASTM Certificate of Compliance will be kept on file and verified annually.

g. Inserts: Inserts will be used only as recommended by the suppliers within their published data. All data on inserts and hardware will be kept on file and copies furnished to projects when specified.

h. Embeds: Information will be kept on file for all materials used in the manufacturing process. The manufacturers recommended procedures for the use and application will be strictly adhered to.

I. Mix designs: Concrete mix proportions are to be established under carefully controlled conditions. Concrete mixes developed for specific materials may require re-evaluating of the mix design when the materials change. As a general rule petrographic analysis of facing aggregates should be updated every two years. Record of all standard concrete mixes will be maintained and available for specific projects. These mix designs will be verified by an independent testing agency or by the producers testing equipment if such equipment is certified. Test results will include: compressive strength, slump, unit weight, air content and absorption. Copies of verified test results will be kept on file. Tests will conform to appropriate requirements of ASTM standards."

3. Product Testing

Product testing is to maintain production uniformity to ensure conformity to established criteria of reported data. Specimens will be made and tested for each mix used on a weekly basis or for every 100 cu. yds. of any individual mix. Tests may by performed by the producer or an outside testing agency. The observations to be performed and their frequency are to be as specified.

a. Compressive strength: Concrete strength will be determined by methods in accordance with ASTM C 31 or C1194.
b. Slump: Slump test will be made as required and a variation of + or - one inch will be allowed.
c. Air content: Air content for air-entrained concrete will be tested by appropriate methods. Variations will not exceed + or - 1.5 percent points.
d. Other tests: Other test as required by specification will be performed according to established methods.
e. Reinforcing: Product testing will include inspection for conformance to steel placement and design requirements.
f. Hardware: Inspection for conformance to design of hardware, inserts and other embed items will be included in product testing.

4. Equipment Testing
a. Scales: Batch plant scales will be inspected and calibrated on an annual basis. Calibration records will be kept on file and dates will be posted on the equipment.
b. Jacks: Jacks for stressing strand will be calibrated on an annual basis. Calibration records will be kept on file and dates will be posted on equipment.
c. Testing machines: Plant concrete cylinder testing equipment will be calibrated annually. Calibrations records will be kept on file and dates will be posted on the machine.

D. Review Procedures

The scope of quality control reviews to be performed in architectural precast concrete plants shall include the following:

1. Materials: Any required plant testing of materials for acceptance prior to initial casting, and daily visual checks for quality maintenance.
a. Aggregates: Daily visual checks for color and appearance of all aggregates used to insure conformity to accepted standards. Review each new load as they are delivered.
b. Reinforcing: Daily visual checks of all reinforcing to be used, for damage, contamination or excessive corrosion. Reinforcing size, strength, conformity and location is to be as shown and specified.
c. Cement: A visual check at each weighing or batching to observe possible contaminations from moisture or other materials.
d. Embeds/Hardware: All embeds and hardware is to be used according to the manufacturers published use and design data. Embeds positioned prior to concrete

placement should be securely fastened to prevent movement. Protection should be provided for threads, openings and slots from damage or filling with concrete during the pouring process. Protection should also be provided on embeds during finishing, storage and delivery. Anchors applied to embeds should be reviewed for compliance to design requirements. Welded anchors should be tested for compliance after every 100 units. Anchors on embeds should be reviewed prior to positioning in the form.

2. Concrete: Care must be taken to maintain the mix consistency throughout the project. The consistency of temperature, slump and curing conditions are important in the final product finish. Weighing, dispensing, sequencing and mixing of materials should be accurate and consistent to maintain acceptable panel finishes.
3. Form set up: Forms must be fabricated to maintain specified tolerances during concrete placing. Form set-ups for multiple pours should be rechecked daily for dimension tolerance variations. Re-checking form set-up changes prior to concrete placement lessens potential casting errors. Changes involving block-outs, reveals, cast-in items, position and amount of reinforcing should be rechecked following initial positioning and prior to concrete placement. A visual check of the security of these placements should be made during placing the concrete. The fit and sealing of forms should be such that leakage does not occur causing undesirable fins or edges, unacceptable voids, or discoloration.
4. Testing: Select and prepare concrete specimens for testing and perform tests for slump, air content, compressive strength, and other tests as required.
5. Shop Details: Compare finished product to shop drawing details, surface finishes, dimensions, location of embeds and conformance to shape and detailing. Final review of product conformity should be made prior to shipment.
6. Storage area: General observations of storage area for proper blocking methods used for prevention of chipping, warpage, cracking, contamination or blocking stains, and other items that may adversely affect the quality of the product should be made on a regular basis.
7. Final: A final review of the product should be made during loading for proper blocking, to detect stains, chips, cracks, warpage, and other defects.
8. Repairs: Following any repair, a review should be made of its acceptability and soundness.

E. Record Keeping

1. Samples: Mix design and finish information for promotion samples are to be identified and available for reproducing and duplicating.
2. Finishes/Mix Design: Approved project finish requirements and mix design information is to be identifiable and available for each specific project.
3. Materials: Mill test reports for materials not plant tested shall be required of applicable suppliers. A system of identification shall be established to correlate particular materials to a given project. These records should be kept a minimum of two years.

   The following ASTM Certificates of Compliance are to be kept on file.

   a. Cement
   b. Standard or generally used aggregates.
   c. Admixtures (air-entraining and water-reducers.)
   d. Reinforcing (mesh, re-bars, strand)
   e. Pigments
   f. Information on special items are normally filed with the specific project on which they are used.

4. Drawings: Engineering data including any calculations and approved shop drawings is to be identifiable and available for each specific project. This information is to be maintained for future reference to resolve construction disputes and documentation for any litigation.
5. Special items: Keep available records of all product testing performed on specific projects. These include concrete tests, special inspections and any special design or performance testing.

F. Plant Facilities

Quality production of architectural precast concrete requires plant facilities which reflect current concrete technology and attitudes for cleanliness and personnel safety.

1. Material storage:
   a. Cement: Provide contamination free storage for each type of cement used.
   b. Aggregates: Storage of aggregates should be adequate to prevent contamination. Handling should be such that segregation of aggregates is minimal.
2. Batch Plant: Batch plants are to be capable of producing concrete of the quality required for architectural precast concrete including facilities for measuring, mixing, and dispensing.
   a. Batching: Batching equipment shall be such that the concrete is consistent and within specified tolerances.

Scales should be certified annually and verification posted on them. Checking of scales may be required more often.

b. Mixing: Mixing equipment shall be of a capacity and type to produce thoroughly mixed concrete of a uniform consistency.

c. Admixtures: Admixtures used in mix designs are critical in the desired performance of concrete. They must be dispensed consistently, in a timely and accurate manner from batch to batch.

3. Reinforcement: Reinforcement should be stored, sorted and accessible. Areas used for fabrication should be clean and orderly. Personnel safety and keeping the material free from contaminates and damage are the primary concerns.

4. Sub-assemblies: Sub-assembly areas for forms, steel embeds and reinforcing steel should be accessible, capable of producing desired assemblies and adequate for the facility. Assembly of units should be by specification and follow all current industry standards.

5. Casting: Casting areas should be adequate and orderly to control the fabrication process of Architectural precast concrete.

a. Placing: Concrete should be deposited in the forms in methods that maintain a consistent and uniform finish surface. It should not, by means of placing, disturb or displace any embed items previously placed. Care should be exercised to see that form oils or retarders do not inhibit the design performance of anchors or reinforcing. Prevention of corrosion through and on finished surfaces must be considered when placing reinforcing, reinforcing supports, and ties.

b. Consolidating: Vibration in addition to removing air voids should also evenly distribute the concrete and in some cases orientate the aggregates for a desired finish.

c. Curing: Protection must be provided during the initial curing of concrete placement to attain desired concrete strengths. Consistent curing conditions of temperature, humidity and time are required to maintain finish consistency. Controlling excessive heat and air movement reduces conditions that cause shrinkage cracks.

d. Stripping: Removal of the product from its form is most critical in regards to its structural capacity. Stripping methods should not damage the finish surface. Forms should be designed to allow stripping of the product. Concrete strengths are critical for the performance of lifting devices and reinforcing. Proper concrete strengths prior to stripping must be attained. Lifting equipment

must be adequate and in a condition to allow safe and successful stripping of the product.

e. Finishing: Finish areas must be provided to perform the various methods of attaining the final surface treatment of the product. Special considerations should be given for finishing methods using chemicals or that create excessive dust particles. The product should be supported and positioned for the safety of the personnel working on and around the product. Equipment for finishing techniques must be adequate to maintain consistency from piece to piece. Imperfections which appear may require repair. Patching must be aesthetically acceptable and structurally sound.

6. Storage: Products stored for future shipment should be adequately supported and blocked to prevent damage. Position of blocking is determined by design and must be maintained in storage. Precautions should be taken to prevent chipping, warpage, cracking, contamination, or staining of the product in the storage area. It should be stored in an orderly and accessible manner.

7. Shipping: Loaded products must be properly blocked to prevent cracking and damage to the finished surface. Panels must be adequately secured during transporting to prevent shifting and damage. Some instances may require protection from contamination to the finished surface. The product should be scheduled for the desired delivery sequence of the installer. If possible, they should be orientated at the desire of the erector.

G. Safety

1. General: This program will not attempt to address all of the safety requirements that are involved in conducting a safe operation. The OSHA Act of 1970 stipulates all of the requirements for safety and other governmental acts require their compliance. There are some specific areas of safety concerns that directly affect the ability of the personnel and facilities to produce quality precast concrete products.

2. Safety Requirements:

a. Electrical Equipment: General inspection of electrical equipment to assure that proper grounding is in place and that no bare wires are present.

b. Protective Wear: Proper protective wear is used when grinding, welding, (acid) washing, sandblasting, or other operations that may cause damage to the eyes or body. This includes proper breathing apparatus when fumes or dust pose a hazardous condition.

c. Fire Protection: Adequate fire extinguisher or other types of applicable fire fighting equipment.

d. Hazardous Material: Flammable and hazardous materials shall be properly stored with proper protection of personnel from possible injury.

e. Shielding: All saws, grinders, belts, chains, drive shafts and other rotating equipment shall have all safety shields and covers in place and in good condition for a safe operation.

f. Hoisting Equipment: Lifting devices, cranes, forklifts, and other loading and transporting equipment shall be kept in safe working condition. Slings, hooks, shackles, and other rigging shall be regularly inspected for wear and replacement.

g. It is not the intent of the certification program to transfer safety precautions from management to the program inspection. Inspectors will bring any obvious concerns to the attention of management for disposition.

h. Housekeeping: It is the belief of A.P.A. that good housekeeping and an orderly premise will lead to a safer workplace and a higher quality product. Inspectors are asked to note the housekeeping of all work areas and report both positive and negative comments to management.

## APPENDIX A

## STANDARDS CITED IN THE MANUAL AND RECOMMENDED REFERENCE MATERIAL

AMERICAN SOCIETY OF TESTING AND MATERIALS

| ASTM Designation | Title |
|---|---|
| A 36 | Specification for Carbon Structural Steel |
| A 47 | Specification for Ferritic Malleable Iron Castings |
| A 82 | Specification for Steel Wire, Plain, for Concrete Reinforcement |
| A 184 | Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement |
| A 185 | Specification for Steel Welded Wire Reinforcement, Plain, for Concrete |
| A 416 | Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete |

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|---|---|
| A 421 | Specification for Uncoated Stress-Relieved Wire for Prestressed Concrete |
| A 496 | Specification for Steel Wire, Deformed, for Concrete Reinforcement |
| A 497 | Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete |
| A 615 | Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement |
| A 616 | Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement |
| A 617 | Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement |
| A 706 | Specification for Low Alloy Steel Deformed Bars for Concrete Reinforcement |
| C 31 | Method of Making and Curing Concrete Test Specimens in the Field |
| C 33 | Standard Specification for Concrete Aggregates |
| C 39 | Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| C 40 | Standard Test Method for Organic Impurities in Fine Aggregates for Concrete |
| C 42 | Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| C 88 | Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate |
| C 127 | Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate |
| C 128 | Standard Specifications for Specific Gravity and Absorption of Fine Aggregate |
| C 136 | Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates |
| C 138 | Standard Test Method for Unit Weight, Yield, and Air Content ( Gravimetric) of Concrete |
| C 143 | Standard Test Method for Slump of Hydraulic Cement Concrete |
| C 150 | Standard Specification for Portland Cement |
| C 172 | Standard Practice for Sampling Freshly Mixed Concrete |
| C 173 | Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method |
| C 192 | Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory |
| C 227 | Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method) |
| C 231 | Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |

| | |
|---|---|
| C 260 | Standard Specification for Air-Entraining Admixtures for Concrete |
| C 295 | Standard Guide for Petrographic Examination of Aggregates for Concrete |
| C 330 | Standard Specification for Lightweight Aggregates for Structural Concrete |
| C 470 | Standard Specification for Molds for Forming Concrete Test Cylinders Vertically |
| C 494 | Specification for Chemical Admixtures for Concrete |
| C 566 | Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying |
| C 567 | Standard Test Method for Determining Density of Structural Lightweight Concrete |
| C 595 | Standard Specification for Blended Hydraulic Cements |
| C 617 | Standard Practice for Capping Cylindrical Concrete Specimens |
| C 666 | Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing |
| C 805 | Standard Test Method for Rebound Number of Hardened Concrete |
| C 979 | Standard Specification for Pigments for Integrally Colored Concrete |
| C 1194 | Standard Test Method for Compressive Strength of Architectural Cast Stone |
| C 1195 | Standard Test Method for Absorption of Architectural Cast Stone |

AMERICAN CONCRETE INSTITUTE

| ACI Designation | Title |
|---|---|
| ACI 211.1 | Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete |
| ACI 211.2 | Standard Practice for Selecting Proportions for Structural Lightweight Concrete |
| ACI 211.3 | Recommended Practice for Selecting Proportions for No-Slump Concrete |
| ACI 212 | Guide for Use of Admixtures in Concrete |
| ACI 213 | Guide for Structural Lightweight Aggregate Concrete |
| ACI 304 | Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete |
| ACI 305 | Recommended Practice for Hot Weather Concreting |
| ACI 306 | Recommended Practice for Cold Weather Concreting |
| ACI 308 | Recommended Practice for Curing Concrete |
| ACI 309 | Recommended Practice for Curing Concrete |

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|---|---|
| ACI 318 | Building Code Requirements for Reinforced Concrete |
| ACI | Manual of Concrete Practice |
| ACI 533R-93 | Guide For Precast Concrete Wall Panels |

PRECAST/PRESTRESSED CONCRETE INSTITUTE

| PCI Designation | Title |
|---|---|
| MNL-121-77 | PCI Manual for Structural Design of Architectural Precast Concrete |
| PCI Architect-ural Manual | Architectural Precast Concrete (Second Edition) |
| MNL-117-77 | Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products - Second Edition |
| MNL-119 | PCI Architectural Precast Concrete Drafting Handbook |

AMERICAN WELDING SOCIETY

| AWS Designation | Title |
|---|---|
| A 5.1 | Specification for Mild Steel Covered Arc Welding Electrodes |
| A 5.5 | Specifications for Low-Alloy Steel Covered Arc Welding Electrodes |
| D 1.1 | Structural Welding Code |
| D 12.1 | Reinforcing Steel Welding Code |

CAST STONE INSTITUTE

| CSI Designation | Title |
|---|---|
| CSI-04720-90 | Cast Stone Institute Technical Manual with Case Histories. |

## Specific Reference Material

| | |
|---|---|
| ACI-533R-93 | Referenced To Program Review Form |
| Section I | Personnel: These requirements are from typical manufacturing operations and have no industry references. |
| Section II | Records: ACI-533R Section 7.8 |
| Section III | Shop Drawings: ACI-533R Paragraph 5.1.1 |
| Section IV | Samples: ACI-533R Section 1.4 |
| Section V | Concrete Mixes: ACI-533R Section 5.3 |
| Section VI | Dimensions: ACI-533R Section 3.5 Paragraph 5.1.1 and 5.2.7. |
| Section VII | Reinforcing: ACI-533R Sections 4.7 and 5.4 |
| Section VIII | Embeds: ACI-533R Section 4.8 |
| Section IX | Placement: ACI-533R Sections 5.2 and 5.5 |
| Section X | Curing: ACI-533R Section 5.7 |
| Section XI | Stripping: ACI-533R - Section 5.8 and Paragraph 6.2 |
| Section XII | Finishing: ACI-533R - Section 5.6 |
| Section XIII | Delivery: ACI-533R - Section 5.9 |
| Section XIV | Safety: Safety is a general concern and specific references are directed to local authorities and O.S.H.A. |

# APPENDIX B

## TOLERANCES FOR ARCHITECTURAL PANELS

| | |
|---|---|
| Panel length and width: | |
| 10 ft or under | ±1/8" |
| 10 to 20 ft | -3/16", +1/8" |
| 20 to 40 ft | ±1/4" |
| Panel thickness | -1/8", +1/4" |
| Panel Squareness (diagonal lengths): | |
| Per 6 ft of diagonal length | ±1/8" |
| Maximum diagonal variation | ±½ |
| Location of rustication joints | ±1/16" |
| Dimensions of Architectural features and rustications | ±1/16" |
| Length and width of blockouts | ±1/4" |
| Location of blockouts hidden from view and used for HVAC and utilities | ±½ |

Some types of windows and equipment require openings more accurately placed. When this is the case, the minimum practical tolerance should be defined by the manufacturer.

| | |
|---|---|
| Panel bowing | ±L/360 |
| Differential bowing between panels | ½ |
| Panel warping | 1/16" per ft |
| Location of embed plates and angles | ±1" |
| Flushness and rotation of embeds | ±1/4" |
| Location of inserts | ±½ |
| Location of handling devices | ±3 |
| Location of tendons | ±1/8" |

| | |
|---|---|
| Location of haunch or bearing angles..... | ±1/4" |
| Electrical outlets, hose bibs, etc..... | ±½ |
| Reinforcing steel and welded wire fabric..... | ±½ |
| Where position has structural implications or affects Concrete cover..... | ±1/4" |